Response of Home Equity Debt to Mortgage Policy: Evidence from a Kink and a Notch*

David J. Munroe
Columbia University

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*David Munroe: Department of Economics, Columbia University, email address: djm2166@columbia.edu. Financial assistance from the Social Sciences and Humanities Research Council of Canada and the Lincoln Institute of Land Policy is gratefully acknowledged. I am thankful to Ethan Kaplan, Wojciech Kopczuk, Doug Almond, Janet Currie, Chris Mayer, Tomasz Piskorski, Bernard Salanié, and Miguel Urquiola for comments and advice. I would also like to thank the Paul Milstein Center for Real Estate at Columbia University for assistance with data.

Abstract

I estimate the market-level response of the size of home equity loans to two mortgage policies—the home mortgage interest deduction and regulations in Title XI of the Financial Institutions Reform Recovery and Enforcement Act requiring independent appraisals of borrowers' homes at loan origination. Using administrative data on home equity loan originations for California, Illinois, New Jersey, and New York, I employ recent empirical methods that study non-linearities in individuals' budget sets ("kinks" and "notches"). I find robust evidence of bunching of loan principal at the thresholds beyond which mortgage interest is not deductible and licensed appraisals of homes are required. The extent of this bunching at the two policy cutoffs translates to a 20% market-level reduction in loan size in response to removal of the mortgage interest deduction, and a 23% reduction in loan size in response to appraisal requirements. Using data from the Survey of Consumer Finances, I find that the response to the mortgage interest deduction corresponds to an elasticity of debt to interest rates around -30.

1 Introduction

In the wake of the financial crisis of the late 2000s an emphasis has been placed on rethinking home loan policy in the United States. Economists have identified several possible causes of the crisis, including lax underwriting standards and a boom in credit demand and availability (Mian and Sufi (2009); Frame et al. (2008); Dell'Ariccia et al. (2012); Mayer et al. (2009)). In response, as part of the Dodd-Frank Wall Street Reform and Consumer Protection Act, lawmakers and regulators are requiring banks to conduct more thorough reviews of loan applicants and greater independence of home appraisers from banks.[1] Moreover, there is a strong movement toward reconsidering current policies that lower the cost of mortgage debt, especially the Home Mortgage Interest Deduction (MID).[2] However, although these policy changes may increase the likelihood that home loans are repaid, they also change the relative price of home equity debt and may reduce the availability of such loans.

In this paper, I estimate how the size (principal) of home-equity loans taken by homeowners responds to two mortgage policies: the home mortgage interest deduction and home appraisal requirements of the Financial Institutions Reform Recovery and Enforcement Act (FIRREA). By allowing mortgage payments to be deducted from taxable income, the MID lowers the cost of debt to home owners, which may induce borrowers to take larger loans than they otherwise would.[3] Similarly, independent appraisals of homes being used as collateral, as required by Title XI of the FIRREA, not only increase the cost of underwriting loans, perhaps reducing the size or availability of debt, but may also reveal information about borrowers and their property that might increase or decrease lenders' willingness to issue a loan. I use administrative data on home loan originations and take advantage of discontinuities in the application of both policies to estimate whether and by how much the size of home loans falls when home owners cannot deduct their mortgage interest and when independent licensed appraisals are required at origination. Understanding the market-level response of loan principal to these mortgage policies helps inform how such regulations distort the market for home loans.

The desirability of regulating loan markets depends on weighing the benefits from increases in loan quality against the distortionary costs of the regulations themselves. On one hand, mandating lenders to adopt more stringent underwriting standards and/or increasing the cost of debt by eliminating deductibility may improve the quality of loans (e.g., Keys et al. (2012)) and lower

[1]For example, Dodd-Frank requires that, prior to origination, lenders must verify loan applicants' income, employment, current debt obligations, and credit history in order to determine that borrowers can reasonably repay mortgages.

[2]The primary argument for removal of the deduction is that the policy, which is a substantial tax expenditure, benefits relatively wealthy households who are not on the margin of homeownership (Bourassa and Grigsby (2000); Glaeser and Shapiro (2003); Gyourko and Sinai (2004); Poterba and Sinai (2011)). Moreover, there is mixed evidence of the efficacy of the MID in encouraging home ownership. Rosen (1979), Green and Vandell (1999), Bourassa and Yin (2008), Hilber and Turner (2012), and Hanson (2012) find that the MID does not increase home-ownership, and may even reduce it through general-equilibrium housing price effects. To date, there are no studies of how the MID influences the quantity of home equity debt taken.

[3]The MID reduces the effective interest rate: for every dollar of interest paid, a portion of that dollar is returned to the borrower in tax savings.

the probability of housing-debt-driven crises in the future.[4] For example, Mayer et al. (2009) and Frame et al. (2008) document an increase in low- and no-documentation mortgages and smaller down payments leading up to the financial crisis. Jiang et al. (2014) find that low-documentation loans perform much worse than full-documentation loans.[5]

On the other hand, tighter regulation of appraisals may discourage lending, and higher after-tax interest rates (associated with the removal of the MID) may discourage borrowing, reducing the availability of an important source of household debt. Home equity debt is a commonly used tool for consumption smoothing in the U.S. (e.g., Abdallah and Lastrapes (2012); Lovenheim (2013); Johnson (2012)). However, there is relatively little empirical work estimating how regulation of lending standards and the removal of tax deductions for interest payments affect the market for housing debt. Pence (2006) examines state boundaries and concludes that foreclosure laws that favor borrowers result in mortgages that are three- to seven-percent smaller than in lender-friendly states. Maki (2001) and Dunsky and Follain (2000) study the removal of interest deductions for consumer credit in the Tax Reform Act of 1986, and find substantial portfolio shifting to home debt (which maintained deductibility). Similarly, Hanson (2012) finds that mortgage debt drops by 10–18% at boundaries between states that do and do not allow for deduction of mortgage interest payments. To date, however, there have been no studies of the response of home-equity debt to the home mortgage interest deduction.

A key empirical challenge to studying home loan regulation is an absence of identifying variation—much of the policy is set at the national level, with relatively few changes over time. Existing research has relied primarily on cross-sectional or time-series variation in policy. For example, Keys et al. (2009) exploit cross-sectional variation in underwriting regulations faced by different lending institutions, while Pence (2006) uses cross-sectional variation at the state level. Similarly, Hilber and Turner (2012) and Hanson (2012) exploit cross-sectional variation in state tax policy to study the MID, while others have studied the removal of mortgage interest deductions internationally often using low-income households or renters as a control group: Jappelli and Pistaferri (2007) find no effect of removing the deduction in Italy, while Hendershott and Pryce (2006), Fjærli (2004), and Saarimaa (2010) all find reductions in mortgage debt in the U.K., Norway, and Finland, respectively.

To identify the effects of the MID and FIRREA appraisal requirements on home equity debt, I exploit discontinuities in the applications of these policies by loan size. For home equity debt, the MID allows only interest payments on the first \$100,000 worth of debt to be deducted (interest on the 100,001st dollar of debt is not deductible). This limit creates a discontinuity in the marginal after-tax interest rate at \$100,000, and this discontinuous change in the price of debt creates a kink in borrowers' budget sets at the cutoff. Similarly, the FIRREA appraisal requirements are limited: independent licensed appraisals are only required on home equity loans over \$250,000, while below the thresholds banks may perform an in-house "evaluation," creating a discontinuity

[4]Since I rely on loan origination data for my study, I cannot comment on how the MID and FIRREA appraisal requirements affect loan performance.

[5]Mian and Sufi (2009) and Dell'Ariccia et al. (2012) use aggregate data and find similar evidence of low quality loans contributing to the housing crisis.

(or policy “notch”) in both the information that banks are likely to collect and the cost to banks of underwriting a loan (appraisal fees are typically passed on to consumers).

I adapt non-linear budget set methods to exploit the threshold designs of these two policies. A clear benefit of these empirical methods is that they facilitate the study of policies that do not vary across time or geography, as is the case with many mortgage regulations. These techniques are commonly used to estimate behavioral responses to taxation by examining “bunching” of individuals at discontinuities in marginal tax rates (“kinks” in budget-constraints) and average tax rates (discontinuities or “notches” in budget constraints)—examples include Saez (2010), Chetty et al. (2011), Ramnath (2012), Kleven and Waseem (2013), Bastani and Hakan (2014), and Kopczuk and Munroe (2014). Unlike regression discontinuity, which assumes no manipulation of the running variable (debt, in this case) around the threshold, non-linear budget set methods explicitly study how economic agents sort to one side of the cutoff. Specifically, these methods ask the question of how responsive individuals must be to the given price or policy change at the threshold to induce the amount of bunching seen at the threshold. Recent work studying tax notches (Kleven and Waseem (2013) and Kopczuk and Munroe (2014)) focuses not only on the excess mass bunching at the threshold, but also distortions to the distribution just above the threshold. I argue herein that the response to a notched policy (such as the FIRREA appraisal requirement) can be estimated by comparing the size of the mass bunching at the threshold to a missing mass above the threshold.

I find evidence of a substantial reduction of home equity debt in response to the removal of the mortgage interest deduction and the imposition of the FIRREA appraisal requirements. Bunching at the $100,000 and $250,000 thresholds imply that loans are reduced by 20% in response to the removal of the MID and by 22% in response to appraisal requirements. These estimates are robust to functional form assumptions, and I find no evidence of a similar response at various placebo thresholds (including estimates at other round numbers as well as estimates at the same thresholds in the distribution of refinances for which these discontinuities do not apply).

Studying the dynamics of the response to the FIRREA threshold over the late 1990s and early 2000s reveals a limited relationship between this policy and the lending boom. I do not find any evidence that FIRREA appraisal regulations have a dampening effect on lending during the credit expansion; for example, if the policy is effective in sorting out lower quality borrowers, then we might expect a larger response to the policy during the lending boom when more low-quality borrowers were applying for loans.

In addition to understanding the distortionary effects of the MID on the size of home loans, the response of home equity debt to the MID reveals information about the elasticity of debt to interest rates, since the policy reduces the after-tax interest rate. This elasticity is of considerable value for understanding the welfare costs of policies that tax or subsidize savings and debt (Bernheim (2002)). However, there are few credible estimates of this elasticity for the U.S. (see Bernheim (2002) for a summary of older estimates and the problems with these). Gross and Souleles (2002a) study the response of credit card debt to quasi-exogenous increases in credit limits and interest rates and find an elasticity between about -4.9 and -9.1.[6] Studying the market for auto loans, Attanasio et al. (2008) estimate an elasticity of debt to interest rates between 0 and -14, depending on credit constraints.[7] Relatedly, there is an ongoing literature studying the response of household savings to various policies in the U.S. (e.g., Duflo et al. (2006); Madrian and Shea (2001); Poterba et al. (1996); Weber (2012)). My research contributes to this literature by using a novel identification strategy to provide an estimate of the market-level response of debt to lending policies for the U.S. for a different, but important, source of debt.

Converting my estimate of response to removal of the MID to a market-level elasticity of debt with respect to interest rates yields a relatively large elasticity. I first establish that the response to the removal of the MID increases with proxies for the implied change in after-tax interest rates at the kink: estimates increase with adjusted gross income (individuals who face higher marginal tax rates benefit more from the MID), are positively correlated with market interest rates over time (more interest payments means a larger benefit from the deduction), and state-year estimates of response at the kink are positively correlated with imputed state-year averages of the after-tax interest-rate change at the kink. Secondly, using marginal tax and interest rate estimates from the Survey of Consumer Finances, I convert the response to the MID kink to an elasticity of debt with respect to after-tax interest rates of around -30.[8] Interpretation of this elasticity estimate as a structural parameter representing borrowers' preferences relies on the assumption that there is no supply-side response to the policy (I cannot observe lender behavior in my data) and that there is no shifting of debt to other sources.[9]

2 Policies

2.1 The Home Mortgage Interest Deduction

The Home Mortgage Interest Deduction (MID), which has existed in the U.S. since the introduction of federal income taxes, allows taxpayers to deduct interest payments on loans secured by primary or secondary homes from their taxable income.[10] The MID is the second-most commonly claimed tax deduction in the U.S., although the benefits of the deduction mainly accrue to wealthier taxpayers

[6] In their paper, Gross and Souleles (2002a) present elasticities relative to a change in r, while myself, Attanasio et al. (2008), and others present elasticities relative to $1+r$. I rescale the elasticities from Gross and Souleles (2002a) using the mean interest rate in order to compare them to elasticities relative to $1+r$. For example, the estimates (with respect to r) from Gross and Souleles (2002a) range from 0.7 to 1.3 and the average interest rate that they report is 16.6%. At this interest rate, a 1% increase in $1+r$ requires a 7.02% increase in r—thus, I rescale the estimates by a factor of 7.

[7] Using an interest-rate offer experiment in South Africa, Karlan and Zinman (2008) estimate an elasticity around -4, while Dehejia et al. (2012) find slightly smaller estimates studying variations in interest rates across branches of lending institutions in Bangladesh.

[8] While this elasticity may seem large, remember that this is the elasticity with respect to $1+r$. A one-percent change in $1+r$ is about a one percentage-point change in r. For example, if r is 5%, a one-percent increase in $1+r$ is equivalent to a 21% increase in r.

[9] While I can only observe home-equity debt in my data, I argue herein that debt shifting is not likely to be very important since interest rates on home equity debt tend to be among the lowest.

[10] See Ventry Jr (2010) for a detailed history of interest deductions in the U.S.

(Glaeser and Shapiro (2003)). Moreover, the deduction is the second-largest tax expenditure for the federal government, representing about 79.2 billion dollars of foregone revenue in 2010 (Office of Management and Budget 2012).

The MID is applicable to all loans secured by a home, which includes mortgages, refinances, and home-equity loans (HELs) and home-equity lines of credit (HELOCs), and reduces the effective interest rate faced by borrowers.[11] For every dollar of interest paid on an MID-eligible loan, a portion of that dollar is returned to the borrower in tax savings. Specifically, for an individual with a marginal tax rate of t borrowing at an interest rate of $1+r$, the after-tax rate of return faced by this borrower is $(1+(1-t)r)$.

There are limits on the applicability of the MID, which create discontinuities in the marginal after-tax interest rate (budget-set kinks). Under the MID, home loans fall into two categories that determine the limit on deductibility: home-acquisition loans and personal-use loans. To be considered a home-acquisition loan, a loan must be used to purchase a primary or secondary home (as in a first mortgage or a refinance of a first mortgage) or used to build or improve a home (as in an HEL or HELOC specifically used for home renovation/construction). Personal-use loans are all other loans secured by a home, such as HELs used for personal consumption or consolidation of debt. Interest on home-acquisition loans is only deductible on the first million dollars borrowed. The interest on any money borrowed in excess of one million is not deductible. Similarly, for personal-use loans, only interest on the first $100,000 is deductible.[12] For example, if an individual borrows $50,000 for personal consumption, then all the interest is deductible. On the other hand, only 50% of the interest paid on $200,000 of outstanding personal-use debt is deductible.[13] These limits create a jump in the effective interest rates that borrowers face from $(1+(1-t)r)$ to $(1+r)$ at the thresholds, and, in turn, discontinuities in the price of borrowing create kinks in individuals' budget sets. I examine borrower behavior around the jump in the price of home-equity loans to back-out the response of debt to the MID.

2.2 FIRREA Appraisal Requirements

The Federal Institutions Reform, Recovery, and Enforcement Act of 1989 was enacted to tighten regulations of lenders (especially thrifts) in response to the Savings and Loan crisis. A primary

[11] The IRS defines a "qualified home" as a main or second residence, including condominiums, coops, mobile homes and trailers, house boats or "any similar property that has sleeping, cooking, and toilet facilities."(Internal Revenue Service 2011)

[12] Both limits are halved for individuals who are married and filing separately, allowing each half of the couple to claim half of the interest.

[13] The limits apply to the average outstanding balance held by an individual over the course of the tax year. As such, the limits at the time of borrowing will be somewhat higher than $100,000 and $1,000,000, depending on whether or not enough of the balance will be paid down in the year. However, I find that the bulk of response occurs at $100,000. This is consistent with individuals having only moderate information about the deduction at the time of taking their loans—the MID and the limits of $100,000/$1,000,000 are well advertised, whereas the details of how an average balance is calculated are much less visible. Moreover, individuals may have difficulty calculating exactly where their limit will be given the proposed interest rates and repayment schedules (if interest rates and repayment schedules are not certain until the loan is finalized and there is a cost to mental arithmetic, individuals may prefer to go with the concrete limits of $100,000 and $1,000,000).

focus of the FIRREA was to restructure the regulatory system governing thrifts.[14] The FIRREA also tightened regulations on the origination of home loans, including appraisal requirements. The act raised capital requirements for thrifts and established concrete regulations on the appraisal of homes being used as collateral for loans. Title XI of the act, which I focus on, requires that real estate appraisals of homes being used as collateral in "federally related transactions" be conducted in writing by an independent, licensed, appraiser. Title XI also provides minimum standards for appraisals.[15]

Appraisals are conducted to establish an estimate of the value of a home being used as collateral for a loan, to ensure that borrowers have sufficient equity in their homes. Title XI of the FIRREA requires that banks employ an independent licensed appraiser: the individual performing the appraisal must be entirely independent from all other aspects of the underwriting process and must not have any direct or indirect interest in the property or loan. Licensing requirements typically include completion of several courses, an examination, and two years of experience (for example, assisting licensed appraisers). By law, appraisals are required to conform to the minimum standards outlined by the ASB.[16] While licensed appraisals reveal important information for loan underwriting—namely, the value of the collateral—they are costly to lending institutions (around $400–$500 for a typical residence), although this cost is typically borne by the borrower.

Like the MID, the requirement of a licensed appraisal depends on the size of the loan. For loans less than $250,000, lenders have the option of completing an "evaluation" in lieu of a licensed appraisal. Evaluations may be performed by the lending institution and do not require the property to be visited or inspected—lenders have discretion in the methods they choose to estimate a property's value. Thus, the cost of underwriting a home-equity loan (and the information uncovered in the process) jumps discretely at the $250,000 threshold. To the extent that banks pass these costs on to consumers, for example through higher closing fees, interest rates, or by altogether denying loans above the threshold, borrowers also face a discontinuity at the FIRREA limit (creating a discontinuity or "notch" in the borrower's budget constraint). Unlike home equity loans, mortgage refinancing does not face the FIRREA threshold. If borrowers refinance home loans with the same

[14] Dissolving the Federal Savings and Loan Insurance Corporation and putting the Federal Deposit Insurance Corporation (FDIC) in charge of the Savings Association Insurance Fund, replacing the Federal Home Loan Bank Board with the Office of Thrift Supervision (OTS), and establishing the Resolution Trust Corporation to facilitate the closure and liquidation of failing thrifts.

[15] Federally related transactions includes home loans made by federally regulated financial institutions (i.e. regulated by the FDIC, OCC, OTS, or NCUA).

[16] Title XI established the Appraisal Subcommittee of the Federal Financial Institutions Examination Council to oversee licensing and appraisal standards, which are the respective responsibilities of state regulators and of the Appraisal Standards Board (ASB) of the Appraisal Foundation (a non-profit established by the appraisal industry and authorized by congress to regulate appraisal standards). Appraisers are required to identify the property and its intended use (e.g., residence vs. development) and establish an appropriate value for this use. In doing so, appraisers must account for local regulations that may affect the value (zoning, environmental or historical preservation, etc.) as well as anticipated neighboring public or private developments that may affect the value. Appraisers must explicitly identify all assumptions s/he must make to complete the appraisal. Appraisals generally require a visit to the property and the value may be based on one (or more) of three approaches that they deem most appropriate: using the sales price of comparable properties, based on the cost of the proposed use of the property, or based on the potential income stream from renting the property. All details of the appraisal are required to be written up and returned to the lending institution.

lender, no appraisal is required under the FIRREA. Thus, mortgage refinancing provides a useful placebo against which to check the effects I find for home equity loans.

3 Data

To study the market-level response of home equity debt to regulations, I use administrative data on the universe of recorded home loans in recent years in California, Illinois, New Jersey, and New York.[17] I study county-level home equity loan (including home equity lines of credit) and mortgage refinance records collected from county clerks from at least 2002 through 2008, with the majority of counties going back through 1995 (all home loans and deed transfers in the U.S. must be recorded with county officials).[18] These records contain basic information about each home loan, including the loan principal (rounded to the nearest $100), type of loan (refinance vs. home equity), date, and zip code of the home being used as collateral. This data provides accurate information on the date of origination, location of property, and loan principal—the variable that determines the applicability of the MID and FIRREA appraisal regulations with a sufficiently large sample to study distortions in the distribution of loans around regulatory thresholds.

Table 1 presents the breakdown of loans by type. After cleaning the data, I am left with 25,012,077 home loans.[19] Of these, there are about 16.6 million refinances and 8.4 million home-equity loans (including home-equity lines of credit). As would be expected, mean principal of mortgage refinances is larger than for home equity loans: $386,240 for refinances (year 2000 dollars) versus $157,287 for home equity debt. For both types of loans, median principal is smaller than the mean (e.g., $61,606 vs. $146,292 for home-equity loans), suggesting long right-tails to the distributions.

Looking at home equity loans over time illustrates the magnitude of the lending boom in the early 2000s. The upper panel of Figure 1 displays plots of the total amount of home equity debt at origination (in billions) and count of originations by year. There is a clear boom in lending in the early 2000s, as the total amount of debt originated per year increases from about $50B per year in the late 1990s to more than $200B in 2005. Similarly, the number of loans originated increases rapidly over this period from around 400,000 loans in 2000 to 1.2M in 2005. At the same time, the beginning of the bust is evident—lending drops off after a peak in 2004/2005 falling somewhat through 2007.[20] The size of loans increases along with the volume of debt. The lower panel of Figure 1 shows that the median size of a home-equity loan grows rapidly in the early 2000s, doubling from $50k in 2000 to $100k in 2008.

[17]These data were collected from county records by an anonymous data provider and made available to me through the Paul Milstein Center for Real Estate at Columbia Business School.

[18]I discuss county-level entry into the sample over time in the data appendix. My estimates are generally not sensitive to the inclusion of data prior to 2000 (when more than 75% of counties have data available).

[19]In cleaning the data, I drop all duplicate loans (in address, date, and amount), loans with missing addresses, loans with loan amounts = 0 or missing, loans with non-rounded values, and all county-years where more than 20% of records have no associated address. See the data appendix for more details on the cleaning process.

[20]Note that the number of originations in late 2008 is artificially low—many loans that originate in the latter half of 2008 will not have been recorded until 2009 and will not be present in the data set.

Since the loan origination data does not include details about the borrower or about interest rates, I rely on the Survey of Consumer Finances to impute how the MID influences the cost of debt. The SCF is a nationally representative survey of households, conducted every three years. The survey asks detailed questions about households' income, wealth, and use of debt. Details about home equity loans collected in the survey include interest rates and loan principal. I restrict the sample to all households with a home equity loan, and pool this data for 1998, 2001, 2004, and 2007 (leaving a sample of 4144 households). Finally, I calculate marginal tax rates using NBER TAXSIM, accounting for the household's reported adjusted gross income, number of dependents, state of residence, and property taxes (Feenberg and Coutts (1993)).

4 Methodology

4.1 Estimating Response to Policy from a Kink

The discontinuity in marginal prices caused by a tax or policy kink (e.g., MID deductibility limit) may cause agents to bunch at this kink point. Existing work shows how the extent of bunching can be used to uncover the behavioral response to the given tax or policy (Saez (2010); Chetty et al. (2011); Weber (2012)). Intuitively, economic agents cluster just below the kink to avoid the change in policy—if agents are unresponsive to the marginal incentives that change at the threshold, then no one will bunch. The size of the mass bunching at the kink point is, thus, proportional to how responsive agents are to the policy itself. I briefly review the methodology herein.

Suppose that the MID applies everywhere (i.e., there are no limits to deductibility)—individuals will choose their optimal debt, which will generate some distribution of loan originations. Let $\tilde{q}$ represent the optimal loan an individual takes when there is no limit to the deductibility of mortgage interest (and so the effective interest rate is $1 + (1 - t)r$ everywhere), and $f_0(q)$ represent the distribution of these loans. This distribution of debt may be generated by heterogeneity in income, need for debt (e.g., health shocks, children going to college), or preferences.

Following the argument outlined by Saez (2010), if the government imposes a deductibility limit at some level, q^*, individuals will either continue to choose debt equal to $\tilde{q}$ or reduce their debt in response to the higher price, with some mass of borrowers reducing debt exactly to the kink point. At q^*, the marginal cost of debt increases discontinuously from $1 + (1 - t)r$ to $1 + r$. This change in price is represented for a simple two-period decision in Panel (a) of Figure 2, where q_t is debt taken for consumption in the first period, C_{t+1} is consumption in the second period, and Y is exogenously given second-period income. Let $\check{q}$ denote the optimal choice of debt under this kinked policy. Borrowers with $\tilde{q} \leq q^*$ are unaffected by the kink and can achieve their optimal loan under the lower effective rate, $1+(1-t)r$, giving $\check{q} = \tilde{q}$.[21] This is illustrated in Figure 2 as the individual borrowing $\tilde{q_A} = \check{q_A}$. When $\tilde{q} > q^*$ the optimal no-kink loan, $\tilde{q}$, is unattainable—individuals will reduce their demand for debt. In particular, for $\tilde{q}$ sufficiently large, individuals will now choose

[21] As discussed in Kopczuk and Munroe (2014), this relationship assumes that there are no general-equilibrium spillovers of the policy on the availability or cost of debt to those borrowing below the kink point.

$\check{q} = \phi\tilde{q}$, where $\phi > 0$ is a reduced-form parameter capturing the response of the market to the removal of the policy. This is illustrated in Figure 2 for the individual who moves from $\tilde{q_C}$ to $\check{q}_C$. Note, however, that individuals who originally choose debt $\tilde{q}$ "just above" the kink point will bunch at the threshold. Specifically, if $\tilde{q} \leq \frac{1}{\phi}q^*$, then borrowers will choose $\check{q} = q^*$; once $\phi\tilde{q}$ drops below the threshold, borrowers no longer face the higher marginal interest rate and choose the largest loan (closest to $\tilde{q}$) that they can achieve without crossing the kink point. The "marginal buncher" appears in Figure 2 as the individual who moves from $\tilde{q_B}$ to $\check{q}_B = q^*$. Notice that this creates a mass of individuals bunching at the kink point. Debt under the kinked policy can be summarized as:

$$\check{q} = \begin{cases} \tilde{q}, & \tilde{q} \leq q^* \\ q^*, & q^* < \tilde{q} \leq \frac{1}{\phi}q^* \\ \phi\tilde{q}, & \tilde{q} > \frac{1}{\phi}q^* \end{cases} \tag{1}$$

The corresponding distribution of debt under the kinked policy will feature bunching at the kink from which ϕ can be uncovered. Let $f(q)$ denote the empirical distribution of debt under the kinked policy. From the relationship between $\check{q}$ and $\tilde{q}$ given above:

$$f(q) = \begin{cases} f_0(q), & q \leq q^* \\ \int_{q^*}^{\frac{1}{\phi}q^*} f_0(x)dx, & q = q^* \\ \frac{1}{\phi}f_0(\frac{q}{\phi}), & q > q^* \end{cases} \tag{2}$$

Two important features of the empirical distribution are evident from this expression. Firstly, there is a mass bunching at the kink point: $B = \int_{q^*}^{\frac{1}{\phi}q^*} f_0(x)dx$. Secondly, there is a discontinuity in the distribution above q^*: $\underset{q\to q^*_+}{lim} f(q) = f_0(q^*) \neq \frac{1}{\phi}f_0(\frac{q^*}{\phi}) = \underset{q\to q^*_-}{lim} f(q)$. Thus, given an estimate of the excess mass bunching at the kink point, $\hat{B}$, and an estimate of the distribution $f_0(\cdot)$ above the kink point, an estimate of ϕ can be found by solving $\hat{B} = \int_{q^*}^{\frac{1}{\hat{\phi}_k}q^*} \hat{f}_0(x)dx$ (I use the subscript k to denote the response estimated as for a kink (i.e., $\hat{\phi}_k$), and the subscript n to denote the response estimated as for a notch ($\hat{\phi}_n$), which I define below). In other words, the proportional response of debt to the removal of the MID can be estimated by answering the question: how much of the mass above the threshold under the counterfactual no-kink distribution is needed to explain the mass bunching at the kink?

As pointed out by Saez (2010), given an estimate of the function $f_0(\cdot)$, B can be estimated by taking the difference between the observed volume of sales bunching at the threshold and the predicted volume of sales implied by $f_0(\cdot)$. In practice, I allow for individuals to bunch in a range of width $\underline{\delta}$ below q^* and estimate B accordingly: $\hat{B} = \int_{q^*-\underline{\delta}}^{q^*} \left(f(x) - \hat{f}_0(x)\right) dx$. The intuition is illustrated in Panel (b) of Figure 2. Bunching below the threshold is estimated as the distance between the observed distribution and the counterfactual. I then estimate $\frac{1}{\hat{\phi}_k}q^*$ as the value of debt such that the integral under the counterfactual above the threshold equals the excess mass.

4.2 Estimating Response to Policy from a Notch

The observed distribution under a policy notch is similar to that of a policy kink, but has one important distinction—a gap above the threshold (see Kleven and Waseem (2013) for an in-depth discussion of policy notches). Because there is a discontinuity in the average cost of debt at the FIRREA notch, there may be a dominated region within which borrowers would prefer to bunch at the threshold, q^*, even if $\phi\tilde{q} > q^*$ (relying on the same notation from above, where $\tilde{q} \sim f_0(q)$ represents optimal debt in absence of the stricter FIRREA policy, and ϕ represents the response of debt above the threshold to the stricter underwriting standards).[22] In particular, there will be a borrower who chooses a value of debt in absence of the notch, $\tilde{q}_m$, such that under the notched policy the borrower is indifferent between borrowing q^* and avoiding the policy change or borrowing $\phi\tilde{q_m}$ under the stricter policy (notice that a kink is just a special case of the notch where $\tilde{q}_m = \frac{1}{\phi}q^*$). However, this borrower would always prefer to borrow q^* or $\phi\tilde{q}_m$ to $q \in (q^*, \phi\tilde{q}_m)$. This phenomenon is illustrated in Panel (a) of Figure 3, where notation is as in Figure 2 described above and the FIRREA policy increases the cost of debt by some fixed amount, k (although the discussion herein applies to the general case of a discrete jump in r). As with the kinked policy, those who initially borrow below the threshold do not change their behavior (q_A in Figure 3), while those borrowing well above the threshold reduce their demand for debt (q_C in Figure 3). Those who choose debt between q^* and $\tilde{q}_m$ in absence of the notch will bunch at the threshold in the presence of the notch. Then, for the notched policy, the relationship between $\check{q}$ and $\tilde{q}$ is:

$$\check{q} = \begin{cases} \tilde{q}, & \tilde{q} \leq q^* \\ q^*, & q^* < \tilde{q} \leq \tilde{q}_m \\ \phi\tilde{q}, & \tilde{q} > \tilde{q}_m \end{cases} \tag{3}$$

The corresponding empirical distribution of debt is:

$$f(q) = \begin{cases} f_0(q), & q \leq q^* \\ \int_{q^*}^{\tilde{q}_m} f_0(x)dx, & q = q^* \\ 0 & q^* < q \leq \phi\tilde{q}_m \\ \frac{1}{\phi} f_0(\frac{q}{\phi}), & q > \phi\tilde{q}_m \end{cases} \tag{4}$$

Thus, there is a gap above the threshold with a width of $\phi\tilde{q}_m - q^*$. Like the kinked distribution, the distribution of debt under the notched policy displays bunching, equal to $B = \int_{q^*}^{\tilde{q}_m} f_0(x)dx$, and a discontinuity between the distribution below the notch and the distribution above the gap.

The response of debt to the FIRREA notch, ϕ, can be backed out by comparing the mass

[22] For expositional purposes, I discuss the response to policy as though lenders pass on the costs of the FIRREA appraisals to borrowers (anecdotally, they do) and there is no lender response. Nonetheless, the estimates outlined herein are general—in response to the stricter lending standards, debt (local to the threshold) will grow or shrink by some factor, $\phi > 0$, with the corresponding distortions to the distribution (although $\phi > 1$ will result in no bunching, but a depression around the threshold even for a kink). Thus, ϕ represents the market-level response to the changing policy.

bunching at the threshold to the width of the gap. Notice that in the case of the notch, ϕ cannot be backed out from bunching alone. Rather, what is needed is knowledge of the right-hand edge of the gap, the point $\bar{q} \equiv \phi\tilde{q}_m$, which can be found by examining the gap, and of $\tilde{q}_m$ itself, which can be inferred from bunching. In particular, given estimates of $\hat{B}$ and $f_0(\cdot)$, an estimate of $\tilde{q}_m$ can be found as solving $\hat{B} = \int_{q^*}^{\hat{q}_m} \hat{f}_0(x)dx$. Then an estimate of ϕ can be found by taking the ratio $\frac{\bar{q}}{\hat{q}_m}$.

In general, however, the gap above the threshold is not clean—$\bar{q}$ cannot be observed from inspection. Kleven and Waseem (2013) point out that in the presence of heterogeneity in the response to the policy (e.g., due to heterogeneity in preferences or in adjustment costs) the gap is not simply an empty space above the threshold. Rather, there will be a depression in the distribution above the notch that eventually disappears. In other words, there will be a region above q^* where the mass of loans is smaller than would be predicted by the distribution further to the right (i.e., over some range of width, Δ, $\int_{q^*}^{q^*+\Delta} f(x)dx < \int_{q^*}^{q^*+\Delta} \frac{1}{\phi} f_0(\frac{x}{\phi})dx$).

To estimate the value $\bar{q}$, I follow a similar procedure as that used to estimate $\hat{q}_m$. First, I estimate the distribution far above the threshold (to avoid bias from the gap). For notational ease, let $f_1(\cdot) \equiv \frac{1}{\phi} f_0(\frac{\cdot}{\phi})$, and $\hat{f}_1(\cdot)$ be an estimate of $f_1(\cdot)$. Second, I estimate the mass "missing" from the gap by taking the difference between the predicted mass were there no gap and the observed volume of sales for a fixed region of width $\bar{\delta}$ above the threshold: $\hat{G} = \int_{q^*}^{q^*+\bar{\delta}} \left(\hat{f}_1(x) - f(x)\right) dx$. Finally, I estimate $\bar{q}_m$ by taking the integral under $\hat{f}_1(\cdot)$ up until the point that the integrated mass equals the size of the gap: $\hat{G} = \int_{q^*}^{\hat{\bar{q}}} \hat{f}_1(x)dx$, and so $\hat{\phi}_n = \frac{\hat{\bar{q}}}{\hat{q}_m}$. This is illustrated in Panel (b) of Figure 3. I estimate the mass of sales missing from the gap as the dark gray region below the dotted line ($f_1(q) = \frac{1}{\phi} f_0(\frac{q}{\phi})$) but above the solid line of the observed distribution. I then integrate under $f_1(q)$ to find the point $\bar{q}$ where the integrated mass equals the missing mass.

4.3 Implementation

I approximate $f_0(\cdot)$ and $f_1(\cdot)$ by fitting a flexible global polynomial through the histogram of home equity loans.[23] There are several features of the empirical distribution that I accommodate when estimating these functions. First, since loan principal in the data is rounded to the nearest \$100 I treat this as a discrete distribution (i.e., count data). For every \$100 interval of loan principal, q, I generate a count of the number of loans at that value, N_q. I use a poisson regression to relate these counts to a polynomial in loan principal.[24] Second, similar to Kleven and Waseem (2013) and Kopczuk and Munroe (2014) I include a vector of dummy variables, $R_k = \mathbf{1}\left[q = z \cdot 100k : z \in \{1, 2, 3, \ldots\}\right]$ for $k \in \{5, 10, 50, 250, 500\}$, to pick up bunching at multiples of \$500, \$1000, \$5000, \$25000, and

[23] Fitting a global polynomial in this way is a commonly used approach to bunching estimation (e.g., Kopczuk and Munroe (2014); Chetty et al. (2011, 2013); Ramnath (2012); Kleven and Waseem (2013)). An alternative is to construct the counterfactual distribution locally by smoothing the histogram on either side of the bunching region (e.g., Weber (2012); Saez (2010)). While this non-parametric approach is appealing, it is impractical in cases where observations bunch at round numbers that coincide with the threshold—as they do in the case of home equity debt at multiples of \$25k—since it is not clear how to model this rounding non-parametrically.

[24] The estimates are generally insensitive to using the poisson regression vs. a log-linear regression, although the log-linear specification tends to be less robust. Moreover, the log-linear regression performs poorly when sub-setting the data—small subsets may have several \$100 bins with no data, which the log model cannot accommodate.

\$50000. In the baseline specification, I interact these dummies with loan principal to further control for this rounding. Third, as noted above, there is a jump in the distribution at the policy thresholds (kink or notch). I allow for discontinuity at \$100,000 and \$250,000 by including an indicator for loan principal greater than each threshold, $D_t = \mathbf{1}\left[q \geq 1000t\right], t \in \{100, 250\}$. I also allow for a constant discontinuity at all other multiples of \$50,000 to control for any possible jump in the distribution arising from the natural rounding that occurs at these numbers. Taken together, the specification is:

$$N_q = \exp\left(\beta_0 + \sum_{i=1}^{j} \beta_i q^i + \sum_{t \in \{50,100\ldots\}} \delta_0 D_t + \delta_1 D_{100} + \delta_2 D_{250} + \sum_{k \in \{5,10,50,250,500\}} (\gamma_{0k} R_k + \gamma_{1k} R_k q) + \epsilon_q\right) \quad (5)$$

In my baseline specification I use a second-order polynomial ($j = 2$). However, I explore the sensitivity of my estimates to lower and higher order polynomials as well as varying the order of the interaction of q and R_k. For all specifications, I restrict the sample to loans between \$30k and \$475k.

I omit data around the MID and FIRREA thresholds so that the estimates are not influenced by distortions near these cutoffs. In particular, I omit all data between \$10,000 below and \$40,000 above each threshold when I estimate Equation 5 (i.e., I omit data between \$90,000 and \$140,000 and between \$240,000 and \$290,000). This restriction is important for two reasons. First, if bunching in response to a notch is imprecise, the distribution may be elevated below q^* and including this data would bias the estimate of $f_0(\cdot)$, which is based on the distribution to the left of each cutoff. Admittedly, this is unlikely to be a large problem in this case since there are few frictions in determining the value of a loan (as compared to bunching of taxable income—e.g., Saez (2010); Chetty et al. (2011, 2013); Kleven and Waseem (2013)). Second, since the response to a policy notch may open up a gap in the distribution above q^*, a range above the threshold should be omitted from estimation of the no-notch counterfactuals. I choose the omitted region by inspection of the graph of the log distribution of home equity loans and check the robustness of my estimates to the size of this region.[25]

I use the estimate of $f_0(\cdot)$ from Equation 5 to estimate the excess mass bunching below and gap above each threshold. Given an estimate of Equation 5, I define the counterfactuals for threshold q^* as: $\hat{f}_0(q) = \hat{N}_q$ for $q \leq q^*$, $\hat{f}_0(q) = \frac{\hat{N}_q}{\exp(\hat{D}_{q^*})}$ for $q > q^*$, and $\hat{f}_1(q) = \hat{N}_q$ for $q > q^*$.[26] I find the excess bunching at each threshold by comparing the observed mass to the predicted mass in the

[25] Since it is not necessarily the case that the excess mass at the threshold will equal the missing mass in the gap, I cannot use the excess to determine where the end of the omitted gap region should be (unlike Kleven and Waseem (2013)). Estimates of the gap region tend to be small, rarely larger than \$10000 past the threshold.

[26] Recall that the discontinuity, $\hat{D}_{q^*}$, is included to allow for the shift in the distribution in response to the policy. To achieve a proper counterfactual for $f_0(\cdot)$ above the threshold, I must remove the discontinuity at q^*. Correspondingly, I define $f_1\hat{(}q) = \hat{N}_q \cdot \exp(\hat{D}_{q^*})$ for $q < q^*$, although this is only relevant in cases where the missing mass in the gap is negative.

omitted region below q^* (\$10,000 in the baseline). Specifically, I estimate:

$$\hat{B} = \sum_{q^*-10000}^{q^*} \left(N_q - \hat{f}_0(q) \right) \tag{6}$$

I find the gap above the threshold in the same way. Since the gap is the missing mass below the predicted distribution on the right of the threshold, I take the difference between the predicted density and observed data in the omitted region above the threshold (\$40,000 in the baseline):

$$\hat{G} = \sum_{q^*+100}^{q^*+40000} \left(\hat{f}_1(q) - N_q \right) \tag{7}$$

I estimate $\tilde{q}_m$ and ϕ_k by integrating under the relevant counterfactuals. To estimate $\tilde{q}_m$, I integrate under the counterfactual density, $f_0(\cdot)$, up until the point where the integrated mass equals the mass bunching at q^*. Specifically, I find the value, $\hat{q}_m$, that satisfies:

$$\hat{B} = \sum_{q=q^*+100}^{\hat{q}_m} \hat{f}_0(q) \tag{8}$$

Given this estimate of $\tilde{q}_m$, I find an expression for $\hat{\phi}_k$ as $\hat{\phi}_k = \frac{q^*}{\hat{q}_m}$. Notice that for a kinked policy change, $\tilde{q}_m = \frac{1}{\phi} q^*$, and so this estimate of $\hat{\phi}_k$ corresponds to the estimate given above.

As discussed above (and at length by Saez (2010); Weber (2012)), in the case of a kink, $1 - \hat{\phi}_k$, which is the quantity I estimate and present below, can be interpreted as the percent-reduction in debt in response to the higher marginal cost of borrowing above the kink for the marginal individual who moves to the threshold. In turn, this quantity can be used to estimate the elasticity of debt with respect to interest rates. As pointed out by Kleven and Waseem (2013) and Kopczuk and Munroe (2014), in the case of a notch $1 - \hat{\phi}_k$ has an intuitive interpretation, representing the average reduction in debt for marginal borrowers (i.e., those indifferent between $\phi \tilde{q}$ and q^*) who bunch at the threshold—how much is the marginal borrower willing to reduce debt to avoid the stricter policy? This stands in contrast to the value $1 - \hat{\phi}_n$, which represents the general response to the policy—how would the marginal borrower respond if the stricter policy applied everywhere?

Given the estimate of $\hat{G}$, I find $\bar{q}$ by integrating under the predicted counterfactual for $f_1(\cdot)$ above the threshold and compare this to the estimate of $\tilde{q}_m$. I find $\hat{\bar{q}}$ as the value that satisfies:

$$\hat{G} = \sum_{q=q^*+100}^{\hat{\bar{q}}} \hat{N}_q \cdot \exp(D_{q^*} \cdot \mathbf{1}\left[q < q^*\right]) \tag{9}$$

Using my estimates of $\tilde{q}_m$ and $\hat{\bar{q}}$, I arrive at my estimate of the global response of debt to the increase in borrowing costs above the threshold for the marginal borrower: $\hat{\phi}_n = \frac{\hat{\bar{q}}}{\hat{q}_m}$. Again, I present below the quantity $1 - \hat{\phi}_n$, which can be interpreted as the general percent reduction in debt in response to the stricter appraisal requirements. Of course, this parameter is specific to those individuals borrowing in the neighborhood of the notch. I bootstrap standard errors for my estimates by resampling the original data and repeating the entire procedure 999 times.[27]

The identifying assumptions underlying this procedure are standard for bunching estimates. First, I assume that the observed data can be used to construct the counterfactuals $f_0(\cdot)$ and $f_1(\cdot)$. In particular, what this assumes is that the presence of the policy discontinuities does not create any general-equilibrium effects that distort the distributions away from the thresholds (in which case the observed data away from the threshold would not reflect the distributions $f_0(\cdot)$ below the threshold and $f_1(\cdot)$ above). Secondly, I assume that $f_0(\cdot)$ and $f_1(\cdot)$ can be reasonably approximated by fitting a global polynomial through the distribution, omitting data near the thresholds and allowing for discontinuity. I check the sensitivity of this assumption by experimenting with different functional forms. Third, I assume that the distribution, $f_0(\cdot)$ would be smooth in absence of the policy change at the threshold—if there is no kink or notch in the budget set then there is no bunching. In this particular case, this requires the assumption that the round number bunching at other multiples of \$50,000 can be used to construct an appropriate counterfactual for the excess mass at \$100,000 and \$250,000. I check the robustness of this assumption by estimating the response for placebo cutoffs at other multiples of \$50,000. I also estimate placebos using data on mortgage refinances where neither policy threshold exists.

5 Results

5.1 Graphical Evidence of Response to Removal of the MID and to FIRREA Appraisal Requirements

The empirical distribution of home equity loans displays distortions at \$100,000 and \$250,000 that are consistent with a response to the policy discontinuities. As outlined in Section 4, if the market for loans is sensitive to the removal of the MID at \$100,000 or the requirement of independent licensed appraisers above \$250,000, then there should be bunching at these threshold, with a possible depression (gap) in the density just above the thresholds, and a shift in the distribution further above the threshold. Figure 4 presents the histograms of home equity loan and mortgage refinance originations with \$5,000 bins. The distribution displays evident round-number bias; loans cluster at multiples of \$50,000. Despite this, there appears to be excess bunching of home equity loans at \$100,000 and \$250,000—the excess mass at these thresholds is visibly larger than neighboring multiples of \$50,000. Owing to the scale of this figure, the gap above the threshold is not apparent.

Taking the log of the histogram with \$1,000 bins, as in the upper panel of Figure 5, makes the distortions in the distribution at \$100,000 and \$250,000 more apparent. While taking logs compresses the excess mass at the round numbers, the bunching at \$100,000 and \$250,000 still appears out of line with that at other multiples of \$50,000. Moreover, a depression in the distribution

[27] Owing to the very large sample size and a fairly stable distribution, my estimates of $1 - \hat{\phi_k}$ and $1 - \hat{\phi_n}$ are all very precise, and are significant at the 1% level. This is true whether I resample the raw data or whether I resample at a more aggregate level, for example resampling by zip code or year (i.e., randomly choosing a zip code and all the observations associated with it).

is evident just above each policy threshold. At the same time, only minimal depressions can be seen above other multiples of $50,000. As discussed above, I allow for discontinuity at these other round numbers to capture any distortions due to rounding at salient numbers. Finally, a salient feature of the log-histogram is that there is rounding in loan principal at many levels, not just multiples of $50k. Hence, I include fixed effects to control for distortion at round numbers when estimating the counterfactual. I also estimate placebos at these other round numbers and find small or negative estimates.

One concern is that bunching at the policy thresholds is the result of behavioral rounding on the part of consumers at particularly salient numbers—perhaps $100,000 and $250,000 are special and the bunching is unrelated to the policies. If this is the case, however, we might expect similar behavior in the distribution of refinances. Refinances are loans taken to replace original mortgages, typically with better terms. It is common for borrowers to take a loan larger than the existing mortgage, using the difference both to pay for closing fees associated with the new loan, and often for consumption (similar to a home equity loan). Thus, we would expect refinances to display at least some of the rounding behavior of home equity loans. The histogram for refinances over the same period in the same states is also plotted in Figure 4. While general bunching at multiples of $50,000 is present, $100,000 and $250,000 do not appear to be outliers. The lower panel of Figure 5 displays the log of the histograms of refinances, which appears smooth throughout; there are no depressions above $100k or $250k. Despite clustering of loans at salient round numbers, there is no evidence of distortion at $100,000 or $250,000 in the distribution of refinances.

5.2 Baseline Estimates and Robustness

Using the approach described in Section 4.3, I find a significant market-level response of home equity loans to the removal of the MID and to FIRREA appraisal requirements. The first row of Table 2 presents the baseline estimates of response at both thresholds.[28] The first two columns present the "kink" estimates $(\widehat{1 - \phi_k})$ for each policy change—the percent reduction in the marginal loan that bunches at the threshold—while the third column presents the "notch" estimate $(\widehat{1 - \phi_n})$ for the $250,000 cutoff. Recall that for the kinked policy at $100k, the kink estimate can be interpreted as the general response to the policy for the marginal borrower, while for the notched policy at $250k, the notch estimate represents the general response (for loans in the neighborhood of $250k) were the tighter appraisal requirements applied everywhere.

The baseline estimates suggest substantial reductions in loan size in response to the policies. The estimates imply that loan principal drops by 19.96% at $100,000 in response to removal of the MID. This suggests that the deductibility of interest payments encourages home owners to borrower substantially more than they might otherwise. For the FIRREA, the kink estimates imply

[28] In the baseline I fit a global 2nd-order polynomial through the count of home loans (in $100 bins) by poisson regression, omitting data between $90,000 and $140,000 and $240,000 and $290,000. I allow for discontinuity in the distribution at each of these thresholds as well as a constant discontinuity at each multiple of $50k. I include fixed effects for multiples of $500, $1000, $5000, $25000, and $50000 as well as interacting these fixed effects linearly with loan principal.

that marginal borrowers face a reduction of about 23.53% to the threshold in order to avoid the more stringent appraisal requirements above $250,000. The notch estimates imply that when borrowers do not (or cannot) avoid the policy by moving below the threshold, the stricter appraisal requirements reduce the loan principal by 22.02%. Clearly, these threshold policies distort the decisions of agents in this market—a substantial amount of debt is foregone due to the policy changes. After discussing the robustness of these estimates in the remainder of this section, I return to the discussion of these estimates in the following two sections.

The estimates are insensitive to the specification of the model. I vary the order of the polynomial in loan principal (j in Equation 5) and display the estimates in the second panel of Table 2. At $100,000, the kink estimate varies between about 16.6% (for 1st, 5th, and 6th order) and 20% (for 3rd and 4th order). Estimates at the $250,000 threshold are a bit more variable—ranging from a local reduction of 16.7% to 27% and between a 15% and 25.5% general response to the policy. Despite the differences in magnitude, the estimates offer a qualitatively similar conclusion of a large reduction in debt in response to the policies. I also vary the order of the interaction between the round-number dummies and loan principal and display the estimates in the third panel of Table 2. Again, the estimates are somewhat sensitive, although consistently display a large response of similar magnitude to the baseline. The estimates are much less sensitive to varying the width of the omitted region around q^*—see the third and fourth panels of Table 2. I estimate the model allowing only for discontinuity at $150,000 and $200,000 to be used as a counterfactual for the two thresholds, since visual examination of the histogram suggests that the discontinuity is more prominent here than at other multiples of $50,000. I report these estimates at the bottom of Table 2. This procedure results in a slightly larger estimate of the response at $100,000 (23%) and a slightly smaller estimate at $250,000 (18%).

I find no evidence that the response at $100,000 and $250,000 is driven by the salience of large round numbers or is an artifact of the empirical approach itself. A concern is that rounding at salient numbers—multiples of $50,000, in this case—is difficult to model. Since I am using the round-number bunching at other multiples of $50,000 to construct a counterfactual for $100,000 and $250,000, the estimates I find could be spurious if this round-number counterfactual is incorrect. To test this assumption, I estimate placebos at other multiples of $50,000 where there are no policy thresholds. Specifically, I estimate the baseline specification (Equation 5) treating the given placebo cutoff as the policy threshold and report these estimates in Table 3. The kink estimates in the first column (the first two rows replicate the baseline estimates for the sake of comparison) are consistently negative (with the exception of local response for $200,000)—the empirical strategy tends to overstate the excess mass at the threshold rather than understate. These negative estimates likely occur because of, and provides additional evidence of, excessive bunching at $100,000 and $250,000 that overstates the round-number counterfactuals for these estimates. While still negative, notch estimates at the placebo cutoffs, presented in the third column, tend to be close to zero (with the exception of a negative estimate at $150,000). Relative to these placebos, the baseline estimates at $100,000 and $250,000 are clear outliers.

A similar concern is that \$100,000 and \$250,000 are "special" round numbers—individuals (or lending institutions) round their loans to these numbers more than they would at other multiples of \$50,000, making the round number placebos uninformative. To address this, I estimate placebos using the distribution of mortgage refinances. Since the MID cutoff only applies to non-home-acquisition debt and since independent licensed appraisals are generally not required when mortgages are refinanced, there should be no unusual bunching or distortion around \$100,000 and \$250,000 in the refinance distribution. The second and fourth columns of Table 3 display these placebo estimates for refinances at the various cutoffs. Even though Figure 4 shows bunching at round-numbers in the distribution of refinances, the estimation procedure finds no evidence of excess bunching or distortion at \$100,000 or \$250,000 (or the other multiples of \$50k): the kink and notch estimates range between -2.9% and 4.7%. Thus, it does not appear to be the case that \$100,000 and \$250,000 are "special" round numbers in the context of home loans.

5.3 Response of Debt to the Mortgage Interest Deduction

The kink estimates for the MID threshold imply a large (about 20%) reduction in debt in response to removal of the deduction. This response suggests that, at least for those taking home equity loans in the neighborhood of \$100k, eliminating the MID will induce a substantial reduction in the quantity of housing debt that individuals take on (or, conversely, that the presence of the MID induces individuals to borrow substantially more than they otherwise would). Of course, understanding the economic magnitude of this response depends on how large the change in after-tax interest rates is when the MID does not apply. In this section, I show that the response at the MID threshold covaries with marginal tax rates and interest rates, and, thus, the magnitude of the kink. I then present implied estimates of the elasticity of home-equity debt with respect to the after-tax interest rate.

I investigate whether the response to the MID threshold varies with the size of the kink (i.e., the magnitude of the change in after-tax interest rates) by comparing the size of the response to local measures of income. At the threshold, the effective interest rate on the marginal dollar of debt increases from $1 + (1 - t)r$ to $1 + r$; the absolute size of this reduction $(-tr)$ is increasing in both the marginal tax rate and the interest rate. Correspondingly, the kink estimate at \$100,000 should be larger when this change in effective rates is larger. To explore this, I estimate the percent drop in debt by quartile of adjusted gross income (AGI), using this as a proxy for marginal tax rates—individuals in higher-income neighborhoods will, in general, face higher marginal tax rates. I match home equity loans in each zip code to data from the IRS Statistics of Income (SOI), which reports mean zip-code-level AGI among all tax filers within the zip code (the IRS SOI is only available for 1998, 2001, 2002, and 2004–2008). Within each year, I find the quartile of AGI to which each zip code belongs. I then group all loans originated in each quartile and estimate the response to the MID kink as in the baseline specification and present these results in Table 4. I find that the estimated reduction of debt at \$100k is increasing with AGI, from a reduction of 15.22% in the lowest quartile to 19.94% in the highest. These effects suggest that the magnitude of the response may correlate with tax rates. Reassuringly, when I repeat this exercise (also in Table 4) for the \$250,000 threshold—where the magnitude of the policy change does not vary with tax rates or income—the estimates do not display the same increasing pattern.

I also find that the response of debt to removal of the MID moves over time with national interest rates. As with the marginal tax rate, a higher contract interest rate means a larger change in after-tax interest rates at \$100,000. In Figure 6, I plot annual estimates of $1 - \phi_k$ against the national interest rate for a 30-year fixed rate mortgage.[29] In general, response to removal of the MID moves with the interest rate. Conversely, we see that the same baseline estimates for the \$250k cutoff (where the size of the notch does not depend on interest rates) do not move with the rates and tend to grow over time. While there are certainly unobservable factors that are changing over time and influence the borrowing decision, this co-movement of the estimates with the interest rate and the positive correlation between the response and zip-code-level AGI is consistent with bunching at \$100,000 being caused by the removal of the MID.

To investigate these relationships more formally, I relate state-year estimates of local response to state-year averages of the imputed change in after-tax interest rates from the SCF. For each state (CA, IL, NJ, NY) and each year from 1995 through 2007, I estimate $1 - \phi_k$ as in the baseline specification.[30] I then take the full sample of home-equity loan holders from the SCF (pooling the 1998, 2001, 2004, and 2007 survey years) and use NBER TAXSIM to impute the marginal tax rate for this sample were they residing in each state in each year. By using the nationally representative sample, I isolate variation in marginal tax rates due to differing state policies, rather than household selection into states/years (Currie and Gruber (1996)). I then match the state-year tax rates to the annual 30-year fixed mortgage rate, and calculate the average percent-change in after-tax interest rates at the kink. Variation in the rate change is thus coming from two sources: changes in interest rates over time at the national level, and differences across states and over time in marginal tax rates.[31] Finally, I regress the kink estimates for each state/year on the average imputed after-tax interest rate change. I find standard errors by bootstrapping the entire procedure 999 times (resampling SCF data, estimating imputed change in after-tax interest rates, resampling home equity loans, estimating state/year response, and then regressing estimates on imputed change).

Regressing state/year estimates at \$100k on the mean change in interest rates shows a positive relationship between $\widehat{1 - \phi_k}$ and the change in $1+(1-t)r$. I present the results of these regressions in Table 5. The first column presents a bivariate regression of the state/year estimates on the state/year proxies for the change in after-tax interest rates and shows a positive relationship between the two—a larger effect of the removal of the MID on the marginal cost of borrowing means substantially

[29] Mortgage rates are from the Freddie Mac mortgage rate survey (www.freddiemac.com/pmms/index.html). I use the 30-year fixed rate because Freddie Mac does not collect data on home equity loan rates. Nonetheless, home loan rates covary over time and so I do not expect the annual pattern to differ substantially for home equity rates.

[30] As discussed in the data appendix, not all counties have data available in 1995 through 2000. I find similar results for these state/year regressions using only 2000-2007, although the estimates are less precise.

[31] An alternative is to use the reported interest rates in the SCF for each household, although this eliminates any variation over time in interest rates (since households are only surveyed once and the survey is only conducted every three years). Estimates using this approach are similar (although larger) than using the 30-year fixed rate.

more bunching at the kink. The second and third columns include state, and state and year fixed effects, respectively, and again show a large positive relationship.

I repeat this regression exercise for kink estimates at the $250k cutoff to confirm that this correlation between bunching and the interest rate change is not spurious. Since the size of the notch at the $250k cutoff does not depend directly on interest rates or tax rates, there is no reason to expect a positive relationship between the imputed MID interest rate change and the $250k kink estimates. Indeed, the estimates, presented in the fourth through sixth columns of Table 5, show that there is not a positive relationship between the state/year estimates of $\widehat{1-\phi_k}$ and the imputed change in rates at the $250k cutoff.

Under the assumption that only the demand side of the market responds to the removal of the MID at $100k, the response of debt at the kink can be reinterpreted as the elasticity of home equity debt with respect to interest rates (Saez (2010)). In particular, the baseline estimate suggests that the marginal "buncher" reduces his/her debt by 19.96% to arrive at the MID threshold of $100,000. Given an estimate of the change in the after-tax interest rate, this estimate of $1-\phi_k$ can be converted to an elasticity. Since the loan records used in estimation provide no information on interest rates, I turn instead to the SCF. I calculate marginal tax rates for each household with a home equity loan using NBER TAXSIM, as discussed in Section 3. For each household, I find the implied change in the after-tax interest rate from a removal of the MID ($\frac{tr}{1+(1-t)r}$) using the reported interest rate on their home equity loan and the imputed marginal tax rate.

The elasticity of debt with respect to interest rates implied by the response to the removal of the MID is large. Table 6 displays the interest rate and tax rate statistics from the SCF as well as the implied elasticity. Taking the raw change in after-tax interest rates for the home-equity loan households in the SCF, the implied elasticity is -10.505. Restricting the sample to households with loans in the neighborhood of the threshold (between $75,000 and $125,000) raises the implied elasticity to -12.475—while these households typically get lower interest rates, they also face higher tax rates.

Although these estimates are on par with existing studies of the elasticity of debt with respect to interest rates, they likely understate the true elasticity. Since the MID threshold of $100,000 only applies to non-home-acquisition debt, loans being used for home improvements will not be affected by the threshold. However, I cannot distinguish these loans in the origination data. Thus, my sample is contaminated by such borrowers for whom the kink does not apply and so are unresponsive to the threshold. To account for this, I use a question from the SCF that asks borrowers what the primary use of their home equity loan is. I calculate the share of home equity loans used primarily for home improvement as reported by the household (52.5% to 60.5%, depending on the size of the loan) and adjust the average implied change in after-tax interest rates, assuming no change for these home-improvement households (see Table 6).[32] This adjustment of the imputed change in interest

[32] The reports in the SCF may overstate the number of home improvers if at loan origination individuals are either not aware of the exemption of limits for home acquisition loans or are not sure what they will use the money for. The true elasticity likely lies between the unadjusted and adjusted estimates.

rates implies substantially larger elasticities: -28.51 and -39.92 for the two samples.[33]

These adjusted estimates suggest a larger elasticity of debt with respect to interest rates than has been found in existing studies. There are several reasons this may be the case. Firstly, it may be that information about the cost of debt is more visible when borrowers take home equity loans (e.g., required monthly payments are typically calculated for the borrower) than credit card loans (as in Gross and Souleles (2002b)). Secondly, it may be that individuals taking $100,000 home equity loans are less credit constrained than those taking credit card loans or auto loans (as in Attanasio et al. (2008)). Both Gross and Souleles (2002b) and Attanasio et al. (2008) find larger elasticities for individuals facing lower constraints. Thirdly, it is possible that borrowers are shifting the marginal dollars of debt to non-housing debt, and so this is not the response of all debt with respect to interest rates, but of home equity debt to interest rates. However, contract interest rates for home equity debt are generally lower than other sources of debt. In the SCF, the average APR for housing debt is 7.9%, while the average for other lines of credit is 8.5% and for credit cards is 13.9%.[34] Finally, it may be that lenders are themselves responding to the presence of the policy kink, perhaps by restricting access to or increasing interest rates for loans greater than $100,000. Unfortunately, I do not observe lender behavior. Thus, a conservative interpretation is that this is a market-level elasticity of debt to interest rates rather than a structural parameter of borrowers' preferences.

5.4 Response of debt to FIRREA Appraisal Requirements

The baseline estimates at the $250,000 threshold imply that stricter appraisal requirements reduce the size of loans. The estimate of local response to the $250,000 FIRREA notch implies that loans are reduced by 23.53% in order to avoid a licensed appraisal. The general response is comparable—just above the threshold, there is a 22.02% drop in principal relative to how much debt would have been taken in absence of the policy. Taken at face value, requiring licensed appraisals of home loans appears to induce a substantial market-level response of home-equity debt.

This response is large relative to the monetary cost of complying with the tighter appraisal standards (around $400 or $500). However, it may be the case that there are non-pecuniary costs to an appraisal. For example, a licensed inspection and appraisal of a home may cause a costly delay in closing the loan (e.g., scheduling the appraisal, waiting for the report, etc.). Moreover, the formal appraisal introduces uncertainty into the lending process if there is a chance that the appraisal will return a home value different from the borrower and lender's prior (and, in turn, this different home value may affect the size of the loan available to the borrower). Finally, an appraisal

[33] However, as noted in the introduction, elasticities expressed with respect to $1 + r$ tend to appear quite large, in part because a small change in $1 + r$ constitutes a large change in r, and consumers generally observe r, although $1 + r$ is the relevant price in theory (Bernheim (2002)). Expressing my elasticities as the change in debt relative to a percent-change in r gives -1.584 and -1.976 for the two samples (as compared to elasticities around -0.7 or -1.3 with respect to r found in Gross and Souleles (2002a)).

[34] Brito and Hartley (1995) point out that even if rates are lower, if there are large origination fees for home equity loans and uncertainty about the future, borrowers may prefer other sources of debt. However, borrowers bunching at $100,000 are already incurring the origination fees, and so this is unlikely to be an issue in this case.

might reveal information about lower quality borrowers that may cause lenders to increase interest rates or deny the loan altogether. Similarly, if mortgage originators are planning on selling loans on the secondary market, as was common during the lending boom of the early 2000s, they may avoid licensed appraisals in cases where the appraisal might reveal information that lowers the value of the mortgage.[35]

However, the reduction in debt from appraisal requirements may be a desirable outcome—if tighter appraisal standards are costly to low-quality borrowers (or lenders seeking to sell low-quality mortgages on the secondary market), then this suggests that the policy is effective in identifying risky loans. While this will have the effect of reducing access to debt for these marginal borrowers, it may reduce the extent of subsequent loan defaults and foreclosures.

If requiring licensed appraisals successfully weeds out risky borrowers and there are relatively more such borrowers taking loans during a lending boom, then we would expect the response of loans at the notch to be cyclical—costs are higher to these borrowers or lenders hoping to sell the loans on the secondary market. On the other hand, if the response to the FIRREA notch is purely due to the cost of appraisals, we would expect little movement in the response over time. However, I find the opposite—response at the threshold appears counter cyclical during the lending boom of the 2000s. I estimate the general response to the FIRREA policy at the $250k threshold for each year from 1995 to 2008 and plot the estimates along with the total value of home equity loan originations (in billions of dollars) per year on Figure 7. The percent reduction in debt in response to the tighter appraisal requirements is negatively correlated with the number of home loans.

The FIRREA appraisal requirements may fail to dampen lending during a boom because the policy is ineffective in sorting out marginal borrowers. For example, it could be that appraisals exclusively reveal home value and nothing about borrowers' ability to repay (and during the boom home values were increasing sufficiently rapidly that this information was not a strong constraint on lending). Or it may be that during the boom, lenders concealed the information revealed in appraisals from the secondary market (e.g., fraudulent appraisals).

6 Conclusion

In this paper, I use a policy kink and a policy notch to estimate how home equity debt responds to two mortgage policies: the home mortgage interest deduction and the licensed appraisal requirements of the FIRREA. Using administrative data on home loan originations, I find evidence of substantial bunching at the limit of mortgage interest deductibility at $100,000, and at the threshold of $250,000 beyond which home equity loans require a licensed appraisal of the associated property. The corresponding estimates suggest a substantial reduction in debt in response to these policies: removing the mortgage interest deduction reduces loan size by about 20% at origination (for those who take loans in the neighborhood of $100,000), while requiring licensed appraisals reduces loan size by about 22% (for those in the neighborhood of $250,000). Interestingly, I find that response to

[35] Recent research has focused on whether mortgage securitization led to lax underwriting standards; see Bubb and Kaufman (2009), Elul (2011), Jiang et al. (2010), and Keys et al. (2010).

the tighter appraisal requirement decreases during the lending boom of the 2000s, suggesting that licensed appraisals were less effective during that period.

Relating my estimated response of debt to the removal of the mortgage interest deduction, gives a large elasticity of debt to interest rates. I use data from the Survey of Consumer Finances (and NBER TAXSIM) to impute the change in the after-tax interest rate that a typical home-equity borrower would experience. The implied elasticity ranges from -28 to -40, which is substantially larger than estimates the few existing quasi-experimental studies, and suggests that there may be substantial welfare costs to the taxation or subsidization of savings. However, this interpretation relies on the assumption that lenders are not responding to the change in policy, which I cannot explicitly verify. Nonetheless, my estimates suggest a large market-level response of debt to the mortgage interest deduction and appraisal requirements.

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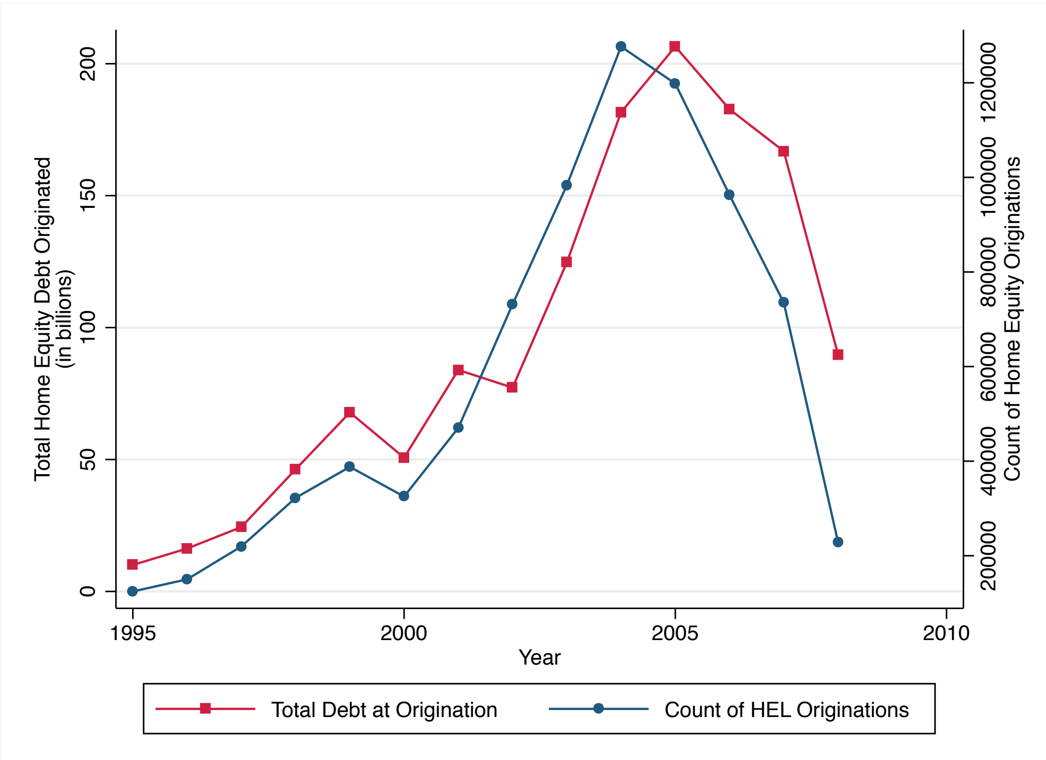
Figure 1: Data Over time

(a) Volume of Home Equity Loans over Time



(b) Median Value of Home-Equity Loans Over Time

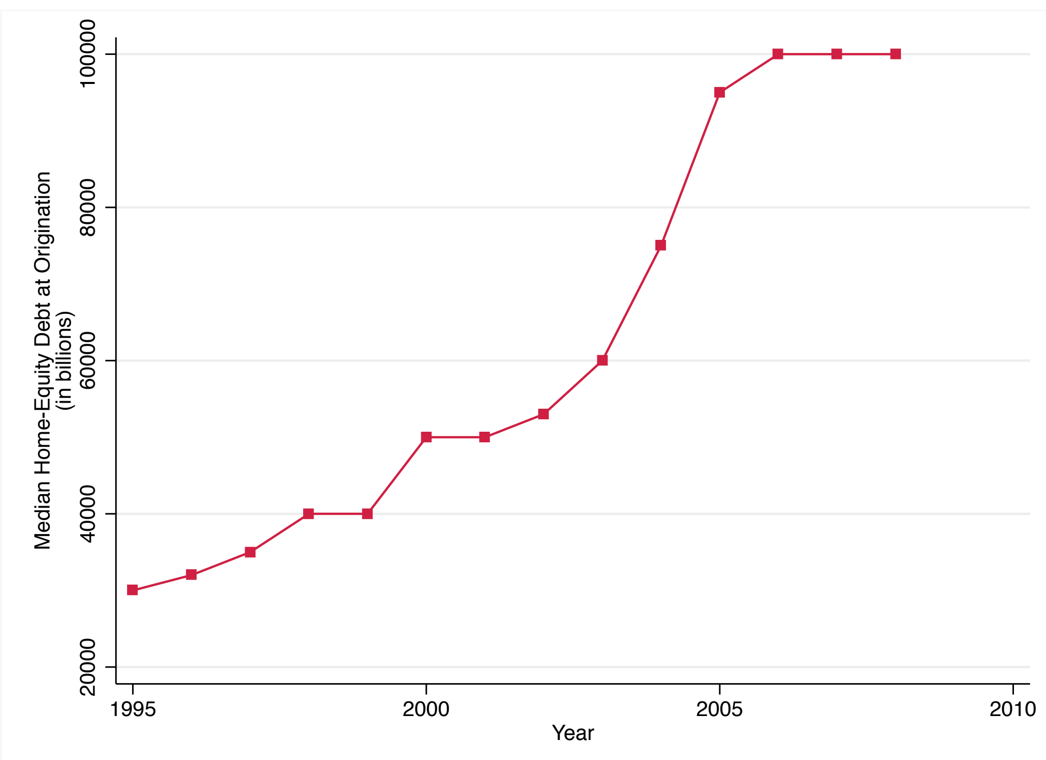
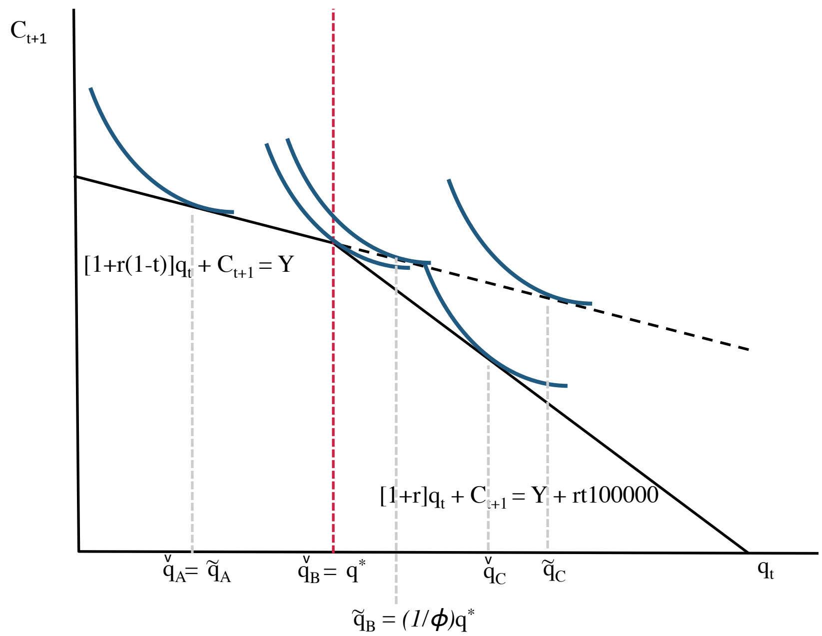


Figure 2: Conceptual Kink Figures

(a) Kinked Budget Set



(b) Kinked Distribution

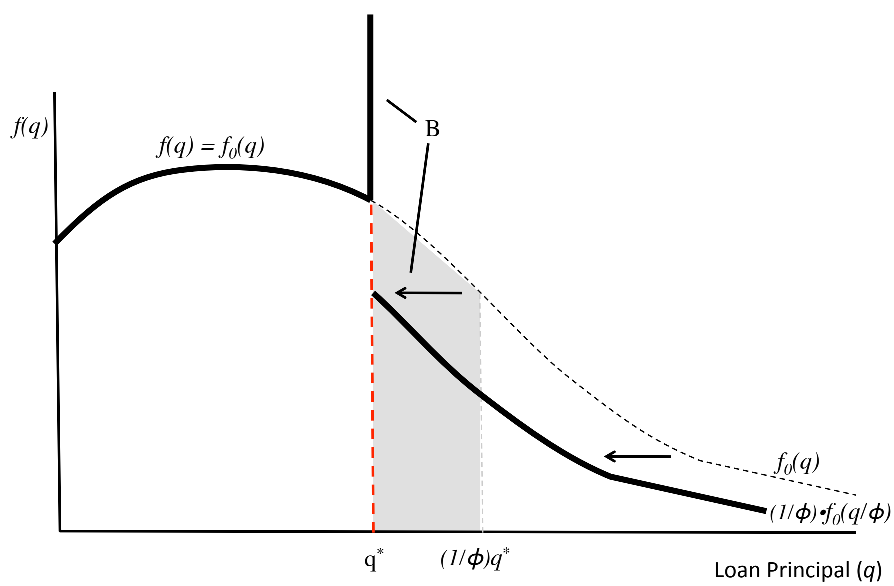
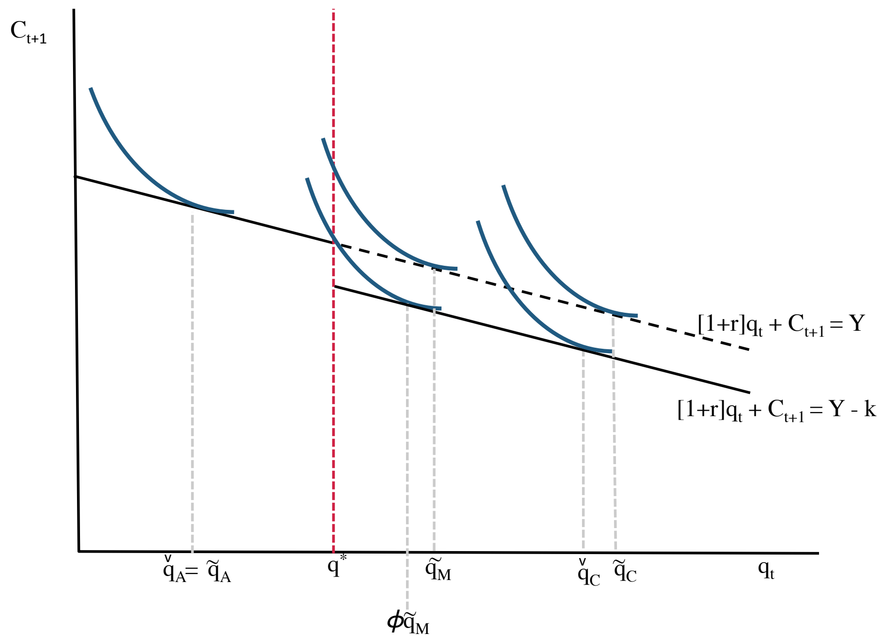


Figure 3: Conceptual Notch Figures

(a) Notched Budget Set



(b) Notched Distribution

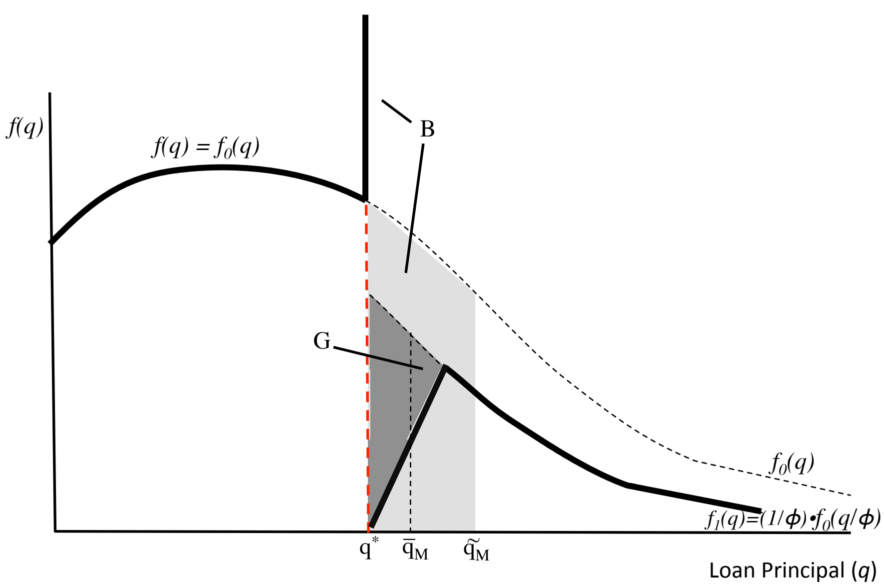
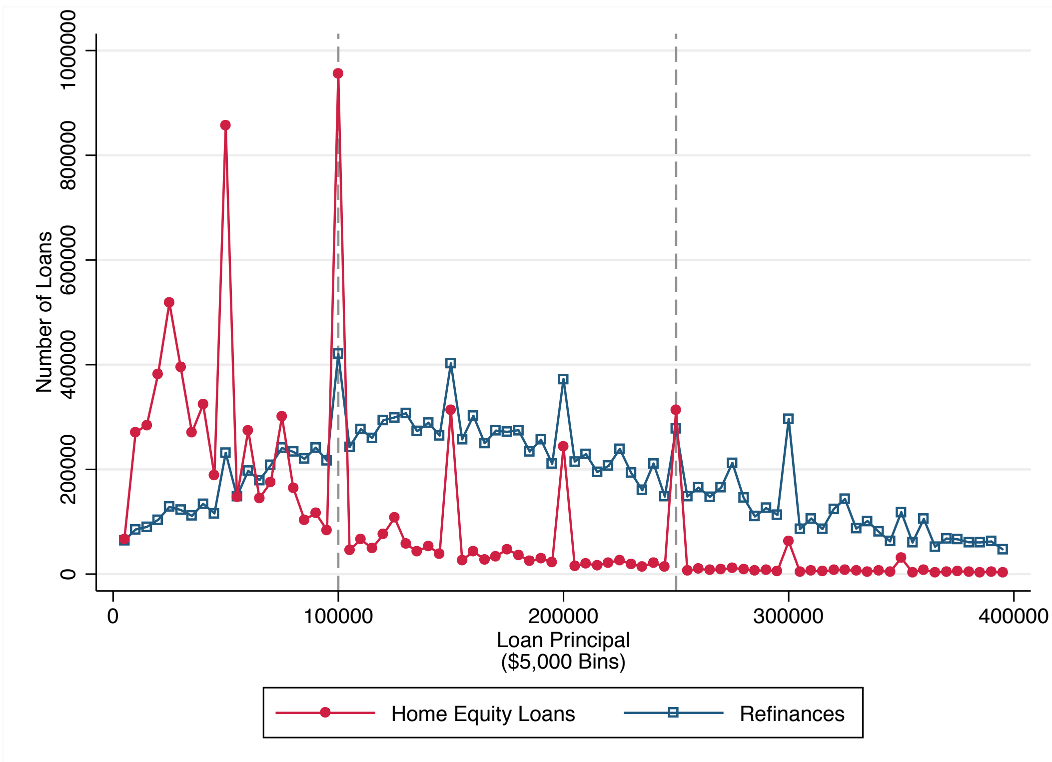


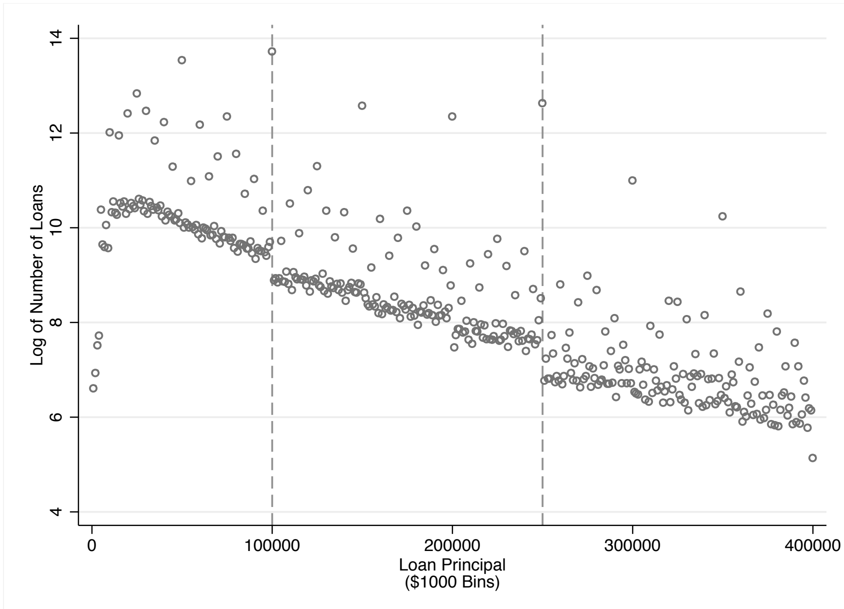
Figure 4: Histogram of Home Loans



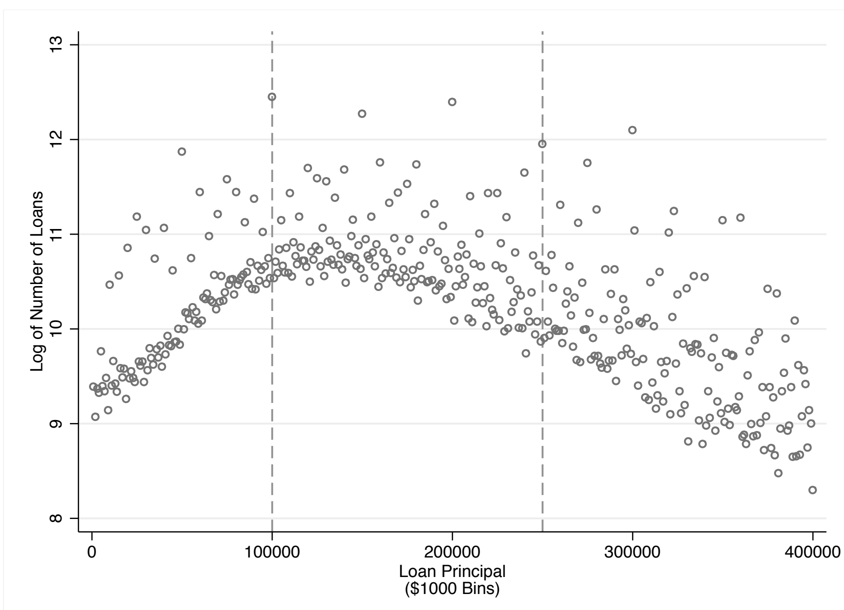
Notes: Histogram ($5k bins) of home equity loan and mortgage refinance originations for CA, IL, NJ, and NY (1995–2008). Dashed lines represent the mortgage interest deduction ($100k) and FIRREA appraisal ($250k) thresholds.

Figure 5: Log of Histogram of Home Loans

(a) Log histogram of Home Equity Loans

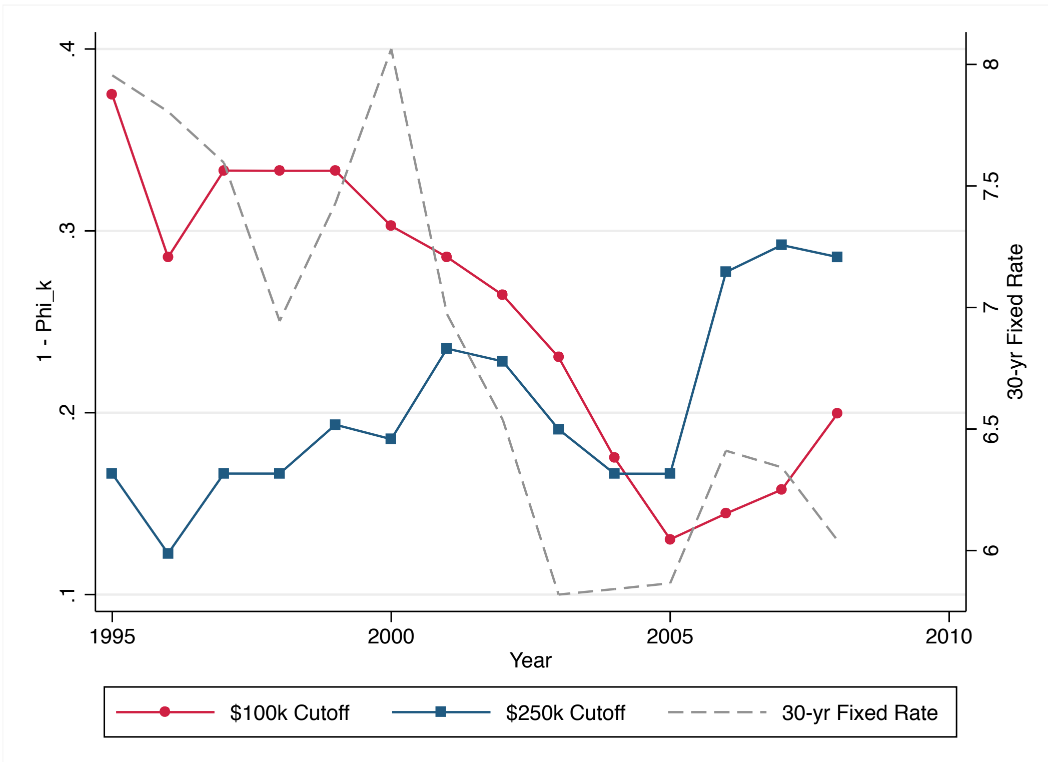


(b) Log Histogram of Refinances



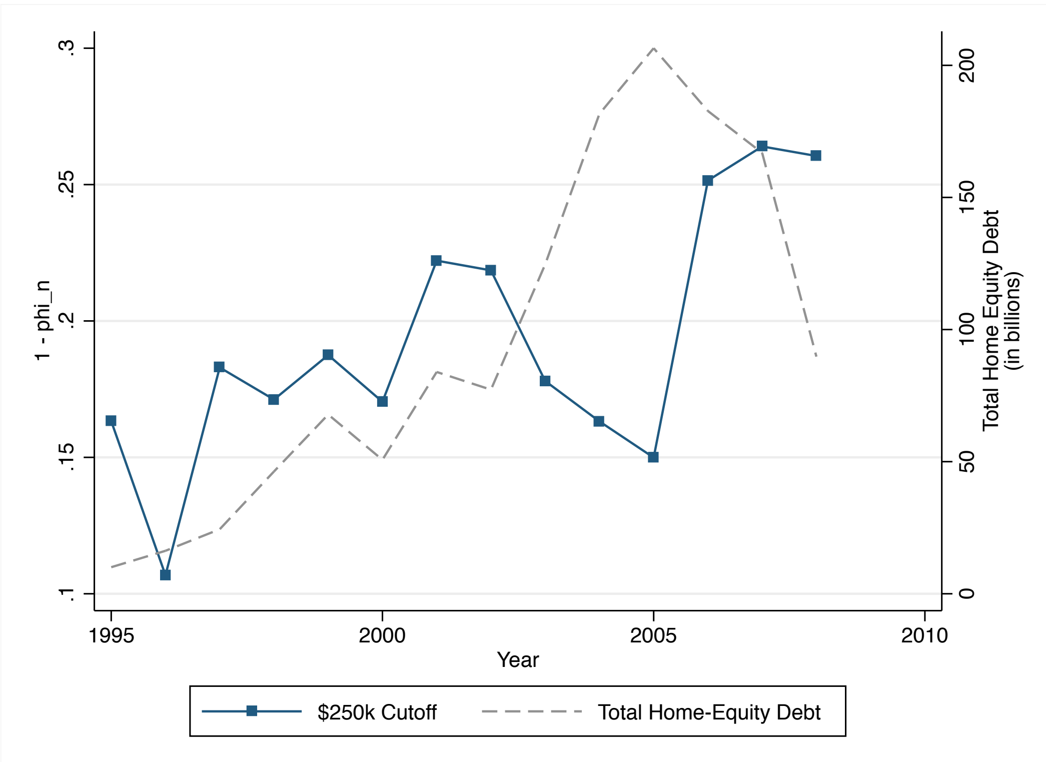
Notes: Histogram ($1000 bins) of home equity loan (upper panel) and mortgage refinance (lower panel) originations for CA, IL, NJ, and NY (1995–2008). Dashed lines represent the mortgage interest deduction ($100k) and FIRREA appraisal ($250k) thresholds.

Figure 6: Kink Estimates Over Time



Notes: Baseline estimates of $1 - \phi_k$ over time for the $100k and $250k thresholds plotted against the 30-year fixed rate mortgage interest rate.

Figure 7: $250k Notch Estimates Over Time



Notes: Baseline estimates of $1 - \phi_n$ over time for the $250k thresholds plotted against the annual total of home equity debt originations (in billions).

Table 1: Home Loan Statistics (1995–2008)

	Home Equity Loans	Mortgage Refinances
Number of Loans	8,405,850	16,606,227
Loans $\in$ 90k–110k	135,134	546,085
Loans $\in$ 240k–260k	58,527	705,495
Mean Loan Principal (Nominal)	174,985	436,130
Mean Loan Principal (2000 Dollars)	157,287	386,240
Median Loan Principal (2000 Dollars)	62,288	173,207

Notes: "Loans $\in$ 90,000–110,000" presents the number of the given loan type with (nominal-valued) principal at origination between \$90,000 and \$110,000.

Table 2: Baseline Estimates and Sensitivity

	$\widehat{(1-\phi_k)}$		$\widehat{(1-\phi_n)}$	
	\$100,000	\$250,000	\$250,000	n
Baseline	0.1996000	0.2353085	0.2201608	4201901
	(0.0000167)	(0.0030037)	(0.0030477)	
1st Order	0.1661398	0.2423946	0.2123417	4201901
Polynomial	(0.0000211)	(0.0020500)	(0.0021275)	
3rd Order	0.1998311	0.1666250	0.1546645	4201901
	(0.0000173)	(0.0000046)	(0.0011514)	
4th Order	0.1998019	0.1666340	0.1522683	4201901
	(0.0000177)	(0.0000048)	(0.0012373)	
5th Order	0.1663140	0.2752993	0.2552296	4485418
	(0.0000455)	(0.0061452)	(0.0059724)	
6th Order	0.1660396	0.2259143	0.2106439	3797876
	(0.000864)	(0.0049487)	(0.0049402)	
No Interaction	0.1994315	0.2707455	0.2184322	4091119
with Round #s	(0.0000157)	(0.0030040)	(0.0031018)	
2nd Order	0.1664815	0.1666452	0.1651159	3602382
	(0.0000323)	(0.0000036)	(0.0016347)	
Omit \$10k Below	0.1689187	0.2039459	0.1953821	4485418
\$20k Above	(0.0020895)	(0.0023308)	(0.0023596)	
\$35k Above	0.1994503	0.2282727	0.2160060	4260866
	(0.0000152)	(0.0025010)	(0.0024762)	
\$50k Above	0.1995467	0.2307022	0.2155439	3797876
	(0.0000165)	(0.0009471)	(0.0010025)	
Omit \$40k Above	0.2288825	0.2519205	0.2371248	4331271
and \$5k Below	(0.0019185)	(0.0026387)	(0.0026761)	
\$15k Below	0.1994722	0.2306717	0.2154378	4091119
	(0.0000188)	(0.0008504)	(0.0008563)	
\$25k Below	0.2258464	0.1934624	0.1775133	3602382
	(0.0030612)	(0.0015077)	(0.0015316)	
Discontinuities at \$100k, \$150k,	0.2306726	0.1495348	0.1663582	4201901
\$200k, and \$250k only	(0.0005878)	(0.0020271)	(0.0021039)	

Notes: Baseline specification omits data in the ranges \$90,000–\$140,000 and \$240,000–\$290,000, and estimates counterfactual by poisson regression of the count of loans per \$100 bin on a 2nd-order polynomial in loan principal, allowing for discontinuity at \$100k and \$250k as well as a fixed discontinuity at multiples of \$50k, and fixed effects for multiples of \$500, \$1000, \$5000, \$25000, and \$50000 plus linear interaction with loan principal. Bootstrap standard errors with 999 repetitions. As described in the text, kink estimates are found by taking excess bunching at kink (difference between mass of observed loans and loans predicted by counterfactual) and integrating under the no-kink counterfactual above the threshold to the point where integrated mass equals bunching ($1-\phi_k$ is the percent reduction from this bunching point to the threshold). Notch estimates are found by finding the "bunching" point as with kink estimation, finding the missing mass from the gap by comparing the counterfactual above the notch to the observed mass of loans above the notch, integrating under the counterfactual above the notch to find the point where this integrated mass equals the missing mass, and comparing this gap point to the bunching point ($1-\phi_n$ is the percent reduction from the bunching point to the gap point).

Table 3: Round Number Placebos

Cutoff	$\widehat{1-\phi_k}$		$\widehat{1-\phi_n}$		n	
	Home Equity	Refinance	Home Equity	Refinance	Home Equity	Refinance
100000	0.1996000	0.0475814	0.1198919	-0.0087601	4201901	1.92e+07
	(0.0000167)	(0.0000357)	(0.0000171)	(0.000141)		
250000	0.2353085	0.0194803	0.2201608	0.0350939	4201901	2.19e+07
	(0.0030037)	(0.0000108)	(0.0030477)	(0.0000999)		
150000	-0.1109449	-0.0267686	-0.1843628	-0.021499	5531743	2.04e+07
	(0.0000379)	(0.000068)	(0.0000403)	(0.0005818)		
200000	0.0697202	0.0025868	-0.0043468	-0.0070201	5743302	2.13e+07
	(0.0011408)	(0.0002833)	(0.0012543)	(0.0002845)		
300000	-0.1995379	-0.0132077	-0.0398446	0.020402	6048969	2.28e+07
	(0.0000011)	(0.0000418)	(0.0002592)	(0.0000404)		
350000	-0.1663163	-0.0203837	-0.0333204	-0.0289084	6091206	2.34e+07
	(0.0000009)	(0.0000621)	(0.0011186)	(0.0000898)		

Notes: Estimates as in baseline specification from Table 2, except treating the given cutoff as the kink/notch (i.e., omitting data round that cutoff rather than $100k or $250k).

Table 4: Estimates by Quartile of AGI

	$\widehat{1-\phi_k}$		$\widehat{1-\phi_n}$	
Quartile of AGI	\$100,000	\$250,000	\$250,000	n
1	0.1521923	0.1665482	0.1555081	192099
	(0.006671)	(0.0027971)	(0.0027699)	
2	0.162068	0.1933219	0.1791202	368878
	(0.0027061)	(0.0038922)	(0.0045289)	
3	0.1663083	0.1709739	0.1546283	831104
	(0.0049238)	(0.0035651)	(0.0043205)	
4	0.1993969	0.1721729	0.1523333	1488503
	(0.0000995)	(0.0035921)	(0.0046358)	

Notes: Estimates as in baseline specification from Table 2, except restricting sample to zip codes in the given quartile of adjusted gross income based on the IRS SOI (1998, 2001, 2002, 2004–2008). Quartiles are calculated within the given year.

Table 5: State-Year Regressions of $1-\phi_k$ on Percent-Change in After-Tax Interest Rate

	\$100k Threshold			\$250k Threshold		
Coefficient on Percent-	0.844***	1.634***	7.705***	0.120*	-0.706***	-0.463
Change in $(1+(1-t)r)$	(0.060)	(0.106)	(1.003)	(0.064)	(0.101)	(1.131)
State Fixed Effects		X	X		X	X
Year Fixed Effects			X			X

Notes: Regression of state/year estimates of $1-\phi_k$ on average imputed state/year change in after-tax interest rates at the MID kink. Estimates of $1-\phi_k$ using the baseline specification from Table 2, except restricting sample to each state in each year. Imputed state/year change in rates from the SCF—marginal tax rates for all households with home equity loans (pooling 1998, 2001, 2004, 2007 survey years) imputed from NBER Taxsim for each state and year (i.e., assume all households live in given state and given year); yearly interest rates for the 30-year fixed rate mortgages as reported in the Freddie Mac mortgage rate survey. Standard errors are found by bootstrapping over the entire procedure (resampling SCF data and home loan data) 999 times.

Table 6: Implied Elasticity of Debt to Interest Rates at \$100,000

	All Home-Equity Loan Households	Loans Between \$75,000–\$125,000
Mean Interest Rate	0.087	0.076
Mean Marginal Tax Rate	0.229	0.197
Percent Change in After-Tax Interest Rate	0.019	0.016
Implied Elasticity	-10.505	-12.475
Share Home Improvement	0.525	0.605
Adjusted Rate Change	0.007	0.005
Adjusted Elasticity	-28.514	-39.920
SCF Sample Size	4,144	397

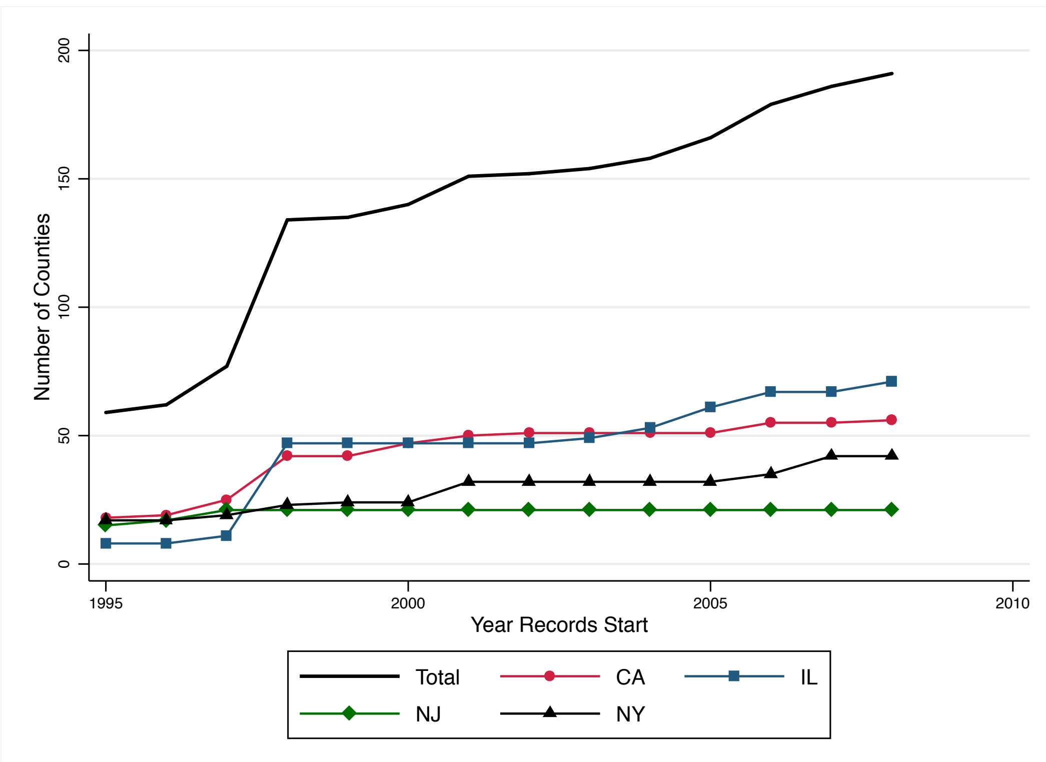
Notes: Average interest rate and rate of use of home equity loan for construction from Survey of Consumer Finances (1998, 2001, 2004, 2007); marginal tax rate imputed for SCF sample using NBER TAXSIM. "All" denotes all SCF households with a home equity loan, \$75k–\$125k denotes all SCF households with a home equity loan in the given range. Marginal tax rate is calculated from survey data (household income, number of dependents, survey year) using NBER TAXSIM. "Home Improvement" indicates that the home equity loan was used for home repairs—change in rates for these households is set to zero to estimate the average adjusted rate change. Percent change in quantity is estimated as in the baseline case of Table 2.

6.1 Data Appendix

My main data set is a collection of home equity loan and mortgage refinance origination records. These records have been collected by an anonymous private firm and made available to me by the Paul Milstein Center for Real Estate at the Columbia Graduate School of Business. The data indicate the size of the loan at origination, the date the loan is made, and the address of the associated property (including zip code). I drop all transactions with missing address or loan principal. I drop county-years in which fewer than 20% of records have valid addresses and counties that are not observed through 2008 (suggesting irregularities in data collection). I also drop duplicate records—multiple loans with identical principal that occur at the same property within 30 days of one another. I keep only loans on residential property.

One concern examining the data over time is that the county-year panels are not balanced—data for some counties is available as of 1995, while others are not available until the mid-2000s. Figure A.1 presents the cumulative distribution of start dates for the counties in the sample (i.e., one observation per county). As of 1995, about 35% of counties are in the sample, and by 2000 more than three quarters of counties have data available. To explore county selection into the dataset I consider three distinct samples: the overall unbalanced data, home-equity loans from counties with data available as of 1995, and home-equity loans from counties with data available as of 2000. Panel a of Figure 1 presents the total number of loan originations by month. This figure demonstrates the dramatic increase in lending over this period—the number of loans increases over time with a slight dip through the 2000/2001 recession followed by a large run-up peaking in 2005. The two balanced samples track the unbalanced sample quite closely. Panel c presents the median loan principal (in year-2000 dollars) by year. Again, there is minimal difference between the total sample and the two balanced samples. Loan principal appears to increase steadily over time—the boom of the early 2000s is not as obvious here, suggesting that the credit expansion operated primarily through an increase in the number of home loans (as in panels a and b) and not the magnitude of loans.

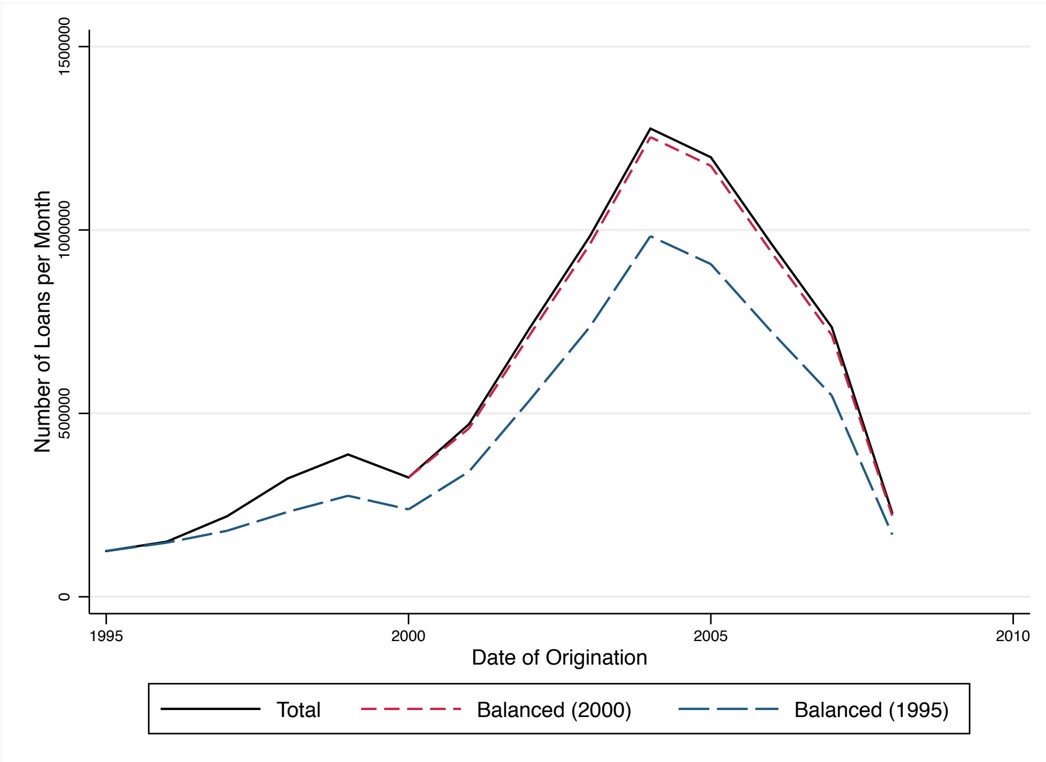
Figure A.1: County Start Dates



Notes: Historical availability of data varies by county. This figure presents a cumulative count of county start years by state. Each point represents the number of counties in the given state with data available as of the given year.

Figure A.2: Loans over Time by Sample

(a) Number of Home Equity Loans Loans Over Time



(b) Mean Value of Home-Equity Loans Over Time