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Mortgages**

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Liquidity Problems and Early Payment Default Among Subprime Mortgages

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Abstract

The lack of property tax escrow accounts among subprime mortgages causes borrowers to make large lump-sum tax payments that reduce liquidity. Different property tax collection dates across states and counties create exogenous variation in the time between loan origination and the first property tax due date, affording the opportunity to estimate the causal effect of loan-level exposure to liquidity reductions on mortgage default. We find that a nine-month delay in owing property taxes reduces the probability of first-year default by about 4 percent, or about one-third of the effect of a reduction in equity from 10% to negative 20%.

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1 Introduction

High rates of early payment default (EPD) among subprime mortgages, which is when a borrower defaults in the first year of mortgage origination, triggered large financial losses among many subprime lenders and contributed to the largest financial crisis since the Great Depression (Mayer, Pence & Sherlund (2009)). The literature on mortgage default presents two reasons why borrowers default: illiquidity that limits a household's ability to make mortgage payments and negative equity that leaves households unwilling to pay even though they may be able. In this paper, we provide evidence that liquidity constraints among subprime borrowers contributed greatly to the high EPD rates.

While establishing and quantifying the relative importance of illiquidity is a topic of vigorous debate, prior work is limited by the inability to observe exogenous, loan-level differences in liquidity.¹ A common strategy found in the literature is to use proxies for liquidity differences among borrowers, such as the unemployment or credit card delinquency rate in a borrower's county, the divorce rate in a borrower's state, or credit card utilization rates (Elul, Souleles, Chomsisengphet & Glennon (2010)).² The problem with this approach is that aggregate proxies like unemployment rates and credit card delinquency rates are often correlated with unobserved determinants of default, such as borrower-specific default costs or expectations of capital gains. For example, borrowers in high unemployment counties may be more likely to default because they expect lower future capital gains than borrowers in counties with low unemployment. Credit card utilization rates face a similar limitation: borrowers with higher discount rates may also have higher credit card utilization and thus value future capital gains less, which may lead to default, irrespective of borrowers' illiquidity. Thus, the endogeneity of the available proxy variables for between-loan differences in borrowers' illiquidity prevents the identification of the causal effect of loan-level liquidity differences on mortgage default.³

We use local property tax due dates to observe plausibly exogenous and anticipated loan-level reductions in borrowers' liquidity. The prolonged absence of property tax escrow accounts in the subprime mortgage market ensures that property tax due dates represent large financial obligations for these borrowers.⁴ In 2007, among housing units with mortgages, the median annual property tax payment was \$2,099, which was 140% of the median monthly housing cost and 2.9% of the median annual household income.⁵ As discussed in Cabral & Hoxby (2010), property tax bills are very salient to homeowners without escrow accounts and large enough that they must either save or increase credit card borrowing to pay these bills. The periods immediately following a property tax

¹See Deng, Quigley & van Order (2000), Bajari, Chu & Park (2008), Foote, Gerardi & Willen (2008), Experian-Oliver Wyman (2009), Ghent & Kudlyak (2009), Mayer et al. (2009) and Vandell (1995) for a summary.

²Fay, Hurst & White (2002) and Keys (2010) observe individual-level adverse events in a studies about bankruptcy.

³In addition to endogeneity, using aggregate proxies prevents the estimation of how the average borrower is affected by illiquidity and assigning aggregate proxies to individual loans introduces classical measurement error, which attenuates our understanding of how illiquidity contributes to mortgage default. Other sources of loan-level liquidity reductions, such as interest rate resets, typically occur two to three years after origination and thus cannot provide information on the causes of EPD.

⁴Industry estimates suggest that prior to 2007 only about 25% of subprime loans had escrow accounts (National Mortgage News MortgageWire Archive, March 7, 2005).

⁵These figures likely underestimate the annual financial obligation among subprime mortgage holders, but, in states with semi-annual installments, may overstate the size of an individual tax bill. Source: U.S. Census Bureau, 2007 American Community Survey.

due date are thus associated with a decrease in cash-on-hand or an increase in debt commitments. Survey evidence from 2006 suggests that property tax liabilities were the proximate cause of as much as 12% of subprime mortgage delinquencies.⁶

By combining loan-level information on the payment status of subprime mortgages with administrative data on property tax collection dates, we observe exactly when an individual borrower faces a property tax due date.⁷ Differences in property tax collection dates across states, counties, cities, and school districts make the timing of the first property tax due date relative to when a mortgage is originated plausibly orthogonal to unobserved determinants of negative equity, default costs, expectations of capital gains, and the size of property tax bills. This natural experiment allows us to observe otherwise-identical borrowers that differ only in the timing of their first property tax due date relative to when a mortgage is originated.

The exogenous variation in the timing of the first due date allows us to identify variation in borrowers' duration of exposure to a reduction in liquidity, which we use to estimate the effect of reduced liquidity on mortgage delinquency and default outcomes. For example, one year after origination, some borrowers have been "treated early" and paid their identical property tax bill 11 months ago, while otherwise similar borrowers have been "treated late" and paid their identical property tax bill only 1 month ago. Unless borrowers are able to quickly increase cash-on-hand or decrease debt commitments, in the first year after origination borrowers treated early are exposed to up to 11 more months of reduced liquidity than borrowers with late due dates. Our estimation strategy thus relies on the identifying assumption, which is consistent with our data, that borrowers originating loans near and far away from property tax due dates are observably and unobservably similar.

Using data on subprime loans originated between 2000 and 2007 for home purchases, we find that an approximately nine month delay in owing property taxes reduces the probability of EPD by about 3 to 4 percent. This estimate suggests that the effect of a nine month delay in owing property taxes is about one-third as large as the effect of a transition from 10% equity to 20% negative equity. If the reduction in liquidity due to property taxes were, on average, immediate and brief, we would expect "early treated" and "late treated" loans to experience similar rates of EPD (i.e., default within the first year of mortgage origination). We therefore infer that the likely mechanism for the estimated effect occurs through the persistence of the liquidity reduction as the first property tax bill increases borrowers' sensitivity to income or expenditure shocks after the due date. That we also find an 11 to 16 percent greater likelihood of making up missed mortgage payments (i.e. "curing") when property taxes are delayed corroborates this interpretation.

2 Property Tax Due Dates, Liquidity, and Default

To understand how less liquidity ensues following a property tax due date, we begin with an explanation of the property tax remittance process in the United States. The property tax remittance process in the United States creates two types of borrowers: those for whom property tax due dates produce no reduction in liquidity because they have escrow accounts and those for whom prop-

⁶See Table 4 in: Partnership Lessons and Results: Three Year Final Report, p. 31 Home Ownership Preservation Initiative (July 17, 2006) at www.nhschicago.org/downloads/82HOPI3YearReport_Jul17-06.pdf.

⁷Knowledge of which borrowers experience a liquidity reduction allows us to avoid the measurement error associated with aggregate proxies and to estimate the effects of liquidity reductions for the average borrower.

erty tax due dates produce a reduction in liquidity because they do not have escrow accounts. A borrower and his lender jointly select one of two processes for remitting property taxes: an equal portion of the total tax payment each month along with the mortgage payment or a lump sum property tax payment on or before a tax due date.⁸ In the case where property taxes are included in the monthly mortgage payment through an escrow account, a property tax due date requires no action and produces no post-due date liquidity reduction. This is because an escrow account, which is a bank account set up by a lender (or servicer) in which he deposits monthly payments collected from the borrower, spreads out the borrower's tax payments over time. A borrower's monthly escrow payments are fixed throughout any single year.⁹ Thus, for escrowed borrowers, a property tax due date is not associated with a post-due date increase in financial obligations nor any direct remittance to the local government.

For borrowers without escrow accounts, which includes upwards of 75% of subprime borrowers, a property tax due date requires action and has effects on their liquidity, even if these bills are well anticipated.¹⁰ A non-escrowed borrower must decide whether or not to remit a lump sum tax payment to the government. Both actions, either paying the tax bill on time or not paying on time, reduce the non-escrowed borrower's liquidity via two mechanisms: less cash-on-hand and an increase in debt commitments.¹¹ If a borrower elects not to pay their property tax bill on time, he increases his debt commitments by incurring tax delinquency penalties and a typical annual interest rate of 18%. If the bill remains unpaid the local government possesses the first lien on the home and has the right to take ownership of the property.¹²

A non-escrowed borrower choosing to pay the property tax bill on time has at least two types of options to finance his payment, both of which result in a reduction in liquidity (albeit with different implications for the magnitude and duration of the reduction). First, if the borrower has adequate cash-on-hand to pay the property tax bill by cash or check, the property tax payment reduces post-due date liquidity by reducing cash-on-hand. For some borrowers, it may take many months to restore their cash-on-hand to their pre-due date levels. Second, a borrower with inadequate cash-on-hand may choose to become delinquent on the mortgage, stop paying non-mortgage bills, such as utility or credit card bills, or increase their borrowing (or some combination of these three actions). Each of these three actions leads to greater debt commitments via increased borrowing and possibly higher borrowing costs, which may take many months to undo. Even if borrowers optimally select the action that least increases their debt commitments, their liquidity is lower after the property tax due date. For example, the permanent income hypothesis predicts that, to smooth consumption, borrowing increases (savings falls) in the period of an anticipated increase in financial obligations. If mortgage delinquency represents the least expensive borrowing vehicle, households may elect to become delinquent to cover their financial obligations.¹³

⁸Note that a borrower's total annual property tax payment does not depend on the remittance process.

⁹A borrower ensures an adequate "cushion", i.e., enough money in the account to pay the tax bill on the due date, over the course of the year by making an initial deposit into the escrow account at closing (Anderson & Dokko (2009)).

¹⁰Mortgage Servicing Bulletin (MSB), March 7, 2005.

¹¹Although this assumes that the tax bill is large enough that it is impossible to finance the tax bill entirely through a decrease in consumption expenditures that leaves cash-on-hand and debt commitments unchanged, we believe this assumption is justified (see Cabral & Hoxby (2010)).

¹²Our review of state statutes suggests that most states' interest charges and delinquency penalties imply an annual interest rate of between 12% and 18%.

¹³Becoming delinquent on a mortgage entails a typical penalty of between 1% and 5% of the mortgage payment. In the subprime market, it is reasonable to expect borrowers to pay around 20% interest on credit card balances.

Depending on the financial resources of borrowers and the size of the property tax bill, the liquidity reduction associated with the remittance of property taxes around the property tax due date can be either brief or persistent. When the liquidity reduction is brief, any effect on delinquency and default decisions occurs contemporaneously with the due date when non-escrowed borrowers choose to become delinquent or default on the mortgage to cover other (tax and non-tax) payment obligations. When the liquidity reduction is persistent, however, a prolonged state of reduced liquidity after the tax due date makes borrowers' decisions on delinquency and default more sensitive to income and expenditure shocks, such as unemployment, furlough days, and serious health problems. Tax remittance can produce a persistent liquidity reduction via higher post-due date debt commitments that cause borrowers to have a higher back-end debt-to-income ratio (DTI).¹⁴ If subjected to an income shock, a borrower with higher DTI may find it optimal to finance his non-mortgage debt commitments (e.g., avoid credit card delinquency or default) by becoming delinquent or defaulting on his mortgage.¹⁵ Thus, regardless of whether or not the liquidity reduction is brief or persistent, it can affect mortgage delinquency and default.

In the empirical analysis we focus on estimating the effect of the timing of the first property tax due date after mortgage origination on the probability of subprime mortgage delinquency and default during the mortgage's first year. The first property tax due date after mortgage origination offers the best opportunity to identify the effect of an exogenous reduction in liquidity occurring over a finite length of time. During the first year of a mortgage, the first property tax due date cleanly demarcates the months prior to the first bill. During this time, a non-escrowed borrower is not exposed to a liquidity reduction prior to the due date whereas afterward, he is exposed to either a brief or persistent state of reduced liquidity.¹⁶ If the liquidity reduction from the first due date is persistent, subsequent property tax due dates do not cleanly demarcate the time before and after a liquidity reduction.¹⁷ Subsequent due dates may, however, exacerbate the liquidity reduction associated with the first due date.

3 Empirical Strategy

3.1 Identification

The objective of the empirical strategy is to estimate the effect of the timing of the first property tax bill on first-year mortgage delinquency and default.¹⁸ Differences in the timing of the first property tax due date relative to loan origination and the size of the property tax bill create between-loan variation in the timing (extensive margin) and magnitude (intensive margin) of the

¹⁴The back-end DTI ratio is the mortgage payment (including any escrowed insurance and taxes), credit card debt, car loans, education loans, and other debts divided by income.

¹⁵Cohen-Cole & Morse (2010) provide evidence that households become delinquent on their mortgage to avoid credit card delinquency.

¹⁶The owner of a property at the due date is legally responsible for remitting the property tax payment. Thus, even if sellers and buyers negotiate, for example, a reduction in closing costs to "compensate" the buyer for their first property tax bill, the buyer (i.e., owner at tax due date) must still remit the taxes and must pay any delinquency penalties.

¹⁷In addition, since some loans will not face a second due date until their second year after origination, focusing on the first due date allows us to focus on delinquency and default in the first year of a mortgage.

¹⁸We define delinquency as one or two missed mortgage payments and default as at least 3 missed payments or a foreclosure start.

post-due date liquidity reduction associated with the property tax bill. We focus on estimating the effect of reduced liquidity along the extensive margin: because homeowners sort into high or low tax jurisdictions based on tastes for public goods, income, and other characteristics that may be correlated with their ability to pay their mortgages, between-loan variation in the timing of due dates is plausibly more exogenous than between-loan variation in the size of property tax bills.

More explicitly, between-loan variation in the timing of the post-due date liquidity reduction arises from between-loan differences in the month of origination and between-jurisdiction variation in the month of property tax due dates. Property tax due dates vary between states and within states. In 33 states, property tax due dates are uniform within the state while the remaining states' due dates vary within a state because counties or other local governments set their own due dates.¹⁹ Table 1, panel A shows that the between-state variation in property tax due dates spans most calendar months as every month except July has at least one state with a due date within it. The most common month for due dates is October and there are fewer states with due dates in the summer. As seen in Table 1, panel B, the origination month of subprime purchase loans varies between loans with a peak in June and a trough in January, similar to the seasonal pattern seen in conforming loans.

Together, variation in due dates and origination months generates between-loan variation in loans' ages at the first property tax due date ("due date age"), as seen in Table 2. All loans face a property tax due date within one year of origination. Although the majority of loans face a due date within the first four months after origination, over 13% of loans face their first property tax due dates nine or more months after origination (panel A). Panel B of Table 2 shows the distribution of due date age, along with some additional borrower characteristics, for each origination month. The average FICO and combined loan-to-value (CLTV) ratio demonstrate that the borrower characteristics identified by the mortgage default literature to be most predictive of delinquency and default are very similar between origination months, suggesting that there is no observable seasonal pattern in the credit quality of borrowers originating mortgages (Mayer et al. (2009)). The within-origination month variation in due date age reported in the last two columns demonstrates that origination month alone does not determine a loan's due date age. In fact, for all origination months, except June, the due date age ranges, inclusively, from one to 12.²⁰

Because of the identifying assumption that due date age is as good as random, pre-determined loan and borrower characteristics observed at origination should not be correlated with loans' due date ages (Holland (1986) and Rubin (1986)). Specifically, loans that are older or younger at the due date should not systematically differ in terms of the differences in borrower characteristics related to delinquency and default decisions such as income, the debt-to-income ratio, and credit-worthiness. We test the implications of this identifying assumption in Table 3, which shows loan characteristics for the entire sample by loans' due date ages. As seen in Panel A, with the exception of the combined loan-to-value (CLTV) ratio at origination, loan and borrower characteristics vary depending on the age of the loan when the property tax bill is due. However, because the maximum due date age varies by state, the composition of states changes as the number of months until the property tax due date increases. For example, in Florida, property taxes are due once a year and a loan may be 12 months old before it faces its first property tax due date but in California,

¹⁹See appendix table for a list of payment installments by state.

²⁰Unlike time until the first property tax due date, time between the first and second due dates does not vary much within-state. In the 13 states with annual due dates, there is no within-state variation in time between due dates. In states with uniform semi-annual due dates the time between due dates takes on, at most, several values.

taxes are due twice a year and a loan can be no older than six months at its first property tax due date. Furthermore, because the composition of states changes across the columns, the distribution of origination year also changes as lending in the subprime market did not decrease as much in 2007 among states with annual due dates (for reasons unrelated to property taxes). Panel B shows the average borrower characteristics after regression adjusting for state, origination year, and the calendar month of the due date. State fixed effects allow for comparisons of average borrower characteristics across the treatment groups holding time-invariant state characteristics fixed. Origination year and due date month fixed effects are also included in the regression adjustment to control for time trends that may be correlated with the composition of states. After regression adjusting the average characteristics, we infer that most of the differences observed in Panel A are due to the changing mix of states in the sample. Indeed, the similarity in the average characteristics in Panel B suggests that conditional on state, origination year, and due date month, there is no *a priori* reason to reject the validity of the research design.

We estimate the following equation using a logit specification:

$$D_i^j = \alpha + \beta_{4-6} Due_{4-6,i} + \beta_{7-9} Due_{7-9,i} + \beta_{10-12} Due_{10-12,i} + \gamma \cdot X_i + \nu \cdot W_i + \epsilon_i \quad (1)$$

where D_i^j equals one if, at any time during the loan's first year, borrower i experiences outcome j and zero otherwise. The four delinquency and default outcomes we are interested in include whether the borrower misses one, two, or three consecutive mortgage payments, leaving him 30, 60, or 90 days delinquent at any point during the first year of the mortgage, as well as whether the lender initiates a foreclosure start. Following conventions in the mortgage default literature, we consider 90-day delinquency or a foreclosure start during a loan's first year as EPD. Later, we also examine whether these same outcomes occur during the first 2 years after origination.

If a loan leaves the sample prior to delinquency or default because the borrower chooses to refinance, then we consider this borrower as not being delinquent or not defaulting (i.e. $D_i^j = 0$ for this borrower). Because we assume that for any loan in a given state, due date ages are as good as random, they are also assumed to be orthogonal to the prepayment incentives borrower i faces, allowing us to estimate (1) in a simple logit framework that need not account for the simultaneity of the borrower's prepayment option (see Deng et al. (2000)).

In equation 1, the three binary property tax due date variables, $Due_{t-k,i}$, divide the sample into four treatment groups and equal one if a loan has property taxes first due at ages t through k during the first year of the mortgage and zero otherwise. For example, if loan i 's first property tax due date occurs at month 7, 8, or 9 since origination, the variable $Due_{7-9,i} = 1$ and the other two due date variables equal 0. Since the omitted category represents loans with due date ages equal to 1, 2, or 3, these loans have $Due_{t-k,i} = 0$.

The four treatment groups categorize loans according to their due date ages and the maximum potential duration of exposure to a persistent liquidity reduction induced by taxes. The between-loan differences in due date age produce the between-loan differences in the duration of exposure. During the first year after origination, loans that are younger when property taxes are due spend more months after the due date, which is a period when they may be exposed to a persistent liquidity reduction.

X_i is a vector of pre-determined loan and borrower characteristics observed at origination including the borrower's FICO score, sales price, a dummy indicating whether the loan was fully

documented, an indicator equal to one if the loan is an adjustable rate mortgage, the initial interest rate, combined loan-to-value ratio, and fixed effects for origination year, the calendar month of the first property tax due date, and state.²¹ Note that we do not need to control for loan age because at the end of their first year all loans are one year old. Since all loans face all 12 calendar months, seasonal differences in default rates will not create between-treatment-group differences in default rates.²² The control variables in X_i address some reasons that are unrelated to property taxes but explain why default rates might be higher (or lower) for borrowers in any of the four treatment groups: borrower-specific risk characteristics such as FICO or CLTV, declining underwriting standards that are proxied for by the loan's origination year, and state-specific factors, such as mortgage lending laws or macroeconomic conditions.

W_i represents a vector of borrower characteristics that are not pre-determined at origination but may be correlated with a loan's age at the property tax due date and also affect a borrower's ability to pay the mortgage and therefore the likelihood of default. These variables include housing equity at the first property tax due date (measured as the mark-to-market CLTV ratio), first-year house price appreciation, and the size of the property tax burden (measured as the ratio of borrowers' county median property tax to county median income). We explore the extent to which loans differ along these dimensions in Table 4. Similar to Table 3, loan age is less likely to be correlated with loan characteristics upon controlling for state, origination year, and due date month (Panel B) than in Panel A, where the composition of states changes across the four treatment groups. For example, within a state, the size of the average annual property tax bill and the number of installments do not vary between groups. The variable ϵ_i is assumed to be a random error term. We show two sets of estimates: those that control for X_i and W_i and those that control only for state, origination year, and the calendar month of first property tax due date. The results are consistent across these two specifications.

In general, identifying the coefficients in equation (1) may be challenging if property taxes do not reduce liquidity and instead, due dates are correlated with loan characteristics, such as down payment amounts or borrowers' creditworthiness. Our natural experiment and the variables in X_i and W_i allow us to credibly estimate the effects of the timing of liquidity reductions. Equation (1), however, does not control for whether borrower i has an escrow account as this information is not observed in most publicly available loan-level administrative data. Hence an important identifying assumption is that subprime borrowers do not elect to open escrow accounts based on the property tax due date, i.e., the fraction of borrowers with escrow accounts is the same across treatment groups. Given that very few subprime borrowers had escrow accounts, this assumption is likely to be met. However, if, for example, borrowers with property tax due dates that are further away from the origination date were more likely to set up an escrow with the lender, they may be less likely to default either because they possess better financial management or because they experience no post-due date liquidity reduction.

An alternative methodological approach to estimating the effect of reduced liquidity using equation (1) is an event study along the lines described in Jacobson, LaLonde & Sullivan (1993).

²¹For states with uniform due dates, the combination of state and the month of first property tax due date is a perfect predictor of origination month. Thus, all three indicator variables cannot be included in the same regression.

²²There are, however, between-loan differences in loan age for each each calendar month. If the order in which a loan faces each month (i.e., March at age 3 months or at age 10 months) affects first-year default probability, an origination-month dummy will control for any effects. Regressions that include origination month rather than property-tax-due-date month fixed effects do not alter any conclusions.

We believe, however, that an event study approach will not identify the causal effect of post-due date liquidity reductions on mortgage delinquency and default because of the difficulty in constructing a counterfactual group of loans that never face property taxes.²³ An event study comparing the delinquency rate of loans before and after the property tax due date would incorrectly infer that a higher delinquency rate after the property tax due date owes to the post-due date liquidity reduction. This approach will be misleading because loans observed after the property tax due date are, by construction, older than they were prior to the event and may be more likely to default because they are older. Because all non-escrowed subprime loans are exposed to property tax due dates, leaving no group of counterfactual untreated loans, an event study without a valid counterfactual is not identified unless strong and likely invalid assumptions are made about the relationship between confounding factors and delinquency (see McCrary (2007) for a more technical explanation).²⁴

In some cases it may be possible to use a comparison group to identify and “difference out” the confounding effects of age on delinquency. Some obvious comparison groups include subprime loans with escrow accounts, which most loan-level data sets do not identify, or loans that have escrow due to the institutional features of mortgage lending, such as many prime loans. Even if loans’ escrow status were observable, it is not randomly assigned and thus selection issues prevent escrowed-loans from offering a valid comparison group. The delinquency and default behavior of subprime and prime loans are so different that the age effects of prime loans that one would “difference out” are not a valid counterfactual and using them as such would lead to misleading inferences.

In sum, we think an event study does not credibly estimate the causal effects of a post-due-date liquidity reduction. Although we do not wish to emphasize them, in the appendix we present event study results consistent with our main results.

3.2 Interpretation

The marginal effects corresponding to the three β s in equation 1 represent the differences in the first-year delinquency and default probabilities relative to the case where property taxes are due in the first three months after origination. We define a liquidity reduction as brief (and thus not persistent) when due dates in previous quarters have no treatment effects in future quarters because liquidity has already recovered to its pre-due date level. Between-group differences in due date age produce between-group differences in delinquency and default rates because either the liquidity reduction is persistent or the treatment strength of a brief liquidity reduction varies by loan age.

As an example, consider the result that the probability of first-year default declines as the due date age increases. This result seems to imply a persistent liquidity reduction, but that is not necessary. In our framework, a declining delinquency or default probability as due date age increases implies that:

$$\beta_{10-12} < \beta_{7-9} < \beta_{4-6} < 0 \quad (2)$$

²³In addition, conceptually, an event study would characterize an outcome related to EPD, such as the fraction of loans that are delinquent in a particular month, but not EPD itself around the property tax due date.

²⁴For example, Agarwal, Liu & Souleles (2007) and Johnson, Parker & Souleles (2006) are able to exploit the random timing of tax rebates to estimate event studies of the consumption response because there is not a confounding variable (e.g. age) correlated with the timing of the tax rebates.

The unique circumstances under which conditions in equation 2 hold are infinite but two special cases are worth mentioning. First, consider the case where the liquidity reduction is persistent. In this case, differences in age at first due date differentially expose borrowers to a persistent liquidity reduction. For example, during the loan’s first year the maximum duration of exposure to a persistent liquidity reduction is longer for borrowers facing property taxes in the second quarter than those with a fourth quarter due date. Accordingly, if exposure to reduced liquidity affects delinquency and default, the first-year delinquency and default probabilities of loans with first quarter due dates are higher than those of loans with later due dates. Second, consider the case where the liquidity reduction is brief and not persistent so that the duration of exposure to the liquidity reduction is the same for all borrowers. In this case, in order for $\beta_{10-12} < \beta_{7-9} < \beta_{4-6} < 0$, it must be the case that the treatment strength of an identical (brief) liquidity reduction declines as age-at-due-date increases. Regardless of the specific circumstances under which $\beta_{10-12} < \beta_{7-9} < \beta_{4-6} < 0$, this result must suggest that property taxes affect mortgage delinquency and default through either a brief or persistent liquidity reduction.

When the liquidity reduction is persistent, first-year delinquency and default is higher for late due loans because censoring outcomes at one year prevents us from observing the effects of the persistent liquidity reduction for late due loans. If the liquidity reduction persists for a finite number of quarters, the uncensored effects are identical across treatment groups.²⁵ If the liquidity reduction is brief, censoring at one-year will not affect our results because we will have observed the total uncensored effect for all treatment groups. In sum, censoring at one year does not create an effect on delinquency and default where none existed; but censoring can reveal an effect, driven by a persistent liquidity reduction, that we might not otherwise see.

The plausibly random assignment of loans into treatment groups implies that if property tax due dates do not affect delinquency and default, loans in the four treatment groups should have equal delinquency and default probabilities. That is, the three β_{t-k} coefficients equal zero. Finding that the β_{t-k} coefficients are not different from zero, however, is a necessary but not a sufficient condition for demonstrating that the post-due date liquidity reduction has no effect on first-year default probabilities. There are two scenarios under which $\beta_{4-6} = \beta_{7-9} = \beta_{10-12} = 0$. First, this may happen when property tax due dates and any associated liquidity reductions have no effect on delinquency and default. Second, $\beta_{4-6} = \beta_{7-9} = \beta_{10-12} = 0$ when the liquidity reduction is not persistent and the effect of the brief liquidity reduction is homogenous across loans in different treatment groups.

4 Data and Sample

We combine data from multiple sources to obtain information on a loan’s payment status over time, pre-determined underwriting characteristics, age at due date, and variables that may be correlated with a loan’s age at the property tax due date and also affect default. Loan-level data on payment status are from CoreLogic (formerly known as LoanPerformance) and these data track whether a loan is current, 30/60/90 days delinquent, or in foreclosure.²⁶ These data also contain limited

²⁵If the liquidity reduction were infinitely persistent, the delinquency and default rates are always different between treatment groups because early-due loans’ would have longer treatment duration than other loans.

²⁶The monthly indicator for foreclosure roughly identifies when the foreclosure process starts, not when it ends, which is typically 8 to 12 months after when the borrower stops making payments (see Cutts & Merrill (2009)).

underwriting information, such as the borrower's credit score (FICO), an indicator for whether the borrower fully documented his income, the combined loan-to-value (CLTV) ratio, and, for about 60% of the observations, the borrower's stated debt-to-income (DTI) ratio at the time of origination.²⁷ CoreLogic's database also includes limited information on loan characteristics that may pose risks to the borrower: the initial contract interest rate, an indicator for whether the mortgage has an adjustable rate, and an indicator for whether there is a prepayment penalty. For each loan in CoreLogic's database, we know the month and year in which loans are originated.

The loan's age at the property tax due date is constructed by combining CoreLogic's data with information on property tax due dates, which we obtained from the *2008 U.S. Master Property Tax Guide*, internet resources, and phone/email contact with property tax-collecting government officials.²⁸ Appendix Table 1 lists the payment installments by state, which we combine with a loan's "birthday" to calculate the loan's age, measured in months, at the time when property taxes are first due.

To control for the magnitude of the property tax burden, we use county median property tax amounts relative to county median income reported in the 2005 American Community Survey (for calendar year 2004). First-year house price appreciation rates are from CoreLogic's ZIP code and state house price indexes. Following Foote et al. (2008), we construct a mark-to-market measure of housing equity at the first property tax due date using these house price indexes and the CLTV ratio at origination.

As alluded to earlier, a key feature of our identification strategy is that we do not need to know whether a loan has an escrow in order to estimate Equation (1). This addresses a limitation of the CoreLogic data where there is no variable indicating the escrow status.²⁹ Because of this data limitation, we analyze all subprime first liens originated for home purchases between 2000 and 2007, including those that may have an escrow.³⁰ We exclude loans originated for refinancing as borrowers with such loans have faced prior property tax due dates and thus the first due date after origination is less likely to provide a clean demarcation of before and after exposure to a liquidity reduction. We also exclude loans packaged into alt-A securities, which typically were originated by investors or borrowers without impaired credit histories who sought out the non-prime market for the mortgages with exotic features, such as interest-only payments or negative amortization, or to provide little to no documentation of their income. These sample exclusions allow us to identify a group of borrowers who are most likely to be financially strained by property taxes.

The loans in the analysis sample were originated in 40 states (including the District of Columbia)

²⁷This variable is missing for so many observations because CoreLogic does not require servicers to submit this information to the database. Because it is missing, we do not include it in our main analysis.

²⁸In a few states administrative delays sometimes cause actual due dates to differ from due dates in statutes. For example, in Cook County, Illinois, due dates are frequently pushed back. In addition to conversations with local officials we consulted newspaper records for reports of delays in due dates and changed due dates when appropriate. In the vast majority of states and counties due dates were never delayed.

²⁹An alternative loan-level dataset from LPS Analytics (formerly McDash) has a variable indicating whether the loan has an escrow. However, this dataset has limited coverage of nonprime loans that is low relative to CoreLogic's coverage, particularly before 2005. Also, the escrow variable is not well populated for around 70-80% of subprime loans, suggesting that there are serious measurement problems associated with it. Furthermore, it is not possible to infer the existence of an escrow account based on the loan's monthly payment amount and tracking how the loan's outstanding balance evolves over time because certain fields in the CoreLogic data are not well populated by the data provider.

³⁰Because of our research design and the plausibly random assignment of loans to treatment groups, the unobserved escrow status does require us to scale our coefficients as intent-to-treat parameters.

identified in Appendix Table 1. We analyze these states because property tax due dates are uniform within either the state or county, which facilitates a merge with the CoreLogic data, where the available geographic identifiers only include state and ZIP code. The 10 excluded states have property tax due dates that vary at the level of the municipality or school district, which are smaller geographic units than the ZIP code, making it impossible to merge with the LP data.

With these restrictions, over two million loans remain, which we are able to track monthly for 12 months. In spite of the sample restrictions, there are nearly 25 million loan-month observations. Due to the computational burden of these data, we conduct our analysis on a 20% random sample. For our main regressions, this produces a sample of 480,738 loans.

5 Results

We now discuss the results of using loan-level variation in the post-due date liquidity reduction to estimate the causal effect of reduced liquidity on subprime mortgage delinquency and default. Each row of Table 5 describes the results of estimating equation 1 and corresponds to one of four different outcome variables. Our regressions compare the first-year delinquency and default outcomes of loans across four treatment groups. For each outcome, Column (1) lists the average delinquency or default rate for loans with due date ages between 1 and 3 months (i.e., “early-due loans”). Columns (2) through (4) display estimates of the three logit regression coefficients, $\hat{\beta}_{t-k}$, transformed into percentage point average marginal effects. The three columns display the average marginal effect, relative to early-due loans, of a loan facing its first due date at ages 4-6 months (i.e., 4-6 month loans), 7-9 months (i.e., 7-9 month loans) and 10-12 months (i.e., late-due loans). The percent reported to the right of each marginal effect expresses the average marginal effect as a percent of the average delinquency or default rate for early-due loans.

In Panel A of Table 5, the marginal effects estimated in columns (2) through (4) include only state, origination year, and due date month as controls. The effects shown in Panel B also include the following control variables: sales price, borrower’s FICO score at origination, indicator for full v. no/low documentation, indicator for adjustable rate mortgage, interest rate at origination, combined loan-to-value ratio at origination, mark-to-market combined loan-to-value ratio at the due date, first-year house price appreciation, the ratio of county median property tax bill to county median income in 2004, and fixed effects for origination year, month of property tax due date, and state. Again, after the first year, all loans are the same age so the outcomes measure delinquency and default rates for similarly aged loans. We present these two sets of results to explicitly demonstrate that, consistent with our identifying assumptions, the inclusion of additional controls does not substantially alter the results.

In Panels A and B of Table 5, the first rows describe the results for first-year 30-day delinquency rate. Column (1) shows that 30.9% of early-due loans miss one mortgage payment at least once in the first year. The results in columns (2) to (4) show that older loans at the time of the first due date are less likely to miss one mortgage payment during the first year. Focusing on the results with the full set of control variables in Panel B, loans with due date ages between 4 to 6 months are 0.004 percentage points less likely to experience a 30-day delinquency in the first year than early-due loans. In column (3), all else equal, loans with due date ages between 7 and 9 months are 0.59 percentage points, or 1.9%, less likely to experience a first-year 30-days delinquency than early-due loans. Finally, the average marginal effect in column (4) suggests that late-due loans are 0.95

percentage points, or 3%, less likely than the early-due loans to experience a 30-day delinquency in the first year.

The results for 30-day delinquencies suggest that borrowers facing property taxes earlier are more likely to default than those with later due dates. However, because missing only one mortgage payment is relatively common and not necessarily indicative of a financial hardship, we examine 60-day delinquencies and EPD in the remainder of Table 5. Focusing on Panel B, we find that for more serious delinquencies and EPD, late-due loans are 0.59 percentage points (3.7%) less likely to experience a first-year 60-day delinquency, 0.34 percentage points (3.2%) less likely to experience a 90-day delinquency, and 0.35 percentage points (5%) less likely to experience a foreclosure start. Further, although we do not have enough power to statistically distinguish the size of the coefficients from each other, we find that $\hat{\beta}_{10-12} < \hat{\beta}_{7-9} < \hat{\beta}_{4-6} < 0$ for 30-day and 60-day delinquency and that $\hat{\beta}_{10-12} < \hat{\beta}_{7-9} \approx \hat{\beta}_{4-6} < 0$ for 90-day delinquency and foreclosure starts.

All of these results lead to the same conclusion: early-due loans display higher first-year delinquency and EPD rates than late-due loans.³¹ Our research design and the control variables in X_i and W_i ensure that a plausible interpretation of our results is that liquidity problems contribute to early payment default. As we argued earlier, between-treatment group differences in average borrower characteristics, housing equity, or economic conditions are unlikely to explain our results.³²

In addition, we posit that the differences between early-due and late-due loans are attributable to differences in the duration of exposure to a persistent liquidity reduction. We base this interpretation on four reasons. First, in addition to 30-day delinquency, rates of 60-day delinquency and EPD are also higher among early-due loans, which suggests that liquidity reductions were persistent rather than brief. If borrowers were able to quickly restore liquidity following a property tax due date, it would be unlikely to also find higher rates of more serious delinquencies and EPD. Because we expect mortgage delinquencies motivated by consumption smoothing to be non-serious, the effects on default are also inconsistent with unconstrained borrowers using mortgage delinquency to smooth consumption.

Second, we believe it is unlikely for brief liquidity reductions to have effects differing by due date age. While our data do not allow us to directly observe how a borrower's liquidity changes due to a property tax due date, we are able to control for some plausible sources of heterogeneity in the treatment effect of a brief liquidity reduction such as the amount of equity at the due date or the magnitude of the property tax bill.³³ Two other sources of heterogeneous treatment strength arising from brief liquidity reductions are surprise and unavoidable low liquidity.³⁴ To rule out the possibility that greater surprise about the property tax bill among early-due borrowers causes higher rates of delinquency and EPD, we note that the disclosures occurring under the Real Estate Settlement Procedures Act (RESPA) ought to make property taxes known and salient to borrowers at closing. Indeed, since early-due borrowers have more recently experienced a home purchase,

³¹Results from an event study framework, which are shown in the appendix, are consistent with this interpretation. The event study results do not control for loan age. Consistent with our argument above, including controls for a linear or quadratic trend in loan age produces estimates that do not afford us the power to identify the size of any effect.

³²Precautionary savings behavior can produce results similar to those implied by liquidity constraints (e.g. Carroll (2001)).

³³Note that due date age explicitly determines the maximum potential duration of exposure to a liquidity reduction, so we cannot hold due date age constant while varying the duration of exposure.

³⁴Brief liquidity reductions with heterogeneous effects can also exist if the month of a due date affects the contemporaneous treatment effect and month of treatment differ among treatment groups. Our inclusion of month-of-due-date fixed effects helps control for any between-group differences in average treatment month.

they ought to be less surprised than late-due borrowers, which works against us finding an effect.³⁵ Unavoidable low liquidity arises when early-due borrowers are unable to prepare for fully anticipated property taxes because they are treated so soon after origination. We find unavoidable low liquidity unlikely because we are unaware of any evidence on whether substantive differences in liquidity exist between, for example, borrowers two months after origination compared with 10 months after origination. Furthermore, if property taxes are not a surprise and all borrowers know when their taxes are due, all borrowers should be equally capable of accumulating adequate liquidity at the due date. For example, early-due borrowers can save more in advance of origination or they can negotiate with the seller to lower closing costs to help finance the property tax payment.

Third, we extend the period of time during which we observe delinquency and default outcomes to two years after origination. The additional year exposes loans to additional periods of possible default risk and, for many loans (see Table 3), an impending interest rate reset at the end of the second year. As Tables 3 and 4 show, these default risks and impending interest rate resets do not differ across the treatment groups and thus do not directly pose a threat to our estimation strategy. Observing loans for two years reveals whether small or temporary effects of property taxes are overwhelmed by other more important shocks, such as those stemming from unemployment. However, as shown in Table 6, we find that early-due loans are more likely to become delinquent and default than late-due loans after two years, which is consistent with a persistent liquidity reduction.

Fourth, the results in Table 7 show that once a loan becomes delinquent or defaults, late-due borrowers are more likely to “cure” these delinquencies by making up missed payments and avoid default (in the first year). The regressions in columns (1) through (4) include only loans that have become delinquent or have reached default status. Column (4) shows that conditional on a borrower missing one payment, borrowers with late-due loans are 3.8 percentage points (12%) more likely to cure that delinquency than are early-due borrowers. The results are similar for the other three outcomes, consistent with the interpretation that prolonged exposure to a persistent liquidity reduction makes early-due borrowers less likely to cure first-year delinquencies. For example, suppose a borrower experiences an income shock at a loan age of 6 months and becomes delinquent. At a loan age of 6 months, an early-due borrower has already faced property taxes whereas a late-due borrower has yet to face them. If it is more difficult for borrowers with less liquidity (i.e., post-due date) to cure a delinquency, then early-due borrowers will be less likely to cure this delinquency. If the liquidity reduction were brief rather than persistent, however, we expect early-due and late-due borrowers to have equal liquidity at a loan age of 6 months and thus they should be equally likely to cure this delinquency, which is not what we find.

To summarize, we interpret our results as driven primarily by the between-group differences in the duration of exposure to a persistent liquidity reduction rather than a brief liquidity reduction with heterogeneous treatment effects by loans’ due date age. That is, early-due loans become delinquent and default more than late-due loans in their first-year because they are exposed to a

³⁵To check our assumption that property taxes are not a surprise we estimated our regressions on a sample of refinance loans. Borrowers who refinance are, by definition, not first-time homeowners and are thus less likely to be surprised by property taxes. If surprise alone explains the high default rate among early-due borrowers with subprime purchase loans, we would expect to find no difference in default rates for early-due and late-due refinance loans, where the borrowers are not surprised. Instead, we find results similar to our purchase loan results. Early-due refinance borrowers default at a higher rate than late-due refinance borrowers, consistent with surprise not playing a major role in our results.

low-liquidity state for an additional seven to 11 months during their first year, not because they are treated “early.”

Our results control for due date equity, the surprise story seems implausible, and we have little *a priori* reason to believe that differences in unavoidable low liquidity explain our findings. However, regardless of the precise liquidity mechanism by which property taxes increase delinquency and default, our results indicate that liquidity in general has a causal effect on mortgage default.

6 Conclusion

We use property tax due dates to observe borrowers’ liquidity reductions at the loan-level. We exploit exogenous variation in the timing of these loan-level liquidity reductions to estimate the causal effect of liquidity reductions on mortgage delinquency and EPD for the average borrower. Prior work has been unable to estimate the causal effects of illiquidity on delinquency and default because available measures of between-loan differences in liquidity are endogenous.

Our regression results demonstrate that loans facing a property tax due date within one to three months after origination have at least 3% percent higher first-year delinquency and default rates than loans that face property tax due date 10 to 12 months after origination. Since we control for differences in property tax bills and borrower characteristics, we argue the most plausible mechanism for these results is the additional 7 to 11 months of exposure to a persistent post-due date liquidity reduction among early-due loans. That is, all else equal, more months of reduced liquidity increases the probability of first-year delinquency and default as borrowers are more susceptible to income and expenditure shocks, such as unemployment, furlough days, and medical expenses.

One way to interpret the size of this effect is to compare the increase in delinquency and default probabilities associated with additional exposure to reduced liquidity with previous estimates of the effect of negative equity. Early-due loans are exposed to reduced liquidity for 3 quarters longer than late-due loans and are 0.59 percentage points more likely to become 60-days delinquent during the first year. In contrast, the estimates in Elul et al. (2010) suggest that an increase in CLTV from 90 to 120, i.e., moving from positive to negative equity, is associated with a 1.9 percentage point increase in the probability of loans becoming at least 60-days delinquent during a year.³⁶ Thus, the effect of three additional quarters of exposure to the post-due-date liquidity reduction is about one-third as large as the effect of a transition to negative equity.

To interpret the results with respect to the magnitude of the liquidity reduction associated with property taxes, consider a subprime household that faces lower liquidity after the property tax due date because they use their credit card to pay a property tax bill comprising 3% of their annual income. The back-end-debt-to-income-ratio (DTI) contains the minimum required monthly payment on credit card balances in its numerator. If the minimum payment is 2% of the balance, since borrowing to pay the tax bill increases the balance by 36% of monthly income, the household’s DTI increases by 0.0072. Suppose there are two identical households with the above characteristics, one that pays property taxes at 2 months, the other at age 11 months. Assuming that each household had the average pre-due date DTI of 0.40, the household that pays its property tax bill

³⁶For this approximation, we calculate the difference in their Table 1 quarterly default estimates ($d = 1.343 - 0.872 = 0.471$) and the implied level difference in the annual hazard rate $1 - (1 - d/100)^4 = 0.0119$. Although these effects are estimated on a different sample of loans, a sample that includes many prime loans, the estimates use data from approximately the same period as our estimates.

at age 2 has an average monthly first-year DTI of 0.4066, while the household that pays at age 11 months has an average monthly first-year DTI of 0.4012.³⁷ This corresponds to a 1.3% higher average first-year DTI for the early-due household, which in turn is associated with a 3.7% increase in the probability of a first-year 60-day delinquency, or an elasticity of approximately 2.9.³⁸

This discussion suggests an important role for illiquidity in EPD and perhaps mortgage default more generally. These tax-induced liquidity reductions are much smaller in magnitude than the liquidity reductions we cannot observe at the loan level, such as those produced by unemployment, health issues, or divorce. Observing these shocks at the loan-level might produce even larger loan-level estimates of the effect of reduced liquidity on delinquency and default. On the other hand, borrowers with prime loans may be less sensitive to liquidity reductions since they are generally less sensitive than subprime borrowers to income and expenditure shocks.

Finally, given survey evidence that households prefer smooth payments of financial obligations to lump sum payments, it appears puzzling that escrow was so uncommon in the subprime mortgage market. Unlike the prime mortgage market, where Fannie, Freddie, and the FHA have long had strict escrow account guidelines, until the Federal Reserve revised the HOEPA rules in July 2008, the subprime mortgage market was devoid of any broad-reaching escrow account guidelines. The lack of escrow accounts may have been peculiar to the dramatic rise in housing prices during 2000 to 2006. Once prices began to decline, some lenders, such as Washington Mutual (now JPMorgan Chase), began requiring escrow accounts on all new subprime loans. The HOEPA rule revisions, phased in during 2010, require escrow accounts for property taxes and homeowner's insurance for all first-lien "higher-priced mortgage loans."³⁹

³⁷The first household has a DTI of 0.4072 for 11 months and 0.40 for 1 month; the other has 0.40 for 10 months and 0.4072 for 2 months. This assumes fixed mortgage payments and monthly income.

³⁸The average back-end DTI ratio in our sample is approximately 40% when computed among the observations that provide non-missing information. Foote et al. (2008) and Amronin & Paulson (2009) provide similar estimates of DTI ratios among subprime borrowers.

³⁹Press Release, Board of Governors of the Federal Reserve System, July 14, 2008.

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Table 1: Property Tax Due Dates and Loan Origination Months

Panel A. Distribution of Property Tax Due Dates in 2007

Month	# of States w/Due Date in Month
January	4
February	7
March	4
April	6
May	7
June	2
July	0
August	2
September	4
October	9
November	7
December	6

Source: Authors tabulations. Notes. Table only includes states 32 with uniform due dates and Washington DC, for a total of 33. Column total does not add up to 33 because states with semi-annual installments are counted more than once. Analysis sample also includes 7 states with non-uniform due dates, where instead due dates vary by county.

Panel B. Distribution of Loan Origination Months, 2000-2007

Month of Origination (%)	Type of Loan			
	<i>Subprime</i>		<i>Conforming</i>	
	Purchase	Refi	Purchase	Refi
January	6.5	7.6	5.7	6.8
February	6.7	7.4	6.2	7.2
March	8.9	8.6	8.3	9.1
April	8.5	8.3	8.5	9.2
May	8.8	8.6	9.3	8.5
June	9.6	8.6	10.0	8.5
July	8.7	8.2	9.5	8.7
August	9.2	8.7	9.8	8.7
September	8.8	8.2	8.6	7.9
October	8.4	8.5	8.5	8.6
November	7.8	8.5	7.9	8.3
December	8.1	8.9	7.8	8.3

Source. For non-prime loans, CoreLogic. Notes. For conforming loans, LPS Applied Analytics. Table entries show, for four types of loans, the percentage of loans originated in each month during the period 2000-2007, inclusive.

Table 2: Loan Age, Origination Months, and Loan/Borrower Characteristics, 2000-2007

Panel A. Age Distribution at 1st Property Tax Due Date

Type of Loan:	<i>Subprime Purchase</i>	<i>Subprime Refi</i>
Loan Age	Distribution of Age at 1 st Due Date (%):	
1	14.4	15.0
2	14.4	15.1
3	14.0	14.6
4	10.3	10.2
5	9.7	9.6
6	8.8	8.6
7	7.2	6.9
8	5.9	5.8
9	3.5	5.5
10	3.6	3.0
11	3.2	3.0
12	3.0	2.8

Source. CoreLogic and authors' compilation of tax due dates. Notes. Loan age is in months. Table entries are the percentage of sample loans that face their first property tax due date at each age.

Panel B. Loan/Borrower Characteristics by Origination Month

Subprime Purchase Loans

Origination Month	FICO	CLTV	% Miss a 1 st year payment	Loan Age at 1 st Tax Due Date:		
				mean	25 th p-tile	75 th p-tile
January	637	91.0	0.319	6.5	2	9
February	636	91.3	0.308	8	7	11
March	636	91.1	0.296	7.4	6	10
April	638	91.0	0.292	6.7	6	9
May	639	91.5	0.290	5.9	5	8
June	640	91.7	0.290	4.9	4	7
July	639	91.6	0.294	4	3	6
August	641	91.8	0.300	3.2	2	5
September	641	91.7	0.294	3.2	1	5
October	639	91.8	0.316	3.7	3	4
November	638	91.4	0.310	3.5	2	3
December	638	90.9	0.307	4.9	1	4

Sources. CoreLogic and authors' compilation of tax due dates. Notes. Statistics computed from 20% random sample of subprime purchase loans originated between 2000 and 2007 in 40 states. See text for additional details. Unless otherwise noted, table entries are means conditional on loans' origination month. Percentiles (p-tile) refer to the percentiles of the conditional distribution of loan age at first property tax due date. For all origination months except June, the range of loan age at first due date is [1, 12].

Table 3: Average Origination Characteristics of Subprime Purchase Loans by Number of Months Until 1st Property Tax Due Date

Panel A. Full Sample	# Months Until 1 st Property Tax Due Date:			
	1-3	4-6	7-9	10 ⁺
Sale Price	163,220	142,127	142,048	100,354
FICO	641	637	636	626
CLTV	91	92	91	92
% w/ Full Documentation	.576	.624	.615	.673
% w/ PP Penalty	.746	.791	.796	.803
Initial Interest Rate	7.9	8.0	8.0	8.4
% ARM	.862	.850	.841	.803
% Miss a 1 st year payment	.305	.306	.312	.338
# States observe	40	40	31	25

Panel B. Full Sample, Adjusted				
Sale Price	148,718	148,781	142,361	141,675
FICO	638	638	637	636
CLTV	92	92	91	91
% w/ Full Documentation	.600	.6091	.615	.615
% w/ PP Penalty	.775	.774	.775	.773
Initial Interest Rate	8.0	8.0	8.0	8.1
% ARM	.849	.849	.847	.849
% Miss a 1 st year payment	.313	.309	.306	.305
Sample Size	203,242	137,480	91,517	48,499

Source. CoreLogic and authors' compilation of tax due dates.

Notes. Statistics computed from 20% random sample of subprime purchase loans originated between 2000 and 2007 in 40 states. All characteristics are averages at origination except for % Miss a 1st year payment, which equals the share of loans that experience at least one 30-day delinquency during their first year after origination. See text for additional details.

Table 4: Evidence on Magnitude of Property Tax Payment by Number of Months Until 1st Property Tax Due Date

Panel A. Full Sample	# Months Until 1 st Property Tax Due Date:			
	1-3	4-6	7-9	10 ⁺
(2004) Median Annual Property Tax as % of Median Income	.045	.040	.039	.037
(2004) Median Property Tax Bill as % of Median Income	.024	.026	.030	.036
# Installments	2.0	1.7	1.4	1.0
Back-end DTI	41.0	40.7	40.7	39.9
Mark-to-Market CLTV	90.0	88.9	87.3	88.0
Panel B. Full Sample, Adjusted				
(2004) Median Annual Property Tax as % of Median Income	.027	.027	.027	.027
(2004) Median Property Tax Bill as % of Median Income	.041	.041	.041	.041
# Installments	1.7	1.7	1.7	1.7
Back-end DTI	40.8	40.7	40.7	40.7
Mark-to-Market CLTV	90.0	89.0	87.5	87.3
Sample Size	203,242	137,480	91,517	48,499

Source. CoreLogic and authors' compilation of tax due dates. Data on county median property taxes and county median income in 2004 are from the 2005 American Community Survey.

Notes. Statistics computed from 20% random sample of subprime purchase loans originated between 2000 and 2007 in 40 states. See text for additional details. The # of installments is the number of times per year property tax payments are due. Property taxes and income are measured at the county level. The median property tax bill is the median annual property tax divided by the number of installments. Back-end DTI is the mortgage payment (including escrowed insurance and taxes), credit card debt, car loans, education loans, and other debts divided by income. The back-end DTI variable is missing for 60% of observations because it was either not recorded by the lender or not reported by the servicer. In some cases, this variable is based on stated income rather than verified income.

Table 5: 1st-year Delinquency and Default Rates by Timing of 1st Property Tax Due Date

	(1)	(2)	(3)	(4)
	# Months Until 1 st Due Date:			
Panel A. Limited Controls	1-3	4-6	7-9	10-12
Outcome	<i>Mean</i>	<i>Regression Adjusted Difference w/r/t Mean:</i>		
30-day	.3087 (.001)	-.0055*** (.0017)	-1.8% (.0020)	-.0096*** (.0025)
60-day	.1589 (.0008)	-.0028** (.0013)	-1.7% (.0016)	-4.3% (.0020)
90-day	.1060 (.0007)	-.0021* (.0011)	-1.9% (.0013)	-3.2% (.0017)
FC Start	.0702 (.0006)	-.0013 (.0009)	-1.9% (.0011)	-3.8% (.0014)
Panel B. Full Controls				
Outcome	<i>Mean</i>	<i>Regression Adjusted Difference w/r/t Mean:</i>		
30-day	.3087 (.001)	-.004*** (.0018)	-1.3% (.0021)	-.0101*** (.0027)
60-day	.1589 (.0008)	-.0026* (.0014)	-1.6% (.0016)	-3.3% (.0021)
90-day	.1060 (.0007)	-.0026** (.0012)	-2.5% (.0014)	-2.1% (.0018)
FC Start	.0702 (.0006)	-.0019* (.0010)	-2.7% (.0011)	-2.4% (.0015)

N=480,738. Source. CoreLogic. Note. Sample includes subprime loans originated for purchases between 2000 and 2007. Estimates obtained from logit regression and calculating average marginal effects. Standard errors obtained using delta method. Column (1) lists the average first-year default rate, for each outcome, among loans with age at due date between 1-3 months. Columns (2)-(4) list the *percentage point* marginal effects from logit estimation. The number to the right of each *percentage point* marginal effect is the marginal effect as a percentage of the mean in column (1). Limited set of control variables include fixed effects for state, origination year, and calendar month of property tax due date. Full set of control variables include these covariates as well as sales price, borrower's FICO score, full v. no/low documentation dummy, indicator for adjustable rate mortgage, initial interest rate, initial combined loan-to-value ratio, mark-to-market combined loan-to-value ratio at due date, the ratio of county median property tax bill to county median income in 2004, and first-year house price appreciation rate.

*** indicates result statistically significant from 0 at the 1% significance level.** indicates result statistically significant from 0 at the 5% significance level.* indicates result statistically significant from 0 at the 10% significance level.

Table 6: 2nd-year Delinquency and Default Rates by Timing of 1st Property Tax Due Date

	(1)	(2)	(3)	(4)
	# Months Until 1 st Due Date:			
	1-3	4-6	7-9	10-12
Outcome	<i>Mean</i>	<u>Regression Adjusted Difference w/r/t Mean:</u>		
30-day	.4430 (.0011)	-.0034* (.0018)	-0.8% (.0022)	-.0087*** -2.0% (.0029)
60-day	.2880 (.0010)	-.0031* (.0017)	-1.1% (.0019)	-.0086*** -2.9% (.0025)
90-day	.2270 (.0009)	-.0010 (.0015)	-0.4% (.0018)	-.0074*** -3.3% (.0024)
FC Start	.1741 (.0008)	.0001 (.0014)	0.0% (.0017)	-.0052** -3.0% (.0022)

N=480,738. Source. CoreLogic. Note. Sample includes subprime loans originated for purchases between 2000 and 2007. Estimates obtained from logit regression and calculating average marginal effects. Standard errors obtained using delta method. Column (1) lists the average first-year default rate, for each outcome, among loans with age at due date between 1-3 months. Columns (2)-(4) list the *percentage point* marginal effects from logit estimation. The number to the right of each *percentage point* marginal effect is the marginal effect as a percentage of the mean in column (1). Control variables include sales price, borrower's FICO score, full v. no/low documentation dummy, indicator for adjustable rate mortgage, initial interest rate, initial combined loan-to-value ratio, mark-to-market combined loan-to-value ratio at due date, the ratio of county median property tax bill to county median income in 2004, two-year house price appreciation rate, and fixed effects for state, origination year, and calendar month of property tax due date.

*** indicates result statistically significant from 0 at the 1% significance level.

** indicates result statistically significant from 0 at the 5% significance level.

* indicates result statistically significant from 0 at the 10% significance level.

Table 7: Probability of Making Up Missed Mortgage Payments (“Curing”) During 1st Year of Mortgage Among Borrowers with Subprime Purchase Loans

	(1)	(2)	(3)	(4)	
	# Months Until 1 st Due Date:				
	1-3	4-6	7-9	10-12	
Outcome	<i>Mean</i>	<u>Regression Adjusted Difference w/r/t Mean:</u>			<u>N</u>
30-day	.3090 (.0019)	.0022 (.0032)	.0186*** (.0038)	.0380*** (.0048)	158,042
60-day	.1960 (.0023)	.0052 (.0040)	.0192*** (.0045)	.0306*** (.0056)	76,540
90-day	.1198 (.0023)	.0009 (.0040)	.0116*** (.0045)	.0162*** (.0056)	50,792
FC Start	.1515 (.0031)	.0044 (.0054)	.0030 (.0062)	.0142* (.0077)	32,999

Source. CoreLogic.

Note. Sample includes subprime loans originated for purchases between 2000 and 2007 that have experienced a particular outcome. The sample size (*N*) varies between the four regressions because, for example, fewer loans have experienced 90-day delinquency than 30-day delinquency. Estimates obtained from logit regression and calculating average marginal effects. Standard errors obtained using delta method. Control variables include sales price, borrower’s FICO score, full v. no/low documentation dummy, indicator for adjustable rate mortgage, initial interest rate, initial combined loan-to-value ratio, mark-to-market combined loan-to-value ratio at due date, the ratio of county median property tax bill to county median income in 2004, first-year percentage appreciation in housing value, and fixed effects for origination year, month of property tax due date, and state.

*** indicates result statistically significant from 0 at the 1% significance level.

** indicates result statistically significant from 0 at the 5% significance level.

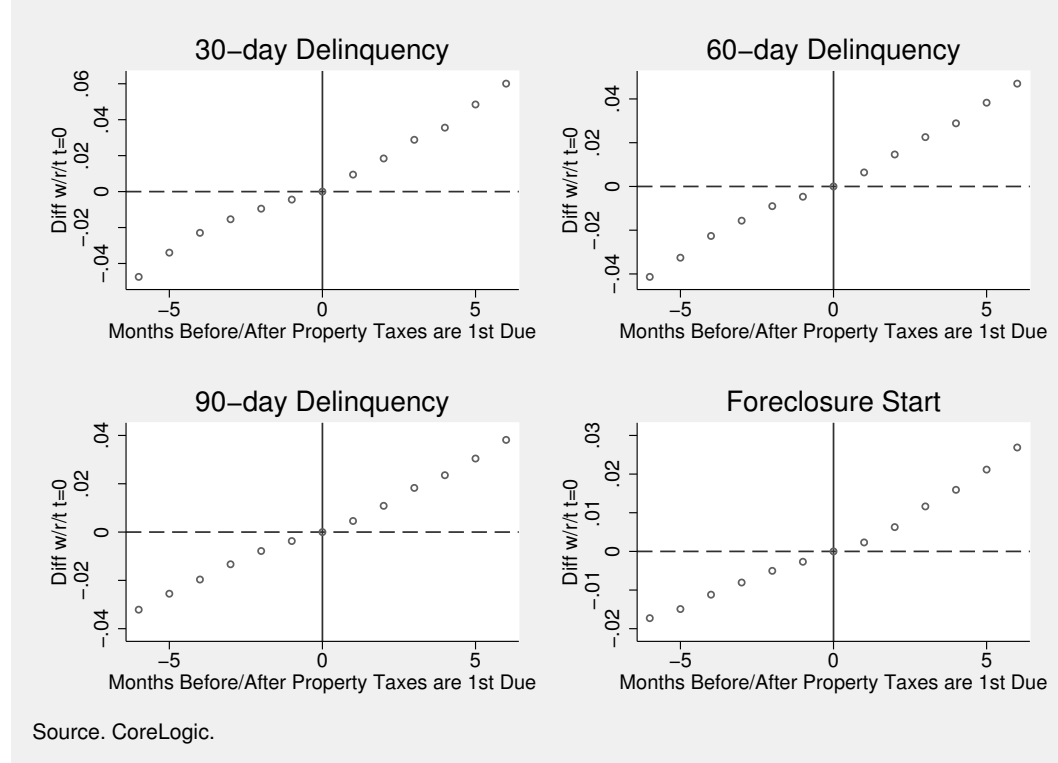
* indicates result statistically significant from 0 at the 10% significance level.

Table A.1: Property Tax Due Dates in the United States

State	Included in Analysis?	# Installments	Uniform within State?
AL	✓	Annual	Yes
AK	✓	Multiple Variations	Varies by Borough
AZ	✓	Semi-annual	Yes
AR	✓	Annual	Yes
CA	✓	Semi-annual	Yes
CO	✓	Semi-annual	Yes
CT	✓	Semi-annual/Quarterly	Varies by Tax District
DE	✓	Annual	Yes
DC	✓	Semi-annual	Yes
FL	✓	Annual	Yes
GA	✓	Annual/Semi-annual	Varies by County
ID	✓	Semi-annual	Yes
IL	✓	Semi-annual	Varies by County
IN	✓	Multiple Variations	Varies by County
IA	✓	Semi-annual	Yes
KS	✓	Semi-annual	Yes
KY	✓	Annual	Yes
LA	✓	Annual	Yes
MD	✓	Semi-annual	Yes
MN	✓	Semi-annual	Yes
MS	✓	Annual	Yes
MO	✓	Annual	Yes
MT	✓	Semi-annual	Yes
NE	✓	Semi-annual	Varies by County
NV	✓	Quarterly	Yes
NJ	✓	Quarterly	Yes
NM	✓	Semi-annual	Yes
NC	✓	Annual	Yes
ND	✓	Semi-annual	Yes
OH	✓	Semi-annual	Varies by County
OK	✓	Semi-annual	Yes
OR	✓	Tri-annual	Yes
SC	✓	Annual	Yes
SD	✓	Semi-annual	Yes
TN	✓	Annual	Yes
TX	✓	Annual	Yes
UT	✓	Annual	Yes
WA	✓	Semi-annual	Yes
WV	✓	Semi-annual	Yes
WY	✓	Semi-annual	Yes

Sources. 2008 *U.S. Master Property Tax Guide*, state websites, county websites, email correspondence, and telephone conversations. The ten states not in the table, and not in the analysis, have due dates that can vary within county.

Figure A.1: Event Study Results: Probability of Delinquency Relative to the 1st Property Tax Due Date



Note. We transform our data to panel data with loan-month observations and drop loans once they become delinquent or default as is common in standard hazard analysis (thus a different set of loans is dropped in each period for each outcome we examine). Using these data, we use ordinary least squares to estimate the following model (Jacobson et al. (1993)):

$$Y_{it} = \sum_{j=-6}^6 \beta_j * 1(RelTime = j)_i + \gamma X_i + \delta W_i + \epsilon_{it},$$

where Y_{it} equals one if loan i is delinquent or defaults in period t , X_i is a vector of pre-determined loan characteristics, and W_i is a vector of borrower characteristics that are not pre-determined at origination but may be correlated with a loan's age at the property tax due date. The regression does not control for loan age. The indicator function $1(RelTime = j)_i$ equals one in period j for loan i , where j denotes the period before or after property taxes are first due. The error term, ϵ_{it} , is assumed to be uncorrelated across loans and over time. The dummies β_j represent the delinquency rate, relative to the rate at the 1st property tax due date, j periods (i.e. months) before and after the first property tax due date.

The figures are consistent with our main set of results because the slope of the delinquency and default function becomes steeper after the first property tax due date, suggesting that the post-due-date liquidity reduction quickens the pace of mortgage delinquency and default.