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More Tax, Less Refi? The Mortgage Interest Deduction and Monetary Policy Pass-Through

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Abstract

We study how the mortgage interest deduction (MID) affects refinancing. Households who deduct mortgage interest from their taxes face a lower post-tax mortgage rate, reducing the interest savings from refinancing net of taxes. We estimate the effect of the MID on refinancing using the Tax Cuts and Jobs Act (TCJA) of 2017 as a natural experiment. The TCJA doubled the standard deduction, reducing MID uptake and value. We show that, following the TCJA, the refinancing rate amongst households who lose the MID increased by 25%. Our results suggest that reducing the MID may improve the pass-through of monetary policy when rates fall.

1 Introduction

Mortgage borrowing is an important channel through which monetary policy stimulates economic activity (Berger et al. (2021), Abel and Fuster (2021), Beraja et al. (2019)). Interest

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rate cuts that lower the cost of mortgage borrowing can spur economic activity. Frictions that disrupt refinancing, such as equity levels, (Beraja et al., 2019), competitive barriers, (Agarwal et al., 2015), or employment requirements, (DeFusco and Mondragon, 2020) can dampen the pass-through of monetary policy. This paper studies an under-explored friction to refinancing: the mortgage interest deduction (MID). Because the take-up and value of the mortgage interest deduction varies based on local factors such as home values, local tax policy, and incomes, changes in the value of the mortgage interest deduction may affect the the geographic distribution of monetary policy pass-through.

What is the mechanism? Households who itemize their taxes can deduct their mortgage interest from their taxes, effectively reducing the interest rate on the portion of their mortgage that falls above the standard deduction.[1] It follows that the change in the interest rate after a refinance is reduced proportionately according to a household's federal and state marginal income tax rate and the degree to which their itemized deductions exceed the standard deduction. Given that the fixed costs associated with refinancing are not tax-deductible, the mortgage interest deduction reduces the incentive of a household to refinance relative to a non-itemizing household, all else equal. The MID also changes the share of the interest savings that households pocket when they refinance. Thus, the MID may constrain refinancing, dampening the transmission of monetary policy. The *aggregate* spending response to a given change in mortgage rates may depend on the share of households who deduct mortgage interest and the size of those households' interest subsidies.

To estimate the effect of the MID on refinancing, we exploit a change in household tax policy in 2018 as a natural experiment. The Tax Cuts and Jobs Act (TCJA), which passed in December 2017, doubled the standard deduction. The doubling of the standard deduction caused many households to stop itemizing, thereby losing the mortgage interest deduction (though on net, most households' tax burdens declined (Dobridge and Hsu (2019)). House-

[1]Households can deduct charitable contributions, state and local taxes, and mortgage interest from their taxes. When the sum of a household's individual deductions exceeds the itemizing threshold, the household itemizes, or reduces their tax liability by the sum of their deductions. Households who do not itemize reduce their tax liability instead by the amount of the itemizing threshold.

holds' exposure to this policy change varied based on their mortgage terms, home value, and state and local tax regimes. To measure the effect of the TCJA, we exploit both the timing of the policy change and variation in the loss of the mortgage rate subsidy. Additionally, we use a rich set of time-varying fixed effects to exploit variation in the components of the overall deduction that determine the value of the MID subsidy. This allows us to isolate the effect of the MID from other borrower and loan characteristics that may be correlated with both the value of the subsidy and the refinancing decision.

We find that the refinancing hazard amongst households who lose the interest subsidy increases by 25% following the policy change. A decline of about 20 basis points in the interest subsidy increases refinancing by 25% for borrowers with positive refinance incentives (i.e. whose rate will be reduced by refinancing). We show that the change in the refinancing hazard increases with the treatment intensity (i.e. the change in the rate subsidy), and that the tax filing season following the passage of the TCJA marked a sharp change in the relationship between the treatment exposure and the refinancing hazard. Lastly, we find that the increase in refinancing from those who lose the subsidy is concentrated amongst borrowers who are historically most responsive to changes in rates - those with interest rates 50-150 bps above prevailing mortgage rates. These patterns cannot be explained by changes in other factors that might influence refinance propensities, such as the pre-tax gains from refinancing, income, and local house prices.

The repeal of the MID may have contributed to recent mortgage rate-lock. Mortgage rates fell to record lows during the pandemic and in response many households refinanced and locked in low rates. Mortgage rates then rose sharply in 2022, driving these refinancing households out of the money. Households are less likely to move when out of the money (Berger et al. (2021)) and widespread out of the money-ness in 2022 caused home sales to fall sharply (Fonseca and Liu (2023)). The repeal of the MID increased the sensitivity of refinancing to mortgage rates, which likely amplified refinancing into low rates in 2020-21, leading to more locked-in borrowers and fewer home sales in 2022-23.

The change in the tax law creates incentives that may offset the effect of increased refinance sensitivity on consumption. In particular, the mortgage interest deduction also affects the post-tax internal rate of return households face when they pay down their loan faster than scheduled. If borrowers pay down their loans faster as they stop itemizing, either by accelerating their payoff schedule or reducing cash-out refinances, households may consume less, even as they refinance more. This is a plausible outcome: Recent empirical research has suggested that at origination, borrowers take on less debt in the absence of a mortgage interest deduction (Gruber, Jensen and Kleven (2021) and Hanson (2020)), consistent to conclusions from theoretical models like Sommer and Sullivan (2018), which predicts lower mortgage debt burdens absent the MID. But in the case of empirical studies, it is difficult to separate the effect of the MID on debt choice from the effect of the policy change on house prices. Because one important dimension of policy interest is the influence of the MID on *leverage*, i.e. loan-to-value ratios, not just debt, we propose a novel approach, in this context, that focuses on the borrower's payment of their existing mortgage debt. We evaluate whether households accelerate their loan payoff as their mortgage interest subsidy declines following the change in the law, thereby decreasing their leverage.

We find no evidence of increased curtailments or cash-in refinances, and we find the law had no effect on cash-out refinance propensities or withdrawal amounts. Together, these results argue against meaningful reductions in leverage for existing mortgages. These findings also suggest that the reduction in mortgage balances and interest costs found in Gruber, Jensen and Kleven (2021) and Hanson (2020) are a function of households' choices at the time of home purchase, and they therefore may reflect a combination of salience at that point in time and the direct impact of the MID on the user cost of housing.

We also test whether, conditional on refinancing, borrowers who lose the tax subsidy spend more - consistent with greater pass-through of the mortgage rate change. However, we find no change in the probability of car-buying post-refinance amongst households who lose the interest subsidy after the TCJA, suggesting that the TCJA did not affect the sensitivity

of consumption to refinancing. This means that the tax change affected consumption by increasing the number of refinances, not altering consumption among those who refinanced.

1.1 Related Literature

This paper contributes to a growing literature that uses the TCJA to explore various dimensions of the relationship between taxes and housing decisions. For example, Dantas and Hembre (2021) evaluate the impact of the change in the homeownership subsidy driven by the TCJA on homeownership and mortgage rates, and find that the TCJA reduced homeownership for those whose tax subsidy most declined. Bishop et al. (2023) quantify how the TCJA changed homeownership subsidies and how these subsidies vary by income and race. Li and Yu (2020) evaluate the impact of the tax change on house prices, liquidity and construction, and found that areas that saw the largest decline in the tax benefit saw reduced construction, market liquidity, and house price growth. But because the TCJA affected so many other dimensions of the tax code, including the deductibility of state and local income and property taxes, this research does not separate the effect of the mortgage interest deduction, per se, from the other tax changes that accompanied it, which also directly affected the value of both owner-occupied and rental housing.

The MID is a large tax expenditure, making it of obvious policy interest. The Joint Committee on Taxation (JCT)[2] estimates the mortgage interest deduction cost $64 billion in 2017, one of the largest US tax expenditures. Well before the TCJA, an active literature explored the effect of the mortgage interest deduction on decisions about homeownership, mortgage size, and the structure of household debt. The mortgage interest deduction enters directly into the user cost of home ownership, and so it theoretically increases the equilibrium difference between house prices and rents (see, e.g. Himmelberg, Mayer and Sinai (2005) and Poterba and Sinai (2008) for a comprehensive discussion of user costs). But the salience of the after-tax cost of debt and how it influences household decision-making are empirical questions

[2]See on Taxation (2017).

with outcomes that may depend on local market characteristics (such as the elasticity of housing supply (Hilber and Turner, 2014) or the segmentation of the rental and purchase markets).

The empirical literature broadly shows that households are sensitive to the after-tax price of mortgage debt in their home purchase and financing decisions. Although homeownership generally appears little affected along the extensive margin, the MID does appear to affect the intensive margin, i.e., how much home to buy (Hanson (2012) and Gruber, Jensen and Kleven (2021)). The MID also appears to affect the structure of household debt; households with a greater tax benefit increase their indebtedness (see e.g. Gruber, Jensen and Kleven (2021), Hanson (2020), and Ling and McGill (1998)). Additionally, Valentin (2021) offers evidence that the benefit of the MID is partially captured by intermediaries.

Sommer and Sullivan (2018) and Floetotto, Kirker and Stroebel (2016) calibrate dynamic models to understand the full implications of a repeal of the MID. Using different approaches, both show that repealing the MID would be welfare-improving. Sommer and Sullivan (2018) find that a full repeal would reduce house prices and therefore would increase home-ownership and reduce leverage.

It stands to reason, given households' apparent attentiveness to their tax subsidy, that their refinancing decisions may also be affected. In their closed form solution to the optimal refinancing decision, Agarwal, Driscoll and Laibson (2013) point out the role of the mortgage interest deduction in reducing the refinance incentive. But given borrowers' general inattention to refinance incentives (Byrne et al. (2023), Keys, Pope and Pope (2016)), it is an open question whether borrowers are aware of how their mortgage interest deduction affects their refinance incentives.

A large literature establishes mortgage refinancing as an important pathway for monetary policy to affect consumption (see for example Di Maggio et al. (2017), Di Maggio, Kermani and Palmer (2020), Abel and Fuster (2021), and Amromin, Bhutta and Keys (2020)). Previous literature has highlighted that differences in household employment, (DeFusco and

Mondragon (2020)), and equity levels (Beraja et al. (2019)), can affect refinancing. We provide evidence of another way through which household heterogeneity affects refinancing and the pass-through of monetary policy.

2 TCJA Background

2.1 Overview of the TCJA

Households can deduct mortgage interest from their income taxes once their deductions exceed the itemizing threshold. Households with high deductions are thereby able to reduce their after-tax mortgage rate.[3] Above the itemization threshold, each dollar of mortgage interest reduces taxable income by one dollar, lowering households' tax liability in proportion to their marginal tax rate, t. Because there are fixed costs to refinancing the 30-year fixed-rate mortgage, households do not always refinance when the market mortgage rate, r_t, dips below their existing mortgage rate, r_0. The fixed costs to refinancing create a wedge between the borrower's existing mortgage rate and the rate at which they are "in the money" to refinance, i.e., refinancing makes financial sense. That wedge should reflect the household's after-tax interest rate rather than their pre-tax interest rate, since the fixed costs to refinancing (other than points) are not tax deductible.

If households itemize their taxes, then they pay $r_t * (1 - t)$ interest on the portion of their mortgage that exceeds the standard deduction, given their other itemized deductions (such as state income taxes or property taxes). As a result, households that deduct mortgage interest realize a benefit of $(1-t)*(r_0-r_t)$ on the portion of the interest above the standard deduction when they refinance, as opposed to a benefit from refinancing of $(r_0 - r_t)$ for households who do not deduct mortgage interest. For this reason, the mortgage interest deduction should soften the sensitivity of refinancing to changes mortgage rates.

[3]Households with deductions above the itemizing threshold "itemize," or deduct certain expenses from their taxes.

The TCJA made a number of changes to the tax code that affected the after-tax cost of owner-occupied housing, especially when financed with a mortgage. Before the TCJA, a household could deduct mortgage interest on mortgages of up to $1,000,000. A household could also deduct all of their state income taxes and local property taxes (SALT). When deductions exceeded $12,700, a household filing jointly would itemize their taxes. Given this structure, households in high SALT areas and households with large mortgages (or high interest payments) generally itemized. Since itemizing is more common for households with high income (higher state income tax), in areas with high house prices (high property taxes and mortgage balance), households who benefited the most from the MID had more wealth and higher incomes.

The TCJA, which passed in December 2017 and became effective January 2018, reduced the maximum balance on which interest could be deducted from $1,000,000 to $750,000. In addition, the TCJA capped SALT deductions at $10,000. Importantly, the TCJA also roughly doubled the standard deduction, to $24,000 for joint filers. The doubling of the standard deduction and the cap on SALT deductions caused many households to stop itemizing and therefore to stop deducting mortgage interest. In 2017, 31 million households deducted mortgage interest.[4] Figure 1 indicates that by 2018, the number of households deducting mortgage interest fell 50%.

The TCJA did not eliminate the mortgage interest deduction, but by increasing the standard deduction and capping the SALT deduction, the bill made it much less attractive to itemize and to deduct mortgage interest. For a more detailed analysis of the incidence of the change in the after-tax cost of housing arising from these tax changes, see Ambrose et al. (2021).

[4]See IRS SOI zipcode tax statistics.

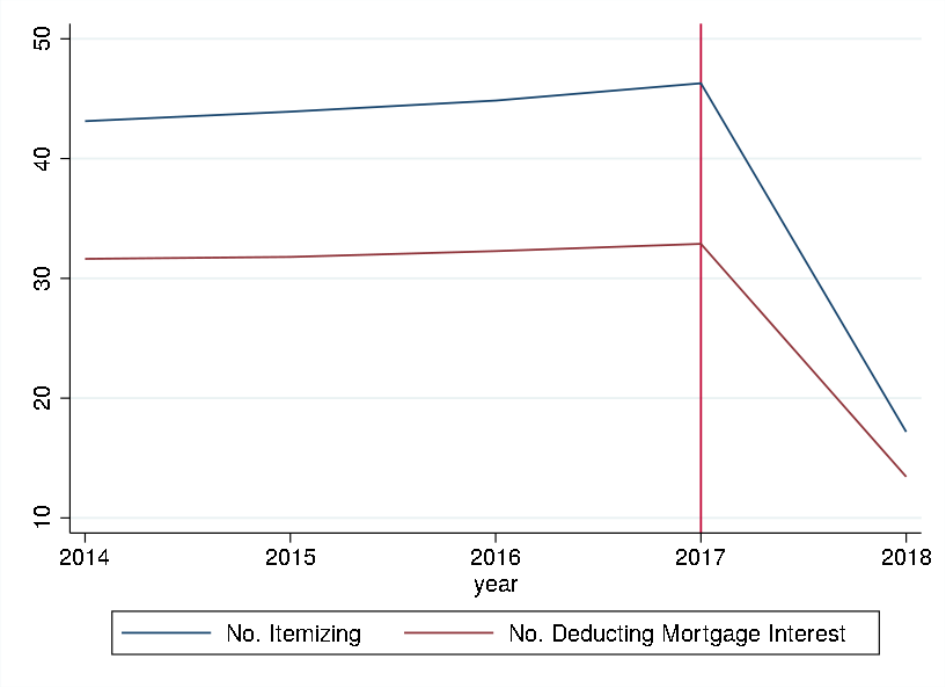


Figure 1. Households itemizing over time. This figure plots the number of households who itemized their taxes and who deducted mortgage interest over time, taken from the IRS SOI zipcode tax statistics.

3 Data and Summary Statistics

3.1 Data

3.1.1 Itemization status and tax rates

We use a number of different data sources in our analysis. We start with the McDash data of mortgage servicing records. This dataset tracks mortgage performance over time, allowing us to see when a loan prepays, the mortgage balance, rate at origination, and a host of borrower characteristics like credit score and mark to market LTV. However, the dataset does not report the reason for a loan's prepayment - i.e., whether the borrower prepays to move, rate-term refinance, cash-out refinance, or pay off the mortgage entirely. We use the Equifax Credit Risk Insight Servicing McDash (CRISM) dataset, which matches anonymized credit bureau records on consumers' credit histories to mortgage servicing records from McDash, to infer the prepayment type. We pull a 10% sample of fixed rate, 30-year mortgages from McDash over the period January 2016 to June 2020.

We do not directly observe whether a household deducts mortgage interest. We therefore infer a household's deduction status using proxies for the components of a household's deduction. To do this, we use the merged HMDA-McDash-CRISM dataset. This dataset merges HMDA information on borrower characteristics at origination, such as income, with mortgage servicing records from McDash tracking interest rates and loan performance, with credit bureau data from CRISM tracking all of a borrower's outstanding loans. We use this detailed dataset to calculate the inputs to a borrower's total deduction amount.

The largest components of a borrower's deduction are comprised of their mortgage interest, their state income tax, and their property tax. We use the data in the combined HMDA-McDash-CRISM dataset to proxy for each of these deduction components. First, we use the interest rate and mortgage balance variables from McDash to calculate the amount a borrower pays in interest. Second, we use the mortgage escrow variable in McDash to proxy for a borrower's property tax amount, as property taxes make up the bulk of households' escrow payment. We use income at origination as reported in HMDA to calculate a household's state income tax. Of course, income changes over time, so this measure of income introduces noise into our analysis. Our measure of property tax also introduces noise into the analysis as the escrow variable may include insurance in addition to property taxes, meaning we over-estimate a household's property tax amount (we exclude borrowers with PMI.) We consider a borrower a joint filer if they have a co-borrower. Finally, we feed the household's state, joint filing status, and income at origination into the NBER TAXSIM program to calculate the household's federal and state income tax burden.

We estimate the household's deduction amount as the sum of state income tax, property tax and mortgage interest. Finally, we use the CRISM portion of the HMDA-McDash-CRISM dataset to distinguish the reason for a loan's prepayment that we observe in McDash, and we focus on rate-term prepayments and equity extraction, rather than prepayments for the purpose of moves.

From this estimate of a household's total deduction, we can infer whether they likely

itemized before and after the law change. Though we cannot observe itemization status at the household level, we validate our construction of itemizing status by plotting the correlation between our measure of itemizing, aggregated to the zipcode level, against zipcode statistics on itemizing shares from the IRS SOI statistics in Appendix Figure A.3. We are able to match zip-level aggregates closely both before and after the TCJA was passed.

3.1.2 Refinance incentives

The interest rate environment changed rapidly around the passage of the TCJA, a fact that complicates comparing refinance rates before and after the law change. To ensure we are picking up a change in refinance behavior driven by the tax change, and not a change in the rate environment that altered refinance incentives in a manner correlated with borrowers' itemization status, we construct a measure of a household's refinance incentive that we call the "rate gap" using an approach that is now standard in the literature. This measure allows us to compare households who lose the subsidy with households who never used the subsidy before and after the law change according to their refinance incentive.

We define the refinance incentive as the borrower's rate gap, or the difference between the borrower's outstanding mortgage rate $r_i^\star$ and the rate available to him if he were to refinance at time t (see Berger et al. (2021)).

$$rategap = r_i^\star - r_{i,t} \tag{1}$$

We estimate the rate available to the borrower at time t using a sample of mortgage rates at mortgage origination from Optimal Blue. Borrowers are in the money to refinance when they have a rate gap slightly above zero.[5] Consistent with Berger et al. (2021), we find that the probability of refinancing follows a non-linear pattern by rate gap (see Appendix Figure A.2).

[5]We consider borrowers to be in the money to refinance when they have a rate gap above 0.5, as opposed to when they have a rate gap above 0, to account for the fixed costs of refinancing.

3.1.3 Structure of the Mortgage Interest Deduction Subsidy

The implications of the MID are different for refinance and mortgage repayment incentives, so we consider them separately.

The mortgage interest subsidy exhibits a kinked pattern by deduction amount. The left panel of Figure 2 plots the average estimated interest subsidy (s) before and after the law change by deduction amount for borrowers with a positive refinance incentive (rate gap $>$ 50 bps). We calculate the imputed tax subsidy rate (s) as tp where p is the portion of mortgage interest that falls above the itemizing threshold and therefore receives the subsidy, and t is the federal tax rate. The after-tax interest rate is $r * (1 - tp)$. For households who do not itemize, i.e., whose deduction falls below the itemizing thresholds highlighted by the vertical red bars in the figure, the share of mortgage interest receiving the subsidy is 0, and therefore the subsidy rate is 0. As households cross the itemizing threshold, they deduct only the portion of the interest that falls above the itemizing threshold; the after-tax cost of each marginal dollar of their mortgage balance falls from r to $r * (1 - t)$. For this reason, the magnitude of the subsidy increases gradually above the itemization threshold. The change in the tax subsidy also increases to the right of the itemization threshold because the federal income tax rate generally increases along with the household's total deduction. In our sample, the pre-TCJA federal marginal income tax rate increases by about 6 percentage points (from about 19 percent to about 25 percent) between \$12,700 and \$24,000 (the old and new standard deduction amounts for joint filers).[6] By doubling the standard deduction, the TCJA set the value of the MID subsidy to zero for households with deductions between \$12,700 and \$25,000. Households with deductions greater than \$25,000 saw the largest decline in the MID subsidy due to the TCJA.

While the MID subsidy is kinked by deduction threshold, in contrast, the after-tax in-

[6] As described in Section 2 the TCJA roughly doubled the standard deduction from \$12,700 for joint filers to \$24,000. Following the TCJA, households with deductions less than \$24,000 lost their interest subsidy. Because the subsidy was increasing between \$12,700 and \$24,000 before the tax change, the change in the interest subsidy increases with deduction amount for borrowers in this region.

ternal rate of return from paying down debt jumps by deduction threshold. The after-tax rate of return from paying down debt drops from r to $(1-t)*r$ as the borrower's itemized deductions exceed the standard deduction. The right panel of Figure 2 illustrates one way of visualizing the post-tax rate of return to households from voluntarily paying down mortgage debt. Households who repay their mortgage ahead of schedule save $F*r^m$ on each dollar of additional principal repaid, where F is equal to 1 for non-itemizers and to $(1-t)$ for itemizers; t represents the household's income tax rate. The figure shows the average value of F (the imputed marginal return) by estimated deduction bin in our sample.[7] The TCJA sharply increased the rate of return on curtailments for households with deduction amounts above the pre-TCJA itemization threshold, as shown by the gap between the black and blue dots.

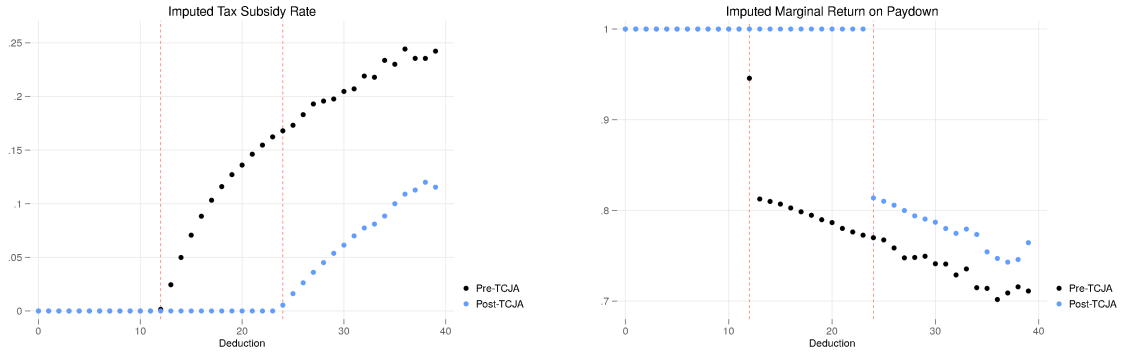


Figure 2. Structure of MID Subsidy by Deduction Amount. The left panel shows the structure of the MID by deduction amount. We calculate the imputed tax subsidy rate (s) as tp where p is the portion of mortgage interest that falls above the itemizing threshold and therefore receives the subsidy, and t is the federal tax rate. The right panel shows the after-tax internal rate of return on debt paydown. Households who repay their mortgage ahead of schedule save $F*r^m$ on each dollar of additional principal repaid, where F is equal to 1 for non-itemizers and to $(1-t)$ for itemizers.

3.1.4 Identification

We want to estimate the effect of eliminating the MID on households' propensity to refinance into lower interest rates and to repay mortgage debt. But households are not randomly assigned into mortgage itemization. Itemization status and the subsidy associated with

[7]For simplicity, we calculate F using only the federal tax rate.

the MID vary with household characteristics that also predict refinance and debt paydown propensities conditional on their observable incentives. For example, mortgage balance, income, and arguably financial savvy are all independently correlated with a household's refinance and debt paydown propensity, and controls for these covariates are imperfect.[8] We cannot therefore compare itemizers with non-itemizers in the cross-section and confidently disentangle the effects of the MID from these confounders.

As evident in Figure 2, the TCJA suddenly changed the structure of the MID subsidy. We use the shock to the MID subsidy structure to address concerns about endogeneity, along with a wide variety of time-varying fixed effects to control for any change in the relationship between borrower and loan characteristics and refinancing behavior over time.

3.2 Summary Statistics

Table I reports summary statistics on the sample of merged HMDA-McDash-CRISM loans. We report statistics separately for "never-itemizers," households who did not itemize in the pre- or post-TCJA periods, "switchers," households who stopped itemizing only in the post-TCJA period, and "always-itemizers," households itemized both before and after the TCJA. Itemizing status is assigned based on a household's deduction amount, calculated as the sum of mortgage interest, property tax, and state income tax.

After the TCJA, the deduction allowed for state income and property taxes was capped, so the primary reason to continue itemizing following the TCJA is high mortgage interest. Therefore, always-itemizers have higher mortgage balances and interest payments than switchers and never itemizers. Always-itemizers and switchers also have higher incomes. The sample of always-itemizers is smaller than the sample of switchers and never-itemizers. Refinancing rates are high for switchers and highest for always-itemizers, driven by these groups' higher mortgage interest payments. In Section 3.1.3 we discuss the incidence of the MID decline for never-itemizers, switchers, and always-itemizers.

[8](Cole, Gee and Turner, 2011) show that wealthier, higher-income households are most affected by the mortgage interest subsidy.

Table I

Summary Statistics

This table shows descriptive statistics of mortgages from a 10% sample of fixed rate, 30-year mortgages from the merged HMDA-McDash-CRISM dataset, spanning 2016m1-2020m3. Never-itemizers are defined as borrowers with deductions below $12,700 in both the pre and post periods. Switchers are defined as borrowers with deductions above $12,700 in the pre period and below $25,000 in the post period. Always itemizers are defined as borrowers with deductions above $25,000 in both the pre and post periods. Deduction calculated as the sum of mortgage interest, state income tax, and property tax. Mortgage interest defined as 0.1 times the interest rate times the mortgage balance. To calculate income tax, income at origination is fed into TAXSIM along with state of residence. Mortgage escrow amounts from McDash are used for property tax. Restricted to joint filers only where joint filer defined as a household with a co-borrower. Households who refi in the pre-period are assumed to have their most recent deduction amount as their post-period deduction. Similarly, households who only appear in the post-period are assumed to have their earliest deduction observation as their deduction in the pre-period. The probability of a rate-term refinance has been multiplied by 100. We restrict to borrowers with rate gaps between -2 and 3, to borrowers with SALT amounts at origination less than $10,000, and to borrowers with principal balance less than $750,000.

	Never Itemizer		Switcher		Always Itemizer		All	
	mean	sd	mean	sd	mean	sd	mean	sd
Prob. Rate Refi	0.08	2.89	0.26	5.09	0.92	9.52	0.16	4.01
Loan Age	23.36	15.80	17.33	13.40	10.40	12.15	20.81	15.18
Orig. Rate	4.28	0.90	4.25	0.73	4.51	0.71	4.27	0.84
Rate Gap	0.18	0.97	0.12	0.83	0.36	0.78	0.16	0.91
Interest (Thous.)	4.06	1.91	8.70	2.97	20.08	3.69	6.08	3.60
Orig. LTV	76.16	20.56	82.36	16.47	81.04	13.44	78.72	19.20
Credit Score	7.43	0.81	7.41	0.76	7.47	0.66	7.42	0.79
Original Bal. (Thous.)	106.09	48.16	218.04	74.26	466.33	101.60	154.52	87.56
Curr. Bal. (Thous.)	97.68	47.92	208.14	73.25	454.17	99.05	145.49	86.54
Income (Thous)	73.24	132.17	98.89	243.06	155.77	93.66	84.34	183.96
Subsidy Change	0.00	0.00	0.06	0.05	0.12	0.04	0.03	0.04
Observations	6740211		4527372		120978		11497960	

The reduction in the value of the mortgage interest deduction varies widely by individual circumstances (property taxes, interest rate, income, etc.) But many of the inputs to the value of the MID have a geographic component, and average differences across different areas of the country reflect house prices, local incomes, and the composition of state and local government revenues. Borrowers in areas where state and local governments rely on income and property taxes to fund their operations, such as California, face larger declines in the value of the MID than do borrowers in areas with, for example, gambling-tax funded or consumption-tax funded operations, such as Nevada. Figure 3 illustrates the geographic variation in the change of the MID subsidy due to the tax law change. Perhaps unsurprisingly, California and the northeast saw the largest changes.

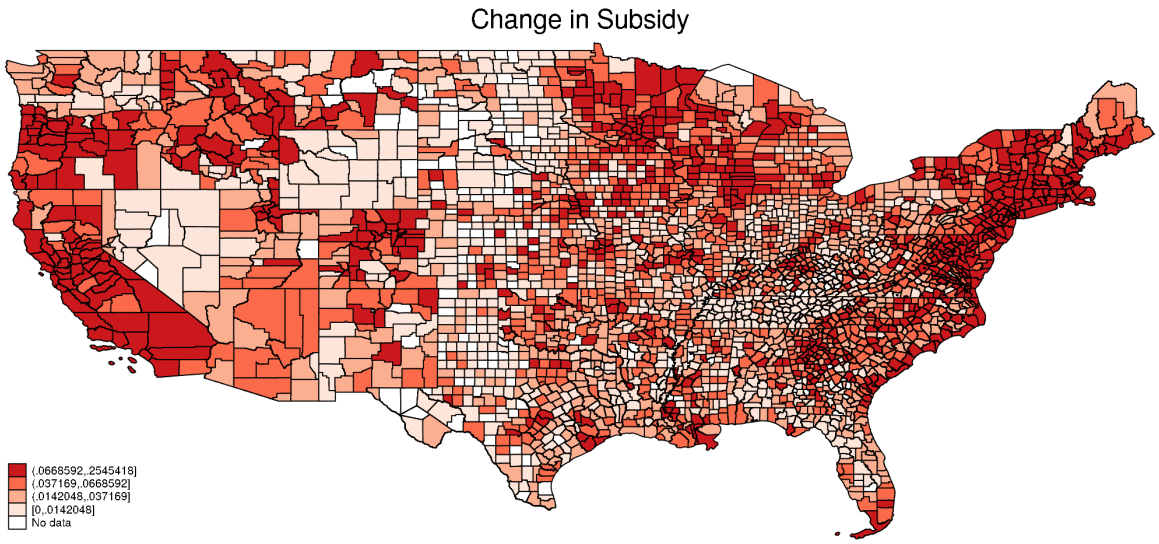


Figure 3. Change in MID subsidy value by county. Figure shows a heatmap of the absolute value of the decline in the MID subsidy due to the TCJA by U.S. county. The calculation of the MID subsidy is described in Section 3.1.1.

4 Motivating Empirical Patterns

In this section, we present raw data that strongly suggests that refinancing patterns before and after the TCJA reflect the change in the structure of the subsidy illustrated in the left panel of Figure 2. In the left panel of Figure 4 we plot the relationship between the borrower's deduction and the refinance probability before and after the TCJA.[9,10] Before the TCJA, the slope of the relationship between refinancing and deductions is steep for low deductions. As households cross the pre-TCJA itemizing threshold, the slope of the relationship between refinancing and deductions flattens, consistent with these borrowers' refinancing becoming less sensitive to mortgage interest because borrowers now deduct mortgage interest from their taxes.

Following the TCJA, the slope of the relationship between refinancing and deduction

[9]We restrict to in-the-money borrowers to focus on a sample who will be likely to refinance, and so that the broad change in mortgage rates does not create large changes in the refinance incentives before and after the law change. We define in-the-money to mean that the rate gap, or the difference between their current mortgage rate and the rate the borrower would receive if they were to refinance at time t, is at least 50 bps.

[10]The TCJA capped state and local taxes (SALT) deductions at $10,000, therefore lowering total deductions for high-SALT households. To ensure that we compare only households whose deduction does not change due to the SALT cap (so that their location on the deduction axis is relatively constant), we restrict this analysis to households with SALT deductions less than $10k.

amount steepens significantly for households with deductions between $12,700 and $24,000. These households can no longer reduce their mortgage rate via the tax code after the TCJA, and so their refinancing becomes *more* sensitive to their interest rate. Refinancing rates also increase absolutely for this group following the TCJA. Refinancing increases the most for households with deductions above $25,000, those borrowers who saw the biggest drop in their imputed subsidy rate. Despite the measurement issues we faced estimating the deduction amount, the pattern of differential refinancing emerges exactly where we would expect if the TCJA were affecting refinancing (between $12,700 and $25,000).

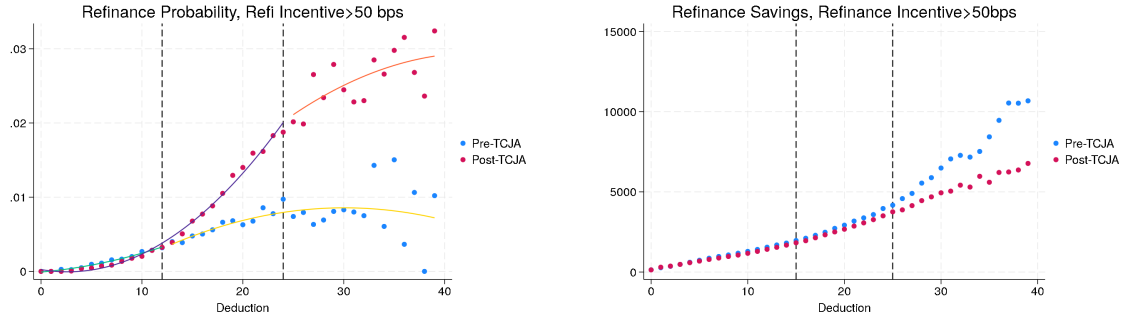


Figure 4. Refinancing Probability and Potential Savings from Refinancing. The left panel plots the the probability of refinancing, before and after the TCJA, by deduction amount. Deduction is defined as the sum of mortgage interest, state income tax, and property tax. Sample includes borrowers with a rate gap of at least 50 bps, whose SALT taxes amount to less than $10,000, and whose principal balance is less than $750,000. The right panel plots the potential annual interest savings available to the borrower upon refinance for the same population.

Interest savings from refinancing is a prime driver of refinancing. If the potential interest savings from refinancing increased on average between the pre- and post-TCJA periods, that may suggest that refinancing increased not because of the law change but because of a change in refinance savings. To explore this possibility, we plot the savings from refinancing by deduction amount in the right panel of Figure 4.[11] We define refinance savings as the mortgage balance multiplied by the difference in the borrower's outstanding mortgage rate and the rate they could obtain if they refinanced. This is a somewhat more nuanced representation of the refinance incentive that may better reflect the fixed costs of refinancing than the rate gap. Potential refinance savings do not substantially change from pre- to

[11] As in the left panel, we restrict to low-SALT, in-the-money households.

post-TCJA – if anything they decline slightly – indicating that a change in refinance savings cannot explain the growth in refinancing after the TCJA observed in the left panel of Figure 4.

5 Empirical Strategy

In this section we estimate the effect of the MID decline on refinancing propensities and on debt paydown.

5.1 Refinancing

To estimate the effect of the TCJA on refinancing, we use a difference in difference framework, formalizing the patterns we see in Figure 4. We compare borrowers with different MID subsidy changes before and after the TCJA passed. In some specifications, we collapse the data into three groups, based broadly on subsidy changes, as we had done in Table I: never-itemizers, itemization-status switchers, and always-itemizers.[12] Motivating this regression analysis, our subsidy estimates from the left panel of Figure 2 suggest that "switchers" saw their subsidy rate decline markedly on average following the TCJA, and those who itemized both before and after the law change, ("always-itemizers"), saw their average subsidy reduced the most.

A household's refinance propensity also depends critically on their refinance incentive, which we estimate as the difference between their current mortgage rate and the rate available to them if they refinance (rategap). A sharp increase in mortgage rates in January of 2018, immediately following the passage of the TCJA, complicates a simple before and after comparison of refinance propensities among those whose itemization status likely switched (see Appendix Figure A.1), because refinance incentives broadly dropped around the time

[12]We define never-itemizers as borrowers with deductions below $12,700 in both the pre and post periods. We define switchers as borrowers with deductions above $12,700 in the pre-TCJA period and below $25,000 in the post period. We define always-itemizers as borrowers with deductions above $25,000 in both the pre and post periods.

of the bill's passage. To circumvent this issue, we compare borrowers before and after the TCJA with the same refinance incentive. The identifying assumption is that the change in the relative refinancing rate among households with similar refinancing incentives is driven by a change in their itemization status. We estimate the change in refinance probabilities by rate gap for in-the-money borrowers, and show that, for households with the same refinance incentive, refinancing is increasing in the magnitude of the subsidy loss.

We estimate the following difference-in-differences style regression:

$$Pr(Refi_{i,t}) = \beta_1 * Post_t * SubsidyChange_i * RefinanceIncentive_{i,t} + \rho X_{i,t} + \psi_{i,t} + \varepsilon_{i,t} \quad (2)$$

Post is defined as a dummy corresponding to post January 2018, when the TCJA came into effect. $SubsidyChange_{i,t}$ is defined as the difference in the borrower's mortgage interest subsidy rate before and after the TCJA. Using the terms from Section 3.1.3, $SubsidyChange_{i,t}$ corresponds to $tp_{post} - tp_{pre}$. $RefinanceIncentive_{i,t}$ refers to a borrower's rate gap, the difference between the borrower's current mortgage rate and the rate available if he were to refinance at time t based on his observable characteristics. $X_{i,t}$ is a vector of controls broadly meant to control for other determinants of a household's willingness and ability to refinance. These controls include quadratics of LTV at origination, mark to market LTV, credit score, loan age, remaining principal balance, and the log of income at origination. Fixed effects ψ_t include time-varying fixed effects, which we discuss further below.

We impose two filters related to TCJA changes to the tax code. First, households could deduct mortgage interest on balances up to $1,000,000 before the TCJA; after the TCJA, this cap was reduced to $750,000. Second, the TCJA capped the amount of state and local taxes (SALT) a household could deduct from their taxes at $10,000. As a result of these changes, households with SALT above $10,000 and households with mortgage balances above $750,000 saw their total deductions decline as a result of the TCJA. Since we want to compare

households before and after the TCJA according to their deductions, deductions should remain relatively unchanged by the TCJA. We therefore restrict our regression analysis to households with SALT less than $10,000 and to households with mortgage balances less than $750,000.

One concern when evaluating refinancing by deduction amounts is that the deduction amount is determined by SALT, mortgage balance, and rate gap, and that one of these components alone could drive an increase in refinancing. For example, it is possible that high balance borrowers, who have higher deductions, increased their refinancing following the TCJA and that this increase drives our result. We want to separate this type of evolution in household behavior from the effects of the tax policy change.

We address this threat using a robust collection of fixed effects. The household's deduction is comprised of three components: interest, property tax, and income tax. The latter two combine to form the state and local taxes (SALT). In all of our specifications, we allow for time-varying fixed effects in each of these dimensions, so that we are identified off of variation in the combination of these components across borrowers with different MID subsidy losses. We control for 50-bps rate gap bins by quarter fixed effects, SALT octile x post, and balance octile x post. We also control for zip x quarter fixed effects, to absorb any variation in refinance activity that is driven by other effects from the law that are highly geographically varied (e.g. via the direct effect of the law on house prices, or via changes in wealth (Dobridge and Hsu (2019)). These fixed effects help ensure that the effects we identify are driven solely by variation in subsidy change itself (and therefore by variation in tax policy), and not by any component of the deduction amount or other geographically-varying effects of the tax law.

We estimate all models using a linear probability model rather than a logit model because of the large number of fixed effects. We cluster errors at the zipcode level. The sample runs from January 2016 through March 2020.

5.2 Debt paydown

For debt paydown, borrowers' incentives are less dependent on the rate environment. We therefore rely primarily on the sharp change in the structure of the MID following the passage of TCJA to evaluate changes in household payment behavior, similar to the approach in Section 4.

6 Results: Refinancing

We formalize the motivating empirical patterns from Section 4 using the difference in differences design described in Equation 2 of Section 5. We estimate here three variations of Equation 2 to show that we see changes in refinance behavior along the subsidy, refinance incentive, and time dimension all at the precise points where we would expect if the tax policy is changing refinancing behavior.

6.1 Effect by Deduction Bin

First, we estimate the change in refinancing following the TCJA according to the intensity of the drop in the subsidy. Recall from Figure 2 that the TCJA change in the mortgage interest subsidy maps to deduction bin. This mapping motivates our estimation of the following variation on Equation 2:

$$Pr(Refi_{i,t}) = \beta_1 * Post_t * DeductBin_{i,t} * InTheMoneyCat_{i,t} + \rho X_{i,t} + \psi_{i,t} + \varepsilon_{i,t} \qquad (3)$$

$DeductBin_{i,t}$ corresponds to $\$1,000$ bins of the borrower's estimated deductions. $InTheMoneyCat_{i,t}$ is a categorical variable indicating Negative (<0), "neutral" (0-0.5ppt), or positive (>0.5ppt and <1.5ppt) rate gaps. Controls and fixed effects are defined as in Equation 2.

We calculate the coefficients on $Post_t x DeductBin_{i,t}$ separately for in and out of the

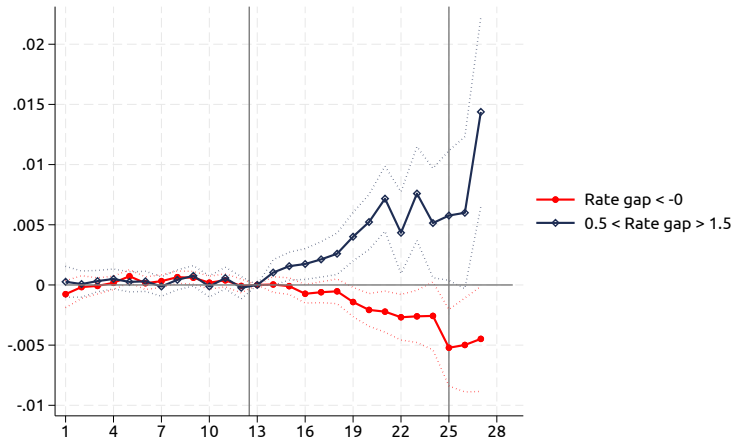


Figure 5. Change in Rate-term Refinances by Deduction Bin. This figure plots the effect of the interest subsidy decline on refinancing sensitivity calculated from a specification allowing the effect of the interest subsidy decline to vary by deduction bin. Estimates were calculated by regressing the probability of refinancing on an interaction of a post-TCJA dummy, with a dummy for being in-the-money to refinance (rate gap between 0.5 and 1.5), with a categorical variable for deduction bin. The figure plots the triple interaction coefficient by deduction bin along with associated 95% confidence intervals.

money borrowers and plot these coefficients by deduction bin in Figure 5. Figure 5 indicates two important results. First, refinancing increased following the TCJA only for in-the-money borrowers. Refinancing did not change for out-of-the-money borrowers, who have no incentive to refinance. Second, amongst the in-the-money group, refinancing increases with the intensity of the change in the mortgage interest subsidy. Figure 2 indicates that the size of the subsidy loss is zero for deductions below $12,700, increases linearly between deductions of $12,700 and $25,000, and plateaus after $25,000. The data is more sparse at deductions greater than $25,000 so this latter effect is more difficult to detect. The overall rise in in-the-money refinancing post-TCJA plotted in Figure 5 is increasing between deductions of $12,700 and $25,000 and is highest for high deduction borrowers $> \$25,000$. Refinancing changes near the precise points in the deduction distribution that we would expect if this behavior reflected a response to the TCJA - especially considering that our estimate for the deduction amount includes homeowners' insurance, which averages about $1,500.

Figure 5 suggests that in-the-money borrowers were much more responsive to the TCJA than out-of-the-money borrowers. We next investigate precisely where in the rate gap dis-

tribution the effect of the TCJA appears.

6.2 Effect by Refinance Incentive

The probability of refinancing does not respond linearly to the refinance incentive, or rate gap. Appendix Figure A.2 plots the probability of refinancing by borrower rate gap. The figure plots the coefficients from a regression of refinancing on 20 basis point bins of borrower rate gap, controlling for borrower characteristics including quadratics of ltv, loan age, remaining principal balance, and for zipcode fixed effects. The figure illustrates that refinancing increases in a step-like fashion with rate gap. For out of the money borrowers, or borrowers with negative rate gaps, refinancing is flat by rate gap. As rate gaps become positive, refinancing linearly increases with rate gap up until rate gaps of approximately 1, and then plateaus. This pattern implies that borrowers with very positive rate gaps are not responsive to changes in the mortgage rates that push them further into the money to refinance. This lack of responsiveness to the rate gap for very in the money borrowers has been attributed to burnout in the literature (Berger et al., 2021). The pattern of refinancing by rate gap in Appendix Figure A.2 implies that the borrowers who are historically most attentive to their refinance incentive have rate gaps between 0 and 1. We next investigate whether the most rate-attentive borrowers are the ones who respond to the loss of the interest subsidy. To do this, we estimate the following version of Equation 2:

$$Pr(Refi_{i,t}) = \beta_1 * Post_t * SubsidyChange_{i,t} * RateGapBin_{i,t} + \rho X_{i,t} + \psi_{i,t} + \varepsilon_{i,t} \quad (4)$$

$SubsidyChange_{i,t}$ is a continuous variable corresponding to the difference in the borrower's imputed mortgage interest subsidy before and after the TCJA. $RateGap_{i,t}$ is a categorical variable referring to 25 basis point bins of borrower rate gap, where rate gap is the difference in the borrower's current mortgage rate and the rate available to them if they were

to refinance at time t. Because this specification does not rely on variation in the deduction bin, we add time-varying deduction bin fixed effects, in addition to the time-varying balance, SALT, rate gap, and zipcode fixed effects. The effect of the TCJA in this specification is therefore identified using within-deduction-bin variation in subsidy bins, which arises from borrowers switching deduction bins due to the SALT cap and variation in state and federal tax rates at the household level.

We calculate the coefficients on $Post_t x SubsidyChange_{i,t}$ for each bin of borrower rate gap and plot these coefficients in Figure 6. Figure 6 indicates that the difference in refinancing before and after the TCJA for borrowers who lose the subsidy relative to those unaffected by the subsidy loss is largest for borrowers with rate gaps between 0.25 and 1.25, exactly the borrowers who have been most attentive to their refinance incentive as suggested by Appendix Figure A.2. The interest subsidy has larger effects on the post-tax refinance incentive, $(1-t)*(r_0-r_m)$, of larger rate gaps, so we would expect the repeal of the subsidy to have a bigger effect for bigger rate gaps. In the region 0-1 in Figure 6, we do in fact see this behavior, that the effect of the TCJA is *increasing* in rate gap up until rate gaps of 1.25, at which point the effect flattens and disappears, consistent with borrowers with very high rate gaps being inattentive to their refinance incentive.

6.3 Effect by Time

We next test whether the increase in refinance propensities for borrowers who lose the subsidy emerges only following the TCJA and is not a continuation of a pre-existing trend. To do this, we estimate a flexible difference-in-differences regression. Specifically, we interact dummies for each quarter of the sample with indicators for a household having lost their interest subsidy further interacted with indicators for the household being in-the-money to refinance.

Specifically, we estimate the following regression:

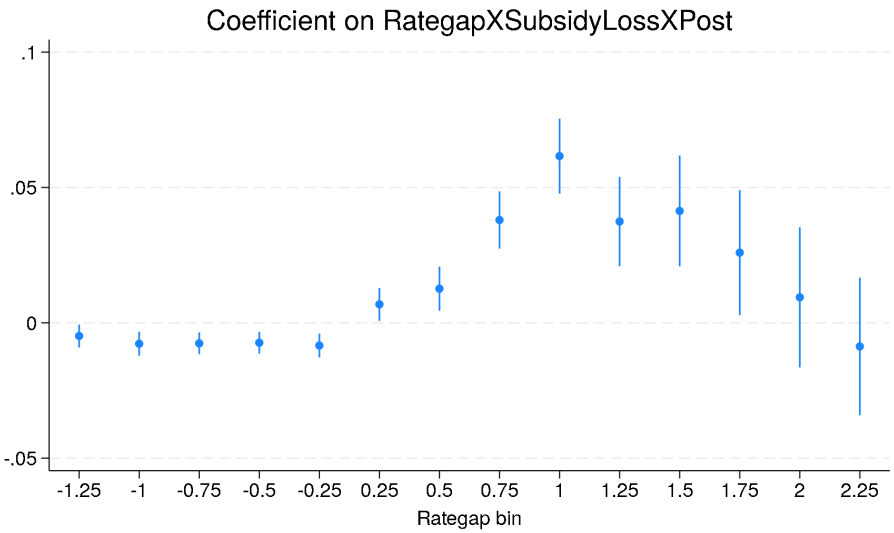


Figure 6. Change in Refinancing Probability by Rate Gap. This figure plots the effect of the interest subsidy decline on refinancing sensitivity calculated from a specification allowing the effect of the interest subsidy decline to vary by rate gap. Estimates were calculated by regressing the probability of refinancing on an interaction of a post-TCJA dummy, with a continuous variable capturing the size of the subsidy decline, with a categorical variable corresponding to 25 basis point bins of borrower rate gap. The figure plots the triple interaction coefficient by rate gap bin along with associated 95% confidence intervals.

$$Pr(Refi_{i,t}) = \sum_{\tau} \delta_t * \beta_\tau ItemizerType_{i,t} * InTheMoneyCat_{i,t} + \rho X_{i,t} + \psi_{i,t} + \varepsilon_{i,t} \qquad (5)$$

As described in the notes to Table I, $ItemizerType_{i,t}$ takes on three values: 1 "Never Itemizers," 2 "Switchers," and 3 "Always Itemizers."[13] $InTheMoneyCat_{i,t}$ is a categorical variable indicating negative (<0), neutral (0-0.5ppt), or positive (>0.5ppt) rate gaps. Controls $X_{i,t}$ + $\psi_{i,t}$ are those as included in Equation 2. The omitted category is set to the fourth quarter of 2017.

We plot the coefficients on the triple interaction term β_τ in Figure 7. The coefficient for Switchers, plotted in red, captures the difference in refinancing for in-the-money borrowers

[13]Never-itemizers are defined as borrowers with deductions below $12,700 in both the pre and post periods. Switchers are defined as borrowers with deductions above $12,700 in the pre period and below $25,000 in the post period. Always itemizers are defined as borrowers with deductions above $25,000 in both the pre and post periods. Never itemizers experience no change in the subsidy. Switchers and Always itemizers see their subsidy decline and Always itemizers experience the largest decline.

relative to out-of-the-money borrowers for Switchers relative to Never Itemizers over time. The Always Itemizers coefficient, plotted in black, has the corresponding interpretation. The figure captures the effect of the subsidy loss by refinance incentive over time.

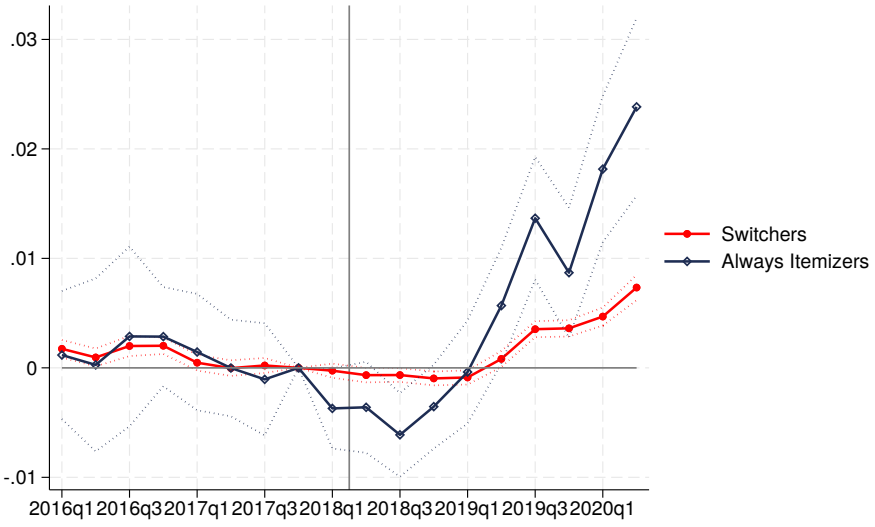


Figure 7. Change in Refinancing Probability over Time. This figure plots the effect of the interest subsidy decline on refinancing sensitivity calculated from a specification allowing the effect of the interest subsidy decline to vary by quarter. Estimates were calculated by regressing the probability of refinancing on an interaction of a categorical variable for itemizer type with a categorical variable corresponding to bins of borrower rate gap with dummies for each quarter of the sample. The figure plots the triple interaction coefficient by quarter along with associated 95% confidence intervals.

The black and red lines rise sharply in 2019, meaning that in-the-money refinancing increased for Switchers and Always Itemizers only following the TCJA and not before, consistent with the TCJA causally affecting refinancing. The effect of the TCJA on refinancing sensitivities does not appear immediately following the enactment of the TCJA in January 2018 but only in 2019. This delayed reaction may reflect the timing of tax returns. The TCJA went into effect at the beginning of 2018, so would have first affected 2018 returns. Households do not file 2018 returns until 2019 and so would likely have not been aware of their changed subsidy amount until 2019, which is when we start to see an effect in the data.

The black line lies above the red line in Figure 7, meaning that borrowers with larger reductions in their subsidy ("Always Itemizers"), have larger responses in their refinancing sensitivities than borrowers less affected by the subsidy decline ("Switchers"), all else equal.

This result underscores the fact that the effect of the TCJA is increasing in the intensity of treatment and is consistent with Figure 5.

7 Robustness

We next run several placebo tests to check that our results are driven by the TCJA and not by other factors.

First, we investigate how the move probability changes following the TCJA. The probability of moving follows a similar but weaker pattern by rate gap as the probability of refinancing: as households move into the money, they become more likely to move, and this effect plateaus at higher rate gaps (Berger et al., 2021). Households may use the interest savings from refinancing to overcome the fixed costs associated with moving and to buy a bigger home.

The TCJA reduced the mortgage interest deduction, increasing the share of interest savings a household pockets when they refinance, which should increase the sensitivity of moving to mortgage rates, all else equal. At the same time, the TCJA also made mortgage debt more expensive on the margin, and many households increase mortgage debt when moving, which suggests the TCJA should reduce the move probability. The total effect on moving is unclear, but on net should be weaker than the effect we document for refinancing, given that moving responds less strongly to the rate gap than refinancing. Therefore, if we find a strong effect of the TCJA on moving, this could suggest our results are biased by other economic factors causing high deduction borrowers to become more likely to both move and to refinance after 2018.

To test this idea, we estimate Equation 3 where the outcome variable is the probability of moving. We calculate the coefficients on $Post_t x DeductBin_i$ as in Equation 3 separately for in and out of the money borrowers and plot these coefficients by deduction bin in the left panel of Figure 8. The figure shows zero effect of the TCJA on moving: unlike our

refinancing results, households who lose the interest subsidy do not become more likely to move, regardless of whether they are in the money to refinance. This suggests the increase in rate-term refinancing we document in Section 6 following the TCJA is not driven by other economic factors affecting high deduction borrowers.

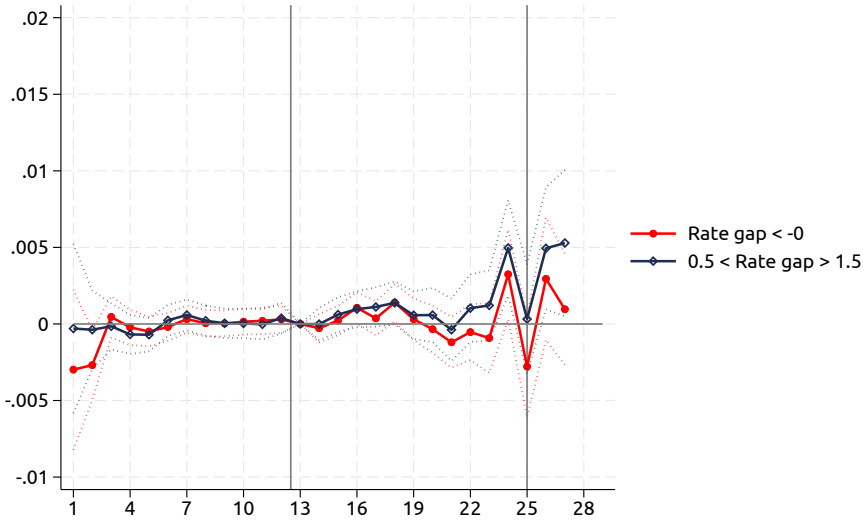


Figure 8. Change in Moving by Deduction Bin. This figure plots the effect of the interest subsidy decline on the move probability calculated from a specification allowing the effect of the interest subsidy decline to vary by deduction bin. Estimates were calculated by regressing the probability of moving on an interaction of a post-TCJA dummy, with a dummy for being in-the-money to refinance (rate gap between 0.5 and 1.5), with a categorical variable for deduction bin. The figure plots the triple interaction coefficient by deduction bin along with associated 95% confidence intervals.

Next, we test how out of the money borrowers' refinancing changed following the TCJA. In Figure 7 we show that the gap in refinancing between in- and out- of the money borrowers' refinancing increases following the TCJA for households who lose the interest subsidy. The TCJA increased the benefit to refinancing when in-the-money and *reduced* the benefit for refinancing when out-of-the-money. Therefore, if we find that out-of-the-money refinancing *increased* following the TCJA, (even as the gap between in- and out-of-the-money borrowers widened), that would suggest some other factor is driving refinancing, rather than the loss of the interest subsidy.

To test this idea, we estimate a version of Equation 5 replacing the categorical variable "Itemizer Type" with a continous variable for the loss of the interest subsidy. We then plot

the coefficients on the triple interaction term β_τ in Figure 9 for each quarter of the sample, separately for in- and out-of-the-money borrowers. In-the-money households who lose the interest subsidy increase refinancing in 2019, the date when households first file tax returns for periods affected by the TCJA. Out-of-the-money households who lose the interest subsidy *decrease* refinancing at exactly the same time, exactly as we would expect if the loss of the interest subsidy were driving refinancing.

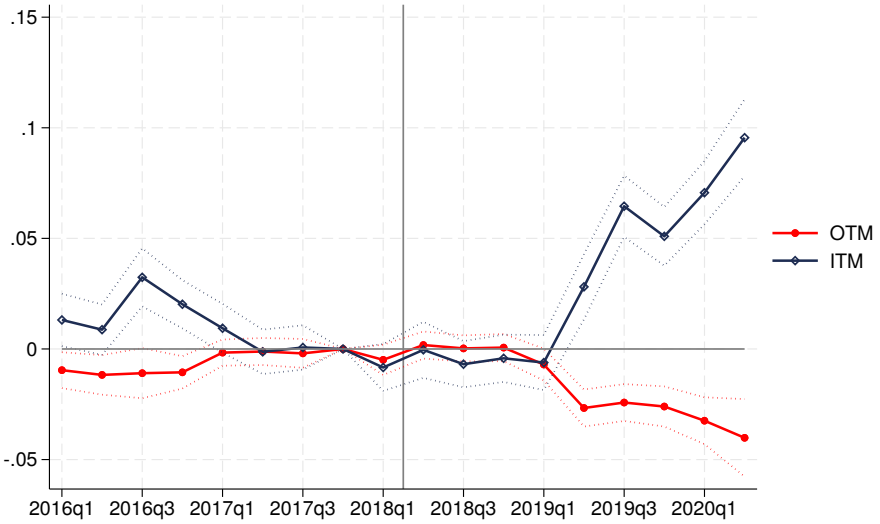


Figure 9. Change in Refinancing Probability over Time by In-the-money-ness. This figure plots the effect of the interest subsidy decline on refinancing sensitivity calculated from a specification allowing the effect of the interest subsidy decline to vary by quarter and in-the-money-ness. Estimates were calculated by regressing the probability of refinancing on an interaction of the subsidy loss with a categorical variable corresponding to a borrower being in or out of the money with dummies for each quarter of the sample. The figure plots the triple interaction coefficient by quarter along with associated 95% confidence intervals.

8 Aggregate Effects

The results from Sections 6.1, 6.2, and 6.3 indicate that the TCJA increased the overall refinancing sensitivity to rates: borrowers became more likely to refinance when in the money and less likely to refinance when out of the money. The TCJA steepened the slope of the refinancing probability by rate gap as plotted in Appendix Figure A.2. The effect of the bill on the aggregate refinancing rate therefore depends on the distribution of rate gap,

whether mortgage rates are high or low. Our results suggest that if rates drop, and more borrowers are pushed in to the money to refinance, then more people will now refinance in response to the rate drop than had in the past.

Figure 10 below plots the aggregate refinance rate and the share of borrowers who are in the money to refinance over time. Although the share of borrowers in the money to refinance in 2019 is about 25% lower than in 2016, the refinance probability in 2019 is nearly as high as the refinance probability in 2016. This suggests that borrowers have now become more likely to refinance when in-the-money than they had in the past, consistent with the TCJA having increased the sensitivity of refinancing to rates.[14]

We can use the TCJA shock to the interest subsidy to derive a causal estimate of the elasticity of refinancing to mortgage rates. Interpreting the coefficient on β_1 in Equation 3 for in-the-money borrowers with deduction bins of 22-26, for a decline of about 20 basis points in the interest subsidy, (equivalent to a 20 basis point rise in the refinance incentive), refinancing increases by 0.5 percentage points, a 25% increase from the baseline refinancing probability.[15]

Our results also suggest that the responsiveness of refinancing to the pre-tax refinance incentive should be greater going forward, given that fewer households deduct mortgage interest. This implies that previous estimates of the elasticity of refinancing to mortgage rates should be adjusted upwards. Interpreting the estimates from Figure 5, we find that amongst in-the-money borrowers, refinancing increases by 0.1 percentage points following the TCJA, a roughly 25% increase from baseline. Di Maggio, Kermani and Palmer (2020)

[14]Of course, the refinancing rate conditional on the in-the-money share could be correlated with other aggregate trends, such as the rise of non-banks, which may facilitate refinancing. Unfortunately, in the aggregate we cannot disentangle the rise of non-banks from the effect of the TCJA because we do not observe lender identifiers in our mortgage performance data. That said, our well-identified loan-level estimates suggest the TCJA did increase refinancing. In addition, refinancing conditional on the in-the-money share sharply increases in 2019, exactly when we see the effect of the TCJA appear in our data, whereas non-banks have been increasing steadily since the early 2010s.

[15]The elasticity of refinancing to mortgage rates is similar when we calculate the effect at other deduction bins: for in-the-money borrowers with deduction bins of 15, for a decline of 10 basis points in the interest subsidy, (equivalent to a 10 basis point rise in the refinance incentive), refinancing increases by 0.05 percentage points, a 10% increase from the baseline refinancing probability.

find that in response to a drop in mortgage rates of 40 basis points during QE1, refinancing increased by 56%. Our results suggest that if mortgage rates were to drop by 40 bps as they did during QE1, then refinancing would now increase by 70% rather than by 56%.

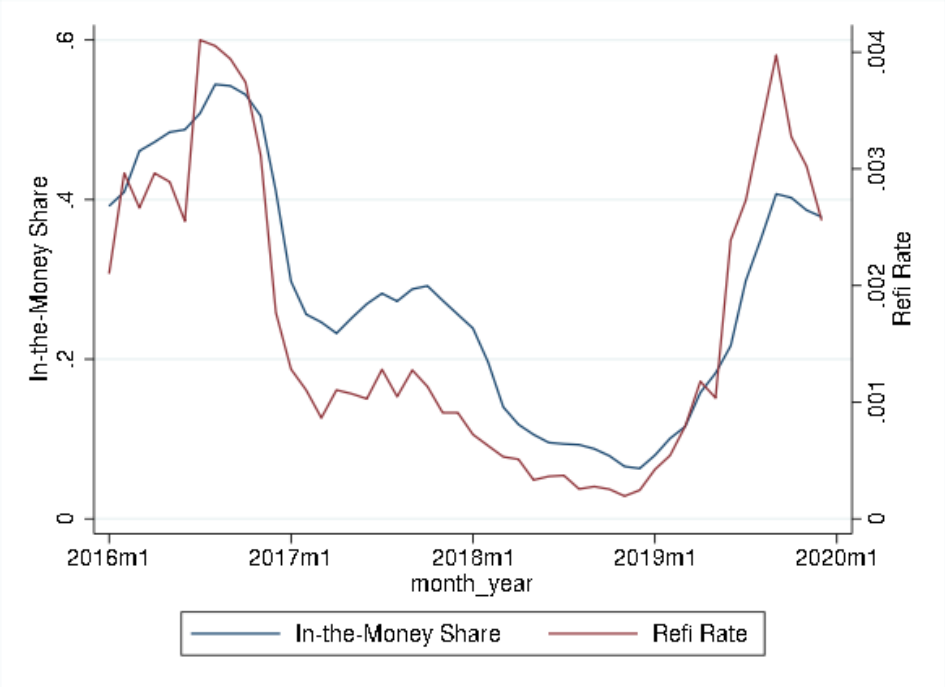


Figure 10. Change in Refinancing Probability and Share In-the-Money to Refinance over Time. This figure plots the mean refinancing probability and the share of borrowers in-the-money to refinance over time.

9 Results: Changes in Leverage

9.1 Debt Paydown

The TCJA increased the interest savings from paying down housing debt ahead of schedule for households who itemized before the tax law change. Households could advance their paydown schedule in several ways: making unscheduled principal payments ("curtailments"), paying down their balance when they refinance, or shortening their amortization term when they refinance. We test the impact of the TCJA on the first two paydown methods here, and leave the third for future work.

To estimate unscheduled principal payments, we construct a measure of "excess debt paydown" as the amount of principal paid down relative the scheduled principal payment based on the mortgage terms. Specifically, excess paydown is calculated as $\frac{P_A}{P_S}$ - 1, where P_A is the actual principal paid in a given month and P_S is the scheduled principal amount. This measure has a minimum value of -1 (indicating a missed payment) and a median value of 0. We winsorize at the 99th percentile to handle extreme positive values, but the qualitative results are robust to unwinsorized inputs and log transformations. Delinquent loans are excluded.

The left panel of Figure 11 shows average monthly excess paydown by deduction amount before and after the TCJA went into effect. In contrast with refinance behavior, where we see a large response to the change in tax incentives, we find no clear change in debt pay-down behavior following the TCJA. To formally capture the effect of the TCJA on debt pay-down, we estimate Equation 3 where the outcome variable is the excess paydown fraction. We plot the coefficients on $Post_t X DeductBin_i$ separately for in and out of the money borrowers in the right panel of Figure 11.[16] The regression yields results similar to the patterns suggested by the raw data: debt pay-down is little changed following the TCJA for both in and out of the money borrowers.

We next test whether the TCJA affected a different type of mortgage de-leveraging: the percent of the household's original mortgage balance that a borrower pays off during a rate-term refinance. Following the TCJA, households face a higher rate of return for paying down their mortgage debt, so if the loss of the MID in the TCJA incentivized de-leveraging, we may see an increase in the percent of equity that is cashed in when rate-term refinancing amongst borrowers with deduction amounts above the pre-TCJA itemization threshold.[17]

The left panel of Figure 12 plots the "cash-in" percent before and after the TCJA by deduction bin. A value of 10% implies that the household reduced their mortgage balance

[16]We restrict to loan-month observations with balances > $25,000 to eliminate cases where borrowers are near the end of their mortgage term and pay off in full.

[17]We define the cash-in amount accounting for the fact that borrowers may roll closing costs into their new loan.

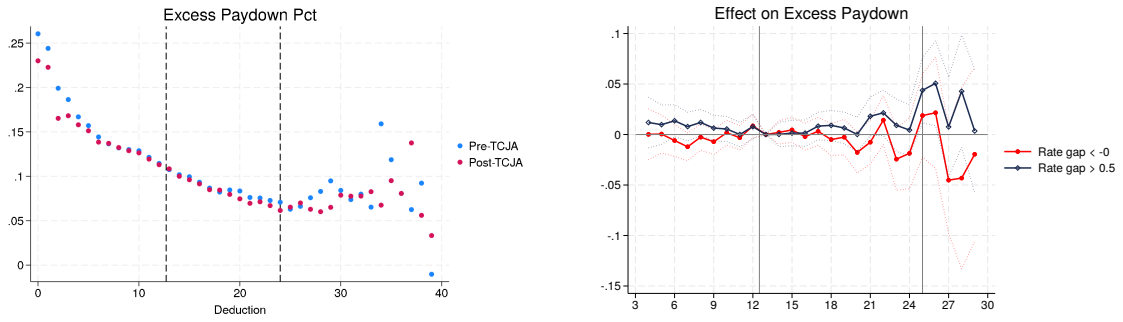


Figure 11. Excess Debt Paydown. The left panel plots excess debt paydown by deduction bin before and after the TCJA. The right panel plots the effect of the interest subsidy decline on excess debt paydown calculated from a specification allowing the effect of the interest subsidy decline to vary by deduction bin. Estimates were calculated by regressing the excess debt paydown percent on an interaction of a post-TCJA dummy, with a dummy for being in-the-money to refinance (rate gap between 0.5 and 1.5), with a categorical variable for deduction bin. The figure plots the triple interaction coefficient by deduction bin along with associated 95% confidence intervals.

by 10% while rate-term refinancing. There is no clear change in the cash-in percent following the TCJA.

To formally capture the effect of the TCJA on de-leveraging, we estimate Equation 3 where the outcome variable is the cash-in percent. We plot the coefficients on $Post_t X DeductBin_i$ separately for in and out of the money borrowers in the right panel of Figure 12. The regression yields results similar to the patterns suggested by the raw data: there is a clear zero effect of the TCJA on the cash-in percent. Similar to our results looking at excess debt paydown, we find no clear change in de-leveraging through the percent cashed-in during a rate-term refinance following the TCJA. We conclude that eliminating the MID did not cause existing mortgage borrowers to de-lever.

9.2 Cash-out Refinancing

Some literature suggests that being in-the-money to refinance induces cash-out refinances (e.g. Eichenbaum, Rebelo and Wong (2018)), because the interest savings from the rate-term refinance allows households to overcome the fixed costs associated with extracting equity. Although the TCJA made mortgage debt more expensive on the margin (especially equity extraction, which is no longer tax deductible), this literature implies that the net impact of

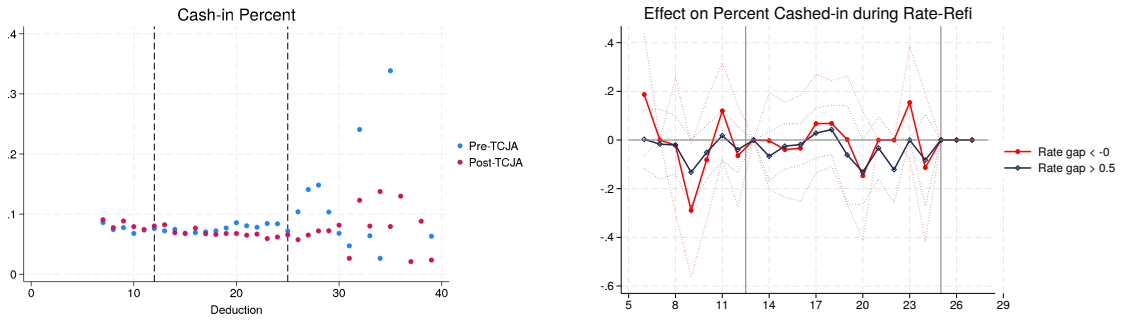


Figure 12. Cash-in Percent. The left panel plots the percent of the original mortgage cashed-in during a rate-term refinance by deduction bin before and after the TCJA. The right panel plots the effect of the interest subsidy decline on the cash-in percent calculated from a specification allowing the effect of the interest subsidy decline to vary by deduction bin. Estimates were calculated by regressing the cash-in percent on an interaction of a post-TCJA dummy, with a dummy for being in-the-money to refinance (rate gap between 0.5 and 1.5), with a categorical variable for deduction bin. The figure plots the triple interaction coefficient by deduction bin along with associated 95% confidence intervals.

the law change on equity extraction is ambiguous: more in-the-money borrowers may drive more cash-out refinancing, but eliminating the tax subsidy may lead to less extraction.

In addition to exploring broad patterns of leverage changes, we need to ensure that the increase in rate-term refinance we document in Section 6 is an increase in total refinancing, not substitution away from cash-out refinances toward rate-term refinances.

In this section, we evaluate whether the TCJA changed households' propensity to cash-out refinance and their extraction amount conditional on cash-out refinancing. First, we estimate the change in cash-out refinancing following the TCJA according to the intensity of subsidy decline. Specifically, we estimate Equation 3 where the outcome variable is the probability of cash-out refinancing. We calculate the coefficients on $Post_t x DeductBin_i$ as in Equation 3 separately for in and out of the money borrowers and plot these coefficients by deduction bin in the left panel of Figure 13. The figure shows a clear zero effect: households who lose the interest subsidy do not become less likely to do a cash-out refinance, regardless of whether they are in the money to refinance. This suggests the increase in rate-term refinancing we document in Section 6 following the TCJA is not due to substitution from cash-out refinances into rate-term refinances. This zero effect may reflect either no impact of the TCJA on cash-out refinancing, or the offsetting effects of increased rate-sensitivity

and a reduced interest subsidy. The former explanation is consistent with the findings of Anenberg, Scharlemann and Van Straelen (2023), who show that households' liquidity needs are sufficiently inelastic that equity extraction is relatively insensitive to price.

We next estimate the effect of the interest subsidy decline on the intensive margin of cash-out refinancing. We track changes in LTV rather than dollar extraction amounts because the loss of the mortgage subsidy may have affected house prices (Sommer and Sullivan, 2018).[18] Specifically, we estimate Equation 3 where the outcome variable is the percentage change in the borrower's LTV following a cash-out refinance. We calculate the coefficients on $Post_t x DeductBin_i$ as in Equation 3 separately for in and out of the money borrowers and plot these coefficients by deduction bin in the right panel of Figure 13. Similar to the extensive margin results for cash-out refinancing, there is a clear zero effect of the TCJA on the intensive margin of cash-out refinancing: households who see their interest subsidy decline do not reduce the amount they borrow through a cash-out refinance.

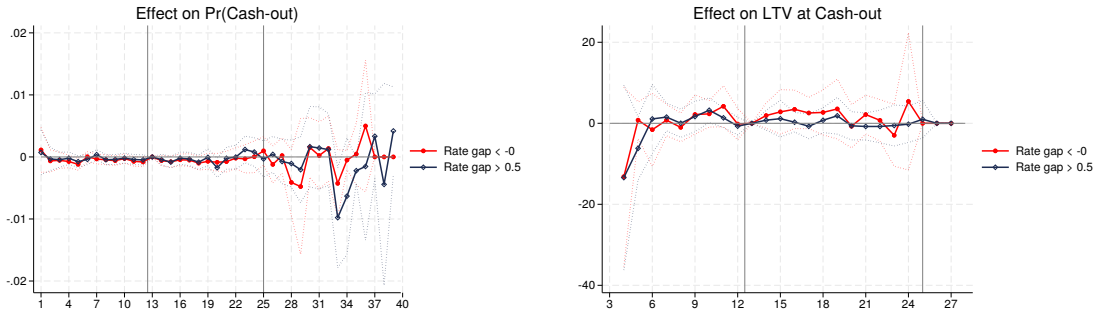


Figure 13. Cash-out refinancing. The left panel plots the effect of the interest subsidy decline on cash-out refinancing sensitivity calculated from a specification allowing the effect of the interest subsidy decline to vary by deduction bin. Estimates were calculated by regressing the probability of cash-out refinancing on an interaction of a post-TCJA dummy, with a dummy for being in-the-money to refinance (rate gap between 0.5 and 1.5), with a categorical variable for deduction bin. The figure plots the triple interaction coefficient by deduction bin along with associated 95% confidence intervals. The right panel plots the effect of the interest subsidy decline on the percent change in LTV when cash-out refinancing, calculated from a specification allowing the effect of the interest subsidy decline to vary by deduction bin. Estimates were calculated by regressing the percent change in LTV when cash-out refinancing on an interaction of a post-TCJA dummy, with a dummy for being in-the-money to refinance (rate gap between 0.5 and 1.5), with a categorical variable for deduction bin. The figure plots the triple interaction coefficient by deduction bin along with associated 95% confidence intervals.

[18]Changes in house prices could directly impact borrowing amounts separately from the subsidy change, though Li and Yu (2020) suggest that in practice, over our sample period, the effect on average LTVs is small. The results look similar we plot levels of equity extraction as well as LTV changes.

In this section, we tested for changes in leverage in response to the loss of the interest subsidy across several mechanisms: borrowers making greater than scheduled mortgage payments and balance changes at the time of refinancing. We find no evidence that existing homeowners responded to the loss of the subsidy by de-leveraging. This result suggests that the response of mortgage debt to the interest subsidy operates entirely through new homeowners taking on more debt at origination and by buying larger homes. The lack of a response amongst existing homeowners to the loss of the interest subsidy could be due to either salience, or to having insufficient cash on hand to de-lever when the interest subsidy disappears.

10 Consumption Responses

The MID reduces the interest savings that a borrower pockets following a refinance. When a borrower deducts mortgage interest, their interest benefit, $(r_0 - r_t)$, shrinks to $(1-t)*(r_0-r_t)$ on the portion of interest falling above the standard deduction when they refinance. The borrower who does not deduct mortgage interest realizes a larger interest savings upon refinancing, all else equal. As a result, the decline in the value of the MID due to the TCJA may have increased consumption not only by increasing the *probability* of refinancing, (which is associated with consumption), but also by increasing a borrower's *tendency to consume out of their interest savings*, post-refinance.

In this section, we test whether the loss of the interest subsidy increased spending out of refinance savings, conditional on refinancing. We do not observe data on spending, so we instead proxy for spending using the opening of an auto loan on a borrower's credit report, as is common in the literature (Beraja et al. (2019), Abel and Fuster (2021), Berger et al. (2021)). The top panel of figure 14 plots coefficients and confidence intervals from a specification in which we regress the probability of opening an auto loan on a series of dummies for time since a refinance. We interact a post-TCJA indicator with the months

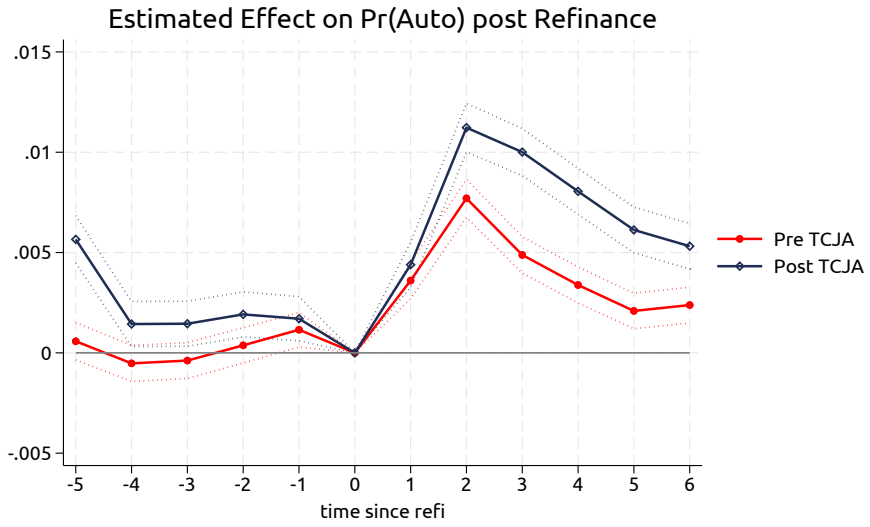
since refinancing dummies to test if the probability of buying a car post-refinance increases following the TCJA. We include controls for origination year, zip code, and loan type (e.g. purchase, refinance).

Summing up point estimates from the pre-TCJA period, the probability of buying a car increases by 2.5 percentage points in the 6 months following a refinance. This is a large effect. The annual average baseline probability of buying a car in the pre-TCJA period is 19.5%, so borrowers who refinance become 12.8% more likely to buy a car over the following six months. The magnitude of the effect is similar to effects found in the literature (Berger et al. (2021)). The probability of buying a car post-refinance increases following the TCJA, consistent with borrowers becoming more likely to spend out of their refinance savings. Panel (A) of Figure 14 shows coefficients from a regression of car-buying probability on month-from-refinance indicators interacted with a post-TCJA indicator. There is a clear increase in the probability of car-buying after the TCJA. However, the increase in car-buying probability post-TCJA is unrelated to the magnitude of the subsidy change. The bottom panel of figure 14 shows coefficients from a triple-difference regression of car-buying probability on month-from-refinance interacted with both a post-TCJA dummy and the absolute value of the subsidy change. The coefficient values are indistinguishable from zero both before and after the refinance.

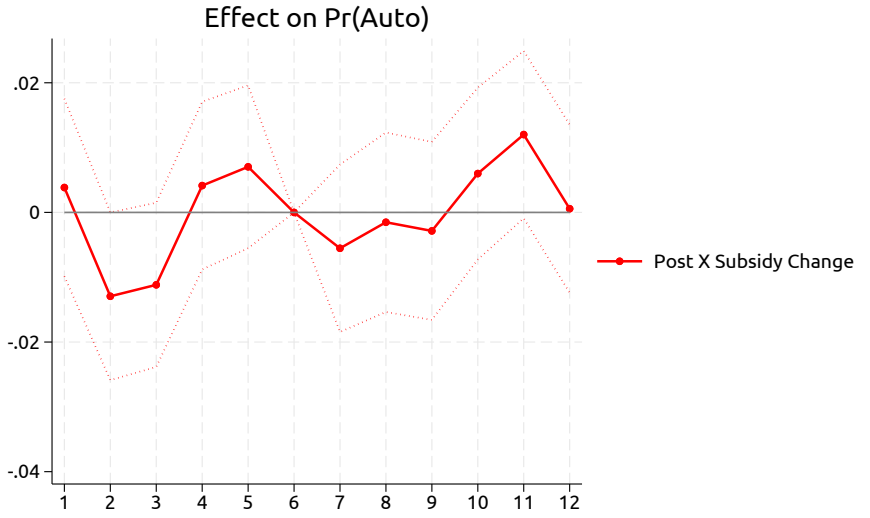
Compared with many studies evaluating the impact of refinancing on consumption, our experimental design faces unique timing challenges. The payment change borrowers observe at the time of refinance are unchanged by the TCJA, since changes in the MID are realized only at tax filing. Most refinances are inframarginal to this law (i.e. they would have happened anyway). It's unclear how attentive inframarginal borrowers are to the law change, or how well marginal borrowers understand the precise change in their post-tax disposable income after refinancing, and so it perhaps unsurprising that this effect is small. Additionally, changes in interest savings due to the loss of the MID are small relative to the car purchase decision. The households most affected by the loss of the interest subsidy had high

deductions, which are associated with higher incomes. High-income households may be less likely to purchase cars with car loans.

To sum up these results, we find that consumption out of refinance savings is unchanged by the law. In aggregate, consumption out of refinance savings increased post-TCJA, (Panel A of Figure 14), but consumption out of refinance savings did not *differentially* increase with the loss of the interest subsidy, (Panel B of Figure 14), implying the TCJA did not affect the tendency to consume out of refinance savings. This means that the primary channel through which the TCJA affected the pass-through of monetary policy is by increasing the quantity of refinances.



(a) Probability of new auto loan after refinancing, before and after TCJA



(b) Change in probability of refinancing by subsidy loss

Figure 14. Response of Auto Purchase to Refinancing. The top figure plots coefficients and confidence intervals from a specification regressing the probability of opening an auto loan on a series of dummies corresponding to months since a refinance. The coefficients are estimated separately before and after the TCJA was passed. The bottom figure plots the coefficients from a difference-in-difference, comparing the probability of new auto loan issuance before and after the TCJA passed by exposure to the law change (the absolute change in subsidy).

11 Conclusion

This paper studies how the mortgage interest deduction affects refinancing and debt pay-down. The MID allows households to deduct their mortgage interest from their taxes and

so the benefit to refinancing and debt paydown is discounted by the tax rate. We study how this tax benefit affects household refinancing and borrowing behavior.

We use the TCJA as a natural experiment to study the effect of the MID. The TCJA of 2018 changed the incentives to itemize, causing many households to stop deducting mortgage interest. We find that in response to the loss of the MID, households became 25% more likely to refinance in response to drops in the mortgage rate. For the most affected borrowers, we find that a decline of 20 basis points in the interest subsidy increases refinancing by 25% when in-the-money. We also show that the difference in refinancing rates between those who lost the subsidy and those who never had the subsidy appeared only following the TCJA and not before. The effect is largest for borrowers most affected by the loss of the subsidy and cannot be explained by other factors that drive refinancing, like pre-tax refinance savings. Finally, we find the effect of the TCJA is strongest for borrowers most attentive to their refinance incentive.

We may overstate the long-run sensitivity of households to their after-tax mortgage rate. The TCJA suddenly brought a number of borrowers into the money who were not in the money to refinance before the law-change; some catch-up refinancing may therefore both be expected and impossible for us to measure.

We also present evidence that strongly suggests the law change had no effect on borrowers' propensity to pay down their existing mortgage debt. This suggests both that the consumption effects of the law change are not offset by increased debt paydown, and also that the law change had little effect on loan-to-value ratios of existing homeowners, an important financial stability consideration.

Our work suggests that the MID has important interactions with the pass-through of monetary policy.

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Internet Appendix for:

"More Tax, Less Refi? The Mortgage Interest Deduction and Monetary Policy Pass-Through"

Tess Scharlemann and Eileen van Straelen

September 11, 2024

A Mortgage rate over time

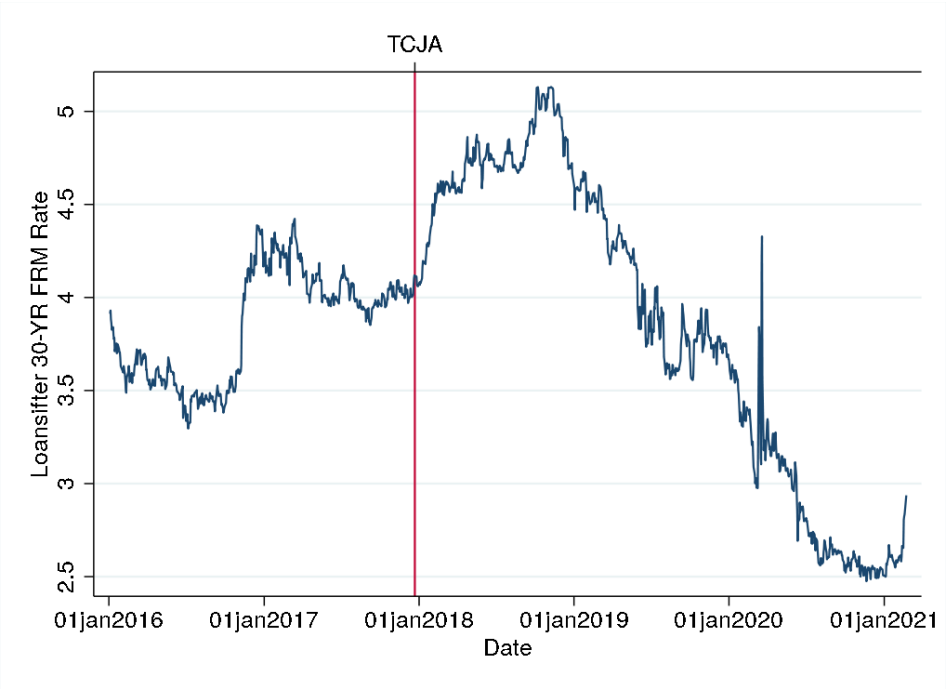

Figure A.1. Mortgage rates following the TCJA. This figure shows the 30-year fixed rate mortgage rate over time. The red line indicates the time period when the TCJA came into effect, in January 2018.

B Refinance probability conditional on rate gap

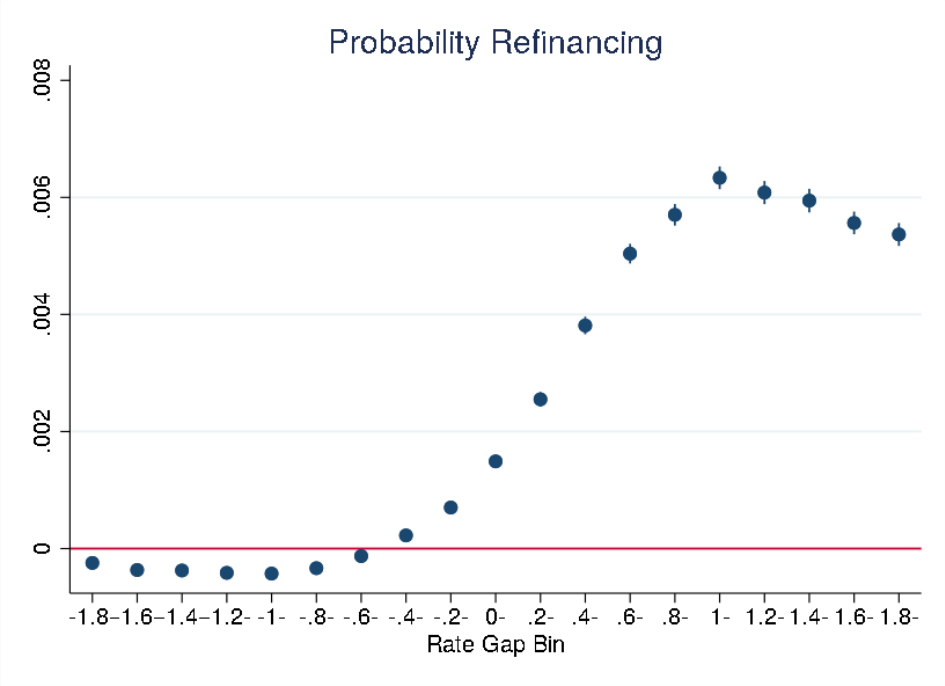

Figure A.2. Refinancing probability by rate gap. This figure plots the probability of refinancing by 20 basis point bins of borrower rate gap. Rate gap defined as the difference between the borrower's current mortgage rate and the rate they are predicted to receive if they were to refinance. A household's predicted mortgage rate is estimated from a regression of mortgage rates on borrower and loan characteristics from Optimal Blue.

C Validate itemizing status using IRS SOI statistics

To validate that we correctly assign itemizing status to borrowers, we compare our measure of itemizing, aggregated to the zipcode level, against zipcode statistics on itemizing shares from the IRS SOI statistics in Figure A.3. In this analysis we restrict to zipcodes with at least 530 personal property tax returns because mis-classifying just a small number of households witin a low population zipcode could generate large swings in the match rate within the zipcode.

Figure A.3 shows that in both 2017 and 2018, the two years of our sample for which we have IRS SOI data, there is a tight correlation between the itemizing share in a zipcode in the IRS SOI statistics and the itemizing share in a zipcode based on our calculations from the HMDA-CRISM dataset, indicating we have correctly identified itemizing status amongst borrowers. There are far fewer zipcodes with large itemizing shares in 2018 than in 2017, reflecting the overall decline in the itemizing share following the passage of the TCJA as seen in Figure 1, and consistent with the TCJA reducing the attractiveness of itemizing.

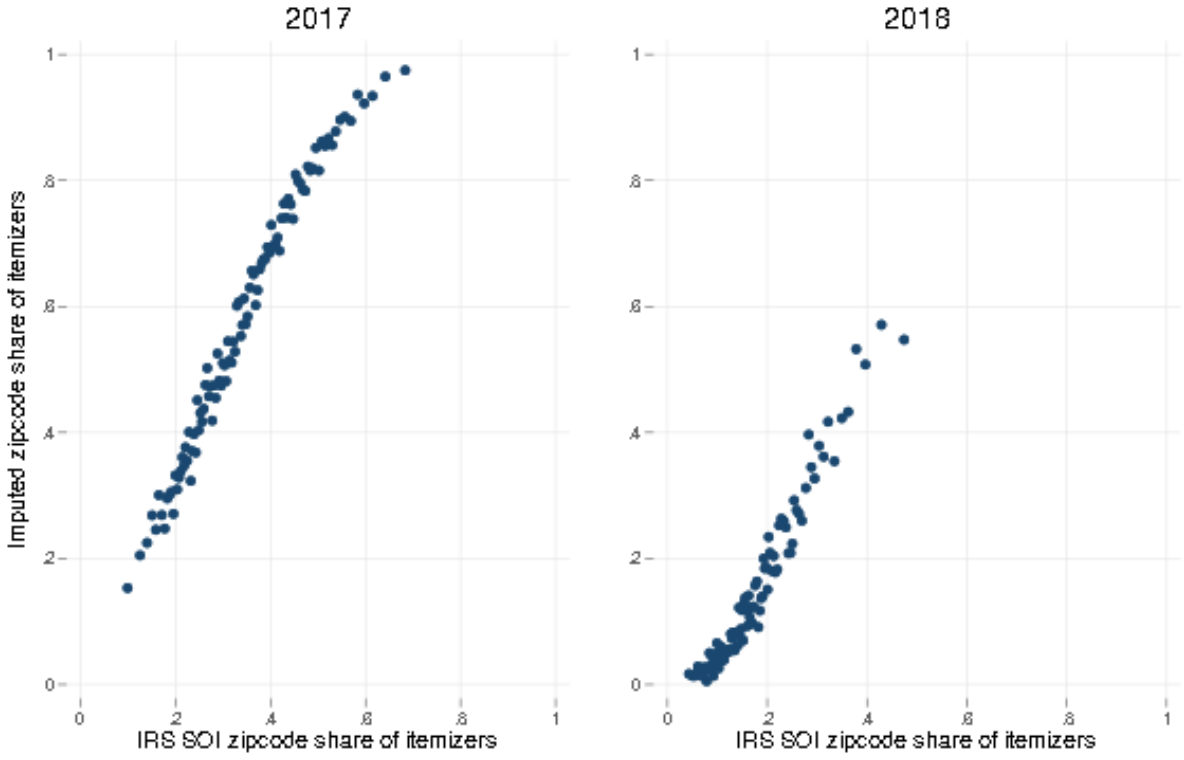

Figure A.3. Correlation between the IRS zipcode share of itemizers and the imputed HMDA-CRISM-Taxsim zipcode share of itemizers. This figure plots binscatters of the zipcode share of itemizers from the IRS SOI statistics against the zipcode share of itemizers calculated using HMDA, CRISM, and Taxsim as described in Section 3.1.1 separately for 2017 and 2018. The unit of observation in the plots is the zipcode-year. Zipcodes with fewer than 530 personal property tax returns have been removed from the sample.

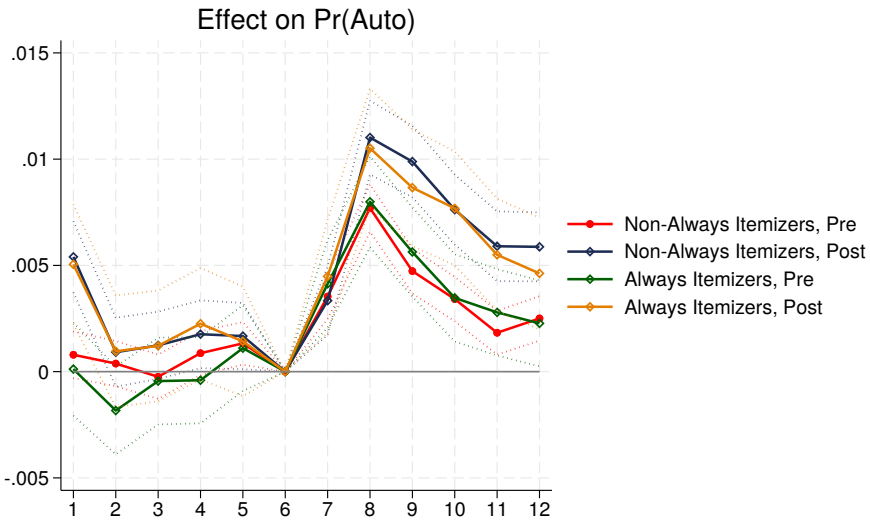

Figure A.4. Response of Auto Purchase to Refinancing. This figure plots coefficients and confidence intervals from a specification regressing the probability of opening an auto loan on a series of dummies corresponding to months since a refinance, interacted with a post-TCJA indicator and an "Always Itemizer" indicator.