The Effect of Advertising on Household Mortgage Decisions*

Vikram Jambulapati† Jack Liebersohn‡

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Abstract

Using discontinuities in local television market borders, we study how mortgage advertising affects whether households refinance and which lender they choose. A one-cent-per-resident increase in total advertising generates 0.68 additional refinances per 10,000 eligible properties over the subsequent three months, with larger responses among households with more to gain from refinancing. The same increase in a lender's advertising leads to 0.18 additional mortgages for that lender; competing lenders receive another 0.50 mortgages, or 73 percent of the total increase. We interpret the estimates through a discrete choice model to quantify the effects for households. Each advertising dollar generates about $1.08 in revenue for the advertiser, largely through borrower substitution from competitors, and $1.84 in mortgage value for borrowers under our benchmark assumptions. The wedge between household and advertiser benefits reduces lenders' incentive to supply advertising that informs households about valuable refinancing opportunities, and to supply it in the times and places where it is most valuable.

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†UC San Diego.
‡UC Irvine.

1 Introduction

Many households leave money on the table by failing to refinance their mortgage, refinancing too late, or shopping too little for the best rate. Delaying refinancing and shopping too little cost households billions of dollars per year.[1] The prevalence of this behavior has led to proposals for information interventions or changes in mortgage design intended to help households refinance more effectively. Pre-approved offers, reminders, and simplified communications can increase refinancing, although even attractive offers often receive a weak response (Johnson, Meier, and Toubia, 2019; Byrne et al., 2023). While policy intervention may indeed help, lenders already have a strong private incentive to inform households about refinancing opportunities, by advertising their own mortgages. Indeed, in 2021, U.S. financial firms spent approximately $17 billion on advertising, including $1.3 billion on mortgages (WARC, 2021).[2] At the same time, financial advertising draws regular scrutiny from regulators concerned that advertisements could mislead borrowers, a concern that is made pressing precisely because borrowers are prone to mistakes.

How might advertisements affect household mortgage choices? On the one hand, mortgage advertisements could provide households with valuable information about refinancing opportunities. On the other hand, they could steer households toward lenders with high rates, or encourage them to refinance too early. The net effect of advertising depends on two things: how lenders that advertise are different from lenders that do not (e.g., whether their rates are higher or lower), and how borrowers respond to the advertisements. For example, if high-rate lenders advertise more but households do not respond to them, then in practice only low-rate lenders' advertisements would matter. Alternatively, if advertisements are especially effective when households have good refinancing opportunities, then advertising may be particularly helpful for borrowers. Conceptually, we think of advertising as having two channels. It can bring in households who would not otherwise have refinanced (which we call the *direct channel*), and it can shift households toward the advertiser and away from its competitors (which we call the *lender channel*). The overall effects depends on both

1. Using data from 2010, Keys, Pope, and Pope (2016) estimate $5.4 billion in present-discounted forgone savings from failing to refinance; using average FHA originations over 2015–2019, Bhutta, Fuster, and Hizmo (2026) estimate $2.75 billion per year in potential savings from eliminating average overpayment among FHA borrowers.

2. Appendix Figure 7 reports measured television advertising spending by industry.

channels and how they interact.

Our strategy to quantify these channels uses discontinuities in local television advertising at Designated Market Area (DMA) borders, where nearby ZIP codes receive different local advertisements. Monthly deeds data identify the effect on total refinancing, while annual Home Mortgage Disclosure Act (HMDA) data identify the effect on lender choice. We combine the two reduced-form estimates in a nested logit model to value advertising for borrowers and advertisers. Our main finding is that advertising creates substantially more value for borrowers than it returns to the lenders that pay for it, because most of the refinancing an advertisement generates is completed with a competitor.

Our first finding is that advertising expands the refinancing market. Using deeds data from 2007 through 2021, we find that a \$0.01-per-resident increase in local television advertising causes 0.68 additional refinances per 10,000 eligible properties within three months and 0.82 within six months. The estimates come from local projections that trace how refinancing evolves in ZIP codes near the border after advertising rises on one side. The response begins in the first month after advertising rises. The twelve-month estimate remains positive, although it is less precise.

Our second finding is that advertising by a particular lender leads to 0.18 additional mortgages for that lender per 10,000 eligible properties. This gain combines market expansion and business stealing. Putting the two designs in common units, other lenders gain another 0.50 mortgages. Thus, 73 percent of the total increase in refinancing goes to lenders other than the one that paid for the advertisement.

We estimate lender choice at two margins. Across DMA borders, an additional cent of advertising per resident raises the advertiser's share of local refinances by 0.124 percentage points. Within an established lender–ZIP relationship, the estimate is 0.058 percentage points.[3] Advertising has the largest effect on lender choice when it introduces current local television exposure and remains effective, though less so, for an established lender.

Balance, pre-trend, and purchase-mortgage placebo tests support the design, and the estimates are robust to alternative controls and geographic specifications.

Households with more to gain from refinancing respond more to advertisements: the

3. Table 4 reports 0.129 percentage points for the full 2007–2021 sample. The 0.124 estimate uses the narrower common sample used by the demand model and value calculation.

estimated three-month effect is 0.30 refinances per 10,000 properties when the rate gap is below 50 basis points and 0.66 when it is at least 50 basis points. Banks' and credit unions' advertisements shift lender choice more than independent mortgage companies' advertisements, and the refinancing response is larger in ZIP codes with a higher share of nonwhite borrowers. Advertising was not concentrated in the months when refinancing opportunities were best. The response gradient and the placement of advertising therefore move borrower value in opposite directions.

To jointly consider both channels, we match a nested logit demand model to the reduced-form estimates. A household first decides whether to refinance and then chooses among lenders. Advertising can enter the refinancing decision directly or make the advertiser more attractive, which can also draw a household into refinancing.[4] In the benchmark, the direct channel accounts for 0.55 of the 0.68 additional refinances and the lender channel for 0.13.

Some refinancing induced by advertising would otherwise have occurred later. To value this acceleration, we use the attention rate estimated by Berger et al. (2025): households reconsider their mortgage once every 4.3 years on average and refinance when the available rate makes doing so worthwhile. Under this benchmark, 46.5 percent of induced households would have refinanced within five years without the advertisement. Advertising is most valuable when it preserves a worthwhile opportunity that would otherwise be delayed or missed.

The average household induced to refinance has 97.1 basis points of available rate savings. Putting the pieces together, a dollar of mortgage advertising generates \$1.84 of mortgage value for borrowers, with a 90 percent confidence interval of [\$0.79, \$3.08] using bootstrapped standard errors. Nearly all of that value comes from households refinancing who otherwise would not have, and almost none from households ending up at a different lender, because the advertiser's rates and fees are on average close to those of the lender the household would otherwise have used. Two features of the data pull the total in opposite directions. Because households with more to gain are more likely to respond, advertising reaches the mortgages where refinancing is most valuable, which adds \$0.64 to the effect. Because advertising was not concentrated in the market-months with the largest available savings, its actual timing

4. We calibrate the substitution parameter to 0.75, close to the retail banking estimate in Dick (2008), and report values from 0.25 to 1. Across that range, the lender channel accounts for at most roughly a quarter of market expansion.

subtracts $0.49. The estimate is somewhat sensitive to how often households would have refinanced on their own: it falls to $1.44 if attention arrives every three years and rises to $2.48 if it arrives every 8.5 years.

Advertisers capture much less. Ten thousand dollars of advertising produces 0.98 additional originations for the paying lender, or about $10,187 per additional loan. Valued at the Mortgage Bankers Association's 2021 industry-wide production revenue, this equals $1.08 of gross revenue per advertising dollar. Because roughly three-quarters of induced refinances go to another lender, the advertiser captures only part of the value it creates.

The paper contributes to three literatures. First, it adds to work on mistakes and limited search in household finance (Gomes, Haliassos, and Ramadorai, 2021; Keys, Pope, and Pope, 2016; Johnson, Meier, and Toubia, 2019; Bhutta, Fuster, and Hizmo, 2026). Previous research has shown that households fail to refinance and pay more than they need to. Our contribution is to ask whether advertising by lenders corrects those mistakes or compounds them, and how it does so. The closest paper in the mortgage setting is Grundl and Kim (2019), who show that direct-mail advertising is both aimed at and more effective on borrowers with valuable refinancing opportunities. We add a causal estimate of how much advertising expands the market as a whole, a separate estimate of the lender-choice response, and a valuation of the net effects for households and for advertisers.

Second, the paper contributes to work on advertising, market expansion, and spillovers. Gurun, Matvos, and Seru (2016) study mortgage advertising during the subprime boom, and we differ from them in three ways: we study the post-2007 market, we use local television rather than lender promotions more broadly, and we estimate the consumer response directly instead of inferring it from the cross-sectional relationship between a lender's advertising and its mortgage terms. More generally, Shapiro (2018) shows that an advertisement can benefit competing products and thereby create a free-riding problem. We find evidence for the same force in the mortgage market.

Third, we relate the reduced-form effects of advertising to the present value calculation for households. Four estimates are central for the calculation: how many households are brought into refinancing, which lender they use, how much those particular households had to gain, and how soon they would have refinanced anyway. Each of these estimates is important for the overall calculation. An advertisement that generates many refinances is

worth little if it moves them forward by only a month, for example, and an advertisement that mainly reshuffles borrowers across lenders may be worth little to households even when each individual advertiser gains a great deal.

The remainder of the paper proceeds as follows. Section 2 describes the mortgage setting, local television markets, and data. Section 3 presents the two border designs. Section 4 reports the reduced-form results. Section 5 puts the estimates into a demand system. Section 6 calculates borrower value and advertiser returns. Section 7 concludes.

2 Setting and Data

2.1 Refinancing mistakes and the role of advertising

The option to refinance is a valuable part of the conventional fixed-rate mortgage that is standard in the United States. However, refinancing is expensive and sometimes impossible. For several reasons, households that do not refinance are not necessarily making a mistake. High closing costs make refinancing a bad deal for mortgages with a small remaining balance, and households with low income or whose home values have fallen may not be able to refinance their mortgage at all. For these reasons, the literature has had to distinguish carefully between a failure to refinance because it is not feasible and a failure that comes from a financial mistake.

The best evidence comes from studies that account for the different reasons a household might fail to refinance. Keys, Pope, and Pope (2016) show that even among unconstrained households, many do not refinance when it would be highly beneficial. Johnson, Meier, and Toubia (2019) send pre-approved offers that remove both the direct financial costs and the psychological and search costs of refinancing. They find that many households still do not take them up, and argue that this is explained by household suspicion of banks' motives.

Berger et al. (2025) model the failure to refinance as rational inattention, in which households pay attention to the mortgage market at random intervals. We use their estimated attention rate to help calibrate our counterfactuals for what households would have done if they had not seen an advertisement. They show that lack of attention reduces household wealth and weakens monetary policy pass-through. Our findings show how an information

nudge coming from the private sector can undo part of that effect.

Even conditional on deciding to refinance, households do not always make the optimal choice. Rates on observationally similar loans vary substantially across lenders, and households with less mortgage knowledge or who do fewer comparisons tend to pay more for their mortgage (Bhutta, Fuster, and Hizmo, 2026). The two types of informational friction identified by the literature map into the two margins we study here: first, a failure to refinance at the right time or at all; and second, a failure to identify the lenders that offer the best available rate.

These two margins do not map neatly into the traditional distinction between informative and persuasive advertising, since either information or persuasion could affect refinancing or lender choice.

Simplified offers, reminders, and other communications can draw attention to refinancing; in a field experiment, Byrne et al. (2023) find that reminders substantially increase both attention and refinancing. Lenders already have a private incentive to supply such nudges because they earn origination revenue and servicing fees, but they maximize lender revenue rather than household savings. Under-refinancing is therefore both a household-side problem and a private opportunity for lenders.

Lenders may therefore steer borrowers toward themselves, toward higher-rate loans, or toward refinancing at the wrong time. Gurun, Matvos, and Seru (2016) find that during the 2002–2007 mortgage boom, heavier advertisers originated more expensive mortgages and that the pattern was strongest among less informed borrowers. We estimate how borrowers respond to advertisements and the resulting mortgage savings.

Mortgage advertising is regulated in both the United States and Europe. Regulators are understandably concerned that households do not understand financial products well and are easily misled, and that the stakes are higher than for most ordinary products. In the United States, Regulation Z requires specified disclosures when an advertisement states credit terms and prohibits a list of misleading claims (Consumer Financial Protection Bureau, 2026). The European Mortgage Credit Directive likewise requires mortgage marketing to be fair, clear, and not misleading, and imposes standardized information requirements when an advertisement quotes rates or other costs (European Parliament and Council of the European Union, 2014). Our findings inform these policies by asking how households respond to television

advertisements in practice, and how this varies with the type of advertiser, household, and product.

2.2 Local television markets and DMA borders

A Designated Market Area, or DMA, is a geographic region used to define a local television market in the United States. Nielsen assigns every county to one of 210 mutually exclusive DMAs, based largely on television viewing patterns. DMAs often cross state lines but generally follow county boundaries. Appendix Figure 8 shows the national map.

The structure of television distribution creates sharp changes in local advertising exposure. Commercial broadcast networks reach viewers through local affiliates, such as a local NBC or CBS station. The Federal Communications Commission's cable and satellite carriage rules define a station's local market using Nielsen DMA assignments (Federal Communications Commission, 2022). A household on one side of a DMA border can therefore receive a different local affiliate, and a different set of local advertisements, than a nearby household on the other side.

The border leaves borrowing markets, bank branches, and other advertising channels unchanged; its narrow effect is to change the local television station and advertisements delivered to cable households. This institutional feature has been used to study television advertising in several product markets (Shapiro, 2018, 2022; Hitsch, Shapiro, and Tuchman, 2021; Sinkinson and Starc, 2019). In our application, the treatment difference is local mortgage advertising per resident.

2.3 Data

We combine three data sources: television advertising from Kantar Media, recorded deeds and mortgages, and HMDA. We measure total refinancing from the monthly deeds data and lender choice from the annual HMDA data.

Advertising. Our advertising measure comes from Kantar Media's Ad$pender data. We aggregate local advertising expenditures to the advertiser-DMA-month level and divide by DMA population, so that exposure is measured in advertising dollars per resident. The

monthly total-refinancing analysis runs from January 2007 through December 2021, a window set by stable national ZTRAX coverage; the annual lender-choice analysis uses Kantar and HMDA records from 2000 through 2021.

After deduplication, the 2007–2021 data contain $918.6 million of local mortgage advertising across 202 media markets; the deeds data cover 194 of those markets and 94.4 percent of the spending. The causal strategy uses local advertisements because they change discontinuously at DMA borders. National advertisements reach both sides of a border and are excluded from the exposure measure, although we aggregate advertising across markets for the counterfactuals.

Matching advertisers to lenders. Linking advertisers to lenders requires a crosswalk, because the advertising data identify brands and parent companies while HMDA identifies legal lending entities. Most links are unambiguous based on names alone; when a name is ambiguous, for example "First Bank," we use the geography of the local advertisements to match the advertiser to the relevant local institution. We link 61.9 percent of 2007–2021 local advertising spending to a lender.[5] The lender-choice analysis uses matched advertisements, while all local mortgage advertising enters the deeds analysis and aggregate counterfactuals.

Deeds and mortgage histories. To measure total refinancing we build monthly property-level mortgage histories from ZTRAX, a national collection of recorded property deeds and mortgages. We classify a recorded mortgage of at least $10,000 as a qualifying refinance when no deed is recorded on the same property within 30 days, which is what distinguishes a refinance from a mortgage taken out to finance a purchase, and when the loan is not classified as construction, commercial, FHA, or reverse. We drop duplicate property-date-lender-amount records.

We organize each property's history into "spells." A spell begins when a mortgage is recorded on the property and ends at the next recorded purchase or qualifying refinance, which in turn begins a new spell; if neither occurs, the spell remains open through the end of the sample. At each exposure month, the eligible stock consists of properties in an open spell: those with a recorded mortgage and no qualifying refinance yet within that spell. A

5. Appendix Table 10 describes the matched and unmatched advertisements.

single property can therefore contribute more than one refinancing over the sample period.

For monthly estimates of total refinancing, the outcome is whether a refinance occurs in a particular month. For cumulative estimates, the outcome is whether it occurs at least once during the next three, six, or twelve months. That way, repeated refinancing on the same property within the time window is not counted twice. Advertising exposure ends in December 2021, and deeds through December 2022 provide complete twelve-month follow-up.

ZTRAX is well suited to measuring total refinancing but does not reliably identify the lender or mortgage rate on every record. HMDA directly measures the near-universe of reported mortgage refinancing, so we use it to validate the constructed ZTRAX measure. Appendix Figure 9 and Table 11 compare the two datasets. Over 2007–2021 the correlation between national annual counts is 0.964, and qualifying ZTRAX events exceed HMDA refinance originations by about 10 percent. The county-year correlation is 0.966, and across common ZIP-years the within-year log correlation is 0.858. The gap in levels comes from differences in reporting coverage and in how the two sources classify a refinancing event.

HMDA. The Home Mortgage Disclosure Act requires covered financial institutions to report loan applications and originations. The data include loan purpose, loan amount, occupancy, property location, lender identity, and borrower demographics. We use annual loan-level records from 2000 through 2021 and retain refinance applications and originations.

We focus on refinancing because HMDA identifies the location of the mortgaged property but not where a purchaser lived before buying a house. For a refinance, the relevant property location is where the household was living when the advertising aired, which is also the location that they originate their mortgage. For each ZIP-year, we calculate the share of refinance originations made by each matched advertising lender. The remaining originations form an all-other-lenders alternative.

Our main lender-choice sample contains, for each border and year, the lenders we are able to match between the advertising data and HMDA. We also construct a larger active-lender sample that includes every lender and ZIP codes in every DMA where the lender *ever* airs an advertisement on one side of the border or the other. The larger sample is what makes specifications with lender-by-ZIP fixed effects usable: it lets us follow the same lender in the same place as its advertising changes, rather than comparing only the places in which the

lender chose to advertise on one side in that year.

Rates and fees. Because advertisement-specific quoted terms are unavailable, we measure average rates and fees on loans originated by each lender. Beginning in 2019, HMDA reports interest rates and detailed loan-cost fields for covered originations. For each year, we regress the reported interest rate on log property value, log borrower income, log loan amount, combined loan-to-value ratio, and debt-to-income ratio, with lender fixed effects; the estimated lender component is the standardized rate term relative to that year's average rate. Fee terms are the 2021 lender-level mean of total loan costs divided by loan amount. Appendix A.2 provides additional construction details.

Lender terms can be attached to 57.2 percent of local advertising spending after requiring a lender match and non-missing rate and fee inputs. For advertisements without usable lender terms, the benchmark valuation uses the national mortgage rate from Freddie Mac's Primary Mortgage Market Survey (Freddie Mac, 2026). Estimates are similar when dropping mortgages without rates from the sample.

Geography and other covariates. We assign each ZIP code to the DMA containing the largest share of its area, including the small number of ZIP codes that straddle a border, and we calculate the shortest distance from its 2010 ZIP Code Tabulation Area boundary to the nearest adjacent DMA boundary. The lender-choice panel stacks lender-border-year tuples to estimate a stacked specification. As described in Section 3.3, we double-cluster standard errors by ZIP code and lender-border-year.

We supplement the mortgage and advertising data with demographic and economic variables from the American Community Survey, Internal Revenue Service ZIP-code files, and ZIP-level employment data. We use these variables for balance tests and to define the predetermined local characteristics in the heterogeneity analysis.

2.4 Samples and descriptive patterns

Table 1 reports distributions of the main outcomes and advertising measures. Appendix Table 9 describes the coverage of the two estimation samples.

Appendix Figure 10 plots the low-frequency comovement of mortgage advertising and

originations. Section 4.4 examines whether advertising is concentrated in high-opportunity months or among lenders offering lower rates; Table 6 states the comparison samples and weights.

3 Empirical Strategy

3.1 Overview

Lenders advertise the most in the regions where they do the most lending. While this association might reflect the causal impact of advertising, it could also result from the location of bank branches or preexisting customers. A naive comparison of high- and low-advertising regions risks conflating these reasons.

Following earlier DMA-border designs (Shapiro, 2018, 2022; Hitsch, Shapiro, and Tuchman, 2021; Sinkinson and Starc, 2019), we compare nearby ZIP codes on opposite sides of a boundary. Mortgage data at the ZIP level let us use a narrow border neighborhood and compare the border-pair estimator with local-linear geographic specifications based on distance to the boundary.

Figure 1 shows how mortgage lending and advertising boundaries look in practice. Both lenders illustrated in the figure, Forum Credit Union and Eastman Credit Union, lend and advertise most heavily near their bases of operation. But within the area where they originate mortgages, the DMA border creates a sharp discontinuity in exposure to advertisements. Pooling such discontinuities across borders, lenders, and years lets us precisely estimate even small treatment effects that would be difficult to detect at any one boundary.

The same variation identifies two outcomes. Monthly deeds data support local projections of total refinancing after an advertising change. Annual HMDA data support a stacked lender–border–year design for lender choice conditional on refinancing.

Both designs keep ZIP codes within ten miles of the boundary. Sections 4.2 and 4.3 summarize the bandwidth and spatial-control results; Appendix Tables 12 and 15 report the full estimates.

3.2 Total refinancing: stacked border-side local projections

For each border, we label the two adjacent DMAs using a fixed rule and retain that orientation in every month. Let A_{dt} be local mortgage television advertising per resident in DMA d and month t. Let y_{dbt} be first qualifying refinances per 10,000 eligible properties among the ZIP codes in DMA d that lie within ten miles of border b. We keep the two border sides as separate observations and estimate every displayed horizon jointly in one stacked regression:

$$y_{db,t+h} = \alpha_{dbh} + \lambda_{bth} + \beta_h A_{dt} + \sum_{\ell=1}^{3} \rho_{h\ell} A_{d,t-\ell} + \sum_{\ell=1}^{3} \phi_{h\ell} y_{db,t-\ell} + \varepsilon_{dbth}, \qquad h \in \mathcal{H}. \tag{1}$$

The fixed effects α_{dbh} are border-pair-by-fixed-side effects specific to horizon h; they absorb persistent differences between the two sides. The effects λ_{bth} compare the sides within the same border pair and exposure month, again separately by horizon. Thus the coefficients are numerically equivalent to those from forming cross-border differences, but the regression is estimated in levels and retains the underlying DMA observations. Following standard local projection methodology, β_h is the response to current advertising conditional on past advertising and past refinancing.

We report the effect of an additional \$0.01 of advertising per DMA resident. Each border-side observation is weighted by its eligible-property stock, the natural denominator of the corresponding refinancing rate, so larger risk sets receive proportionally more weight. We two-way cluster standard errors by constituent DMA and calendar month, allowing dependence across all borders containing the same DMA and across all observations sharing an exposure month.

Figure 3 reports monthly coefficients. Months -3 through -1 enter equation (1) as outcome-history controls and are not plotted as separate coefficients. We estimate placebo coefficients for months -6 through -4 using the same controls. This gives a direct test of whether refinancing starts moving before the advertising innovation.

Our main results measure how much additional refinancing occurs over the several months following an increase in advertising. For $H \in \{3, 6, 12\}$, let E_{dbt} be the number of properties in DMA d near border b that are eligible in month t, and let R^H_{dbt} be the number of those

properties that record at least one qualifying refinance in months $t+1$ through $t+H$. Define

$$Y_{dbt}^{H} = 10{,}000 \times \frac{R_{dbt}^{H}}{E_{dbt}}. \tag{2}$$

A property enters R_{dbt}^{H} at most once, however many times it refinances inside the window. We estimate the three cumulative horizons jointly in one stacked ZIP-level regression. It uses the same horizon-specific controls and fixed effects as equation (1), but retains the ZIP-month observations and weights each by its eligible-property stock. As an alternative, we also add up the monthly flow coefficients β_1 through β_H, computing the standard error of that sum from the full covariance matrix of the single stacked monthly regression.

The baseline aggregates refinancing within ten miles of each border. Appendix B.1 reports ZIP-level robustness specifications with no distance slopes, pooled fixed-side slopes, and persistent border-pair side slopes.

3.3 Lender choice: a stacked fuzzy border RDD

The lender-choice analysis uses annual data because HMDA does not report origination month. The unit of observation is a lender–border–ZIP–year cell. The outcome is the lender's share of refinance originations in the ZIP and year. For lender j, border b, and year t, we compare the lender's annual local television advertising per resident in the two adjacent DMAs.

For assignments with unequal advertising, let D_{ijbt} indicate that ZIP i is on the higher-advertising side. Let r_{ijbt} be distance signed toward that side. For equal-advertising assignments in the larger panel, $D_{ijbt} = 0$ and r_{ijbt} uses a fixed geographic orientation. Define $r_{ijbt}^{-} = r_{ijbt}1\{r_{ijbt} < 0\}$ and $r_{ijbt}^{+} = r_{ijbt}1\{r_{ijbt} > 0\}$. Let A_{ijbt} be lender j's annual advertising per resident in ZIP i's DMA and let s_{ijbt} be lender j's share of refinance originations in ZIP i and year t. We estimate the first stage

$$A_{ijbt} = \gamma_{jbt}^{A} + \pi D_{ijbt} + \delta_{-,jbt}^{A} r_{ijbt}^{-} + \delta_{+,jbt}^{A} r_{ijbt}^{+} + u_{ijbt}^{A}, \tag{3}$$

and the corresponding second stage

$$s_{ijbt} = \gamma_{jbt}^{s} + \theta^{L} \widehat{A}_{ijbt} + \delta_{-,jbt}^{s} r_{ijbt}^{-} + \delta_{+,jbt}^{s} r_{ijbt}^{+} + u_{ijbt}^{s}. \tag{4}$$

Every regression includes lender–border–year fixed effects. The primary specification allows separate linear distance slopes on the two sides of every assignment. Thus, the first stage and outcome comparison are made within a particular lender, boundary, and year. We scale θ^L to report the percentage-point change in the focal lender's refinance share caused by an additional \$0.01 of advertising per resident. With one instrument for one endogenous variable, θ^L is simply the Wald ratio: the reduced-form discontinuity in the lender's share divided by the first-stage discontinuity in its advertising.

Regressions use 2010 ZIP-population weights, and we double cluster standard errors by ZIP code and lender–border–year assignment.

Figure 5 pools the assignments for display. For each assignment, ZIP codes in the lower-advertising DMA are placed to the left and ZIP codes in the higher-advertising DMA to the right. Panel A shows the first-stage jump in the focal lender's advertising. Panel B shows the jump in that lender's share among all refinance originations.

We then run a series of specifications to evaluate the robustness of the results. The first set of specifications adds controls. Holding the 2007–2021 observations in the main lender-choice sample fixed, we add either ZIP-by-year fixed effects or the advertising of the other lenders in the sample. ZIP-by-year fixed effects absorb any local annual condition common to every lender, including the total amount of measured advertising in that ZIP code and year. These specifications ask whether local demand conditions or rival advertising can explain the lender-choice result. Two additional specifications replace the assignment-specific slopes with pooled fixed-geographic-side slopes or persistent lender–border side slopes.

The second set of results identifies a different margin. Using the larger active-lender sample described in Section 2.3, lender-by-ZIP fixed effects absorb a lender's persistent local customer base, branch network, and reputation. Identification then comes from advertising changes for the same lender in the same ZIP code. The cross-sectional border comparison mostly captures low-versus-zero current television exposure, while this specification captures additional advertising within an established lender–place relationship.

3.4 Heterogeneity

The value of market expansion depends on which properties refinance. We therefore estimate the three-month cumulative specification separately by the gross refinancing opportunity in

the eligible mortgage stock. The opportunity is the national mortgage rate when the preceding mortgage was recorded minus the national rate one month before advertising. We also use an estimated dollar opportunity that combines the rate gap with the remaining balance implied by scheduled amortization. Every group comparison uses the same advertising lags, outcome-history controls, fixed border orientation, weights, and clustering as the aggregate estimate. Differences between groups are estimated directly on common border-pair-month support.

We also interact advertising with predetermined ZIP characteristics, principally the prior-year low-income and nonwhite borrower shares calculated from HMDA. These place-level responses combine audience composition, advertising placement, the eligible mortgage stock, and household responsiveness.

For lender heterogeneity, we interact advertising with lagged lender characteristics and instrument each term with the high-advertising-side assignment and its corresponding interaction. We report banks, independent mortgage companies, and credit unions. The table also reports descriptive associations using observed advertising amounts.

As a robustness exercise, we re-estimate the deeds design with advertising by banks, independent mortgage companies, credit unions, and the residual category entering simultaneously, and report fixed spending-weighted combinations with their full covariance matrix.

HMDA also lets us estimate borrower-group differences in the conditional lender-choice response across income and race groups.

3.5 Identification and interpretation

The identifying assumption is that, absent the difference in local television advertising, refinancing outcomes and lender choice would evolve smoothly across DMA borders. The assumption allows lenders and households to differ across the country. It allows advertising to respond to national rates and to a lender's national strategy. It rules out an omitted determinant that jumps at the same local television boundary, in the same direction as advertising, within the border and time comparisons used by the estimator.

The fixed effects address different versions of this concern. Border fixed effects in the monthly design remove permanent cross-side differences. Lender–border–year fixed effects in the annual design compare only ZIP codes exposed to the same lender, boundary, and

year. ZIP-by-year fixed effects hold local annual refinancing conditions fixed across lenders. Lender-by-ZIP fixed effects remove persistent differences in a lender's presence in a place.

We assess this assumption using predetermined-outcome balance tests, pre-advertising refinancing dynamics, and purchase mortgages as a comparison for broader local housing or credit shocks. Section 4.1 reports the estimates.

4 Results

We begin with the evidence that the media-market borders isolate advertising rather than broader differences in mortgage demand. We then report the two main effects: whether advertising brings households into the refinancing market, and whether it shifts households toward the advertiser. The remaining results ask which households respond, whose advertisements are effective, and how the two main estimates fit together in common units.

4.1 Balance, timing, and the purchase comparison

Figure 2 and Table 2 apply the empirical designs to characteristics measured before the advertising exposure. In the total-refinancing design, none of the nine variables is significant at the 10 percent level. The variables include earlier refinancing, the size and mortgage-rate composition of the eligible property stock, local employment, and income. Their joint p-value is 0.937. The point estimates are also small. For example, a one-cent advertising discontinuity is associated with a standardized difference of 0.002 in the preceding month's refinancing rate.

In the lender-choice design, three of eleven coefficients are significant at the 5 percent level: white population share, Latino population share, and log median home value. Their standardized discontinuities are 0.026, 0.020, and 0.025; every other estimate is smaller or less precise.

The dynamic evidence addresses a different concern. If a lender raised advertising in anticipation of a local refinancing boom, refinancing would begin to move before the advertisement. Figure 3 shows no such pattern. The displayed coefficients in months -6 through -4 are jointly indistinguishable from zero ($p = 0.486$); months -3 through -1 are included as outcome-history controls and are therefore not estimated as placebo coefficients.

Figure 4 runs the same timing test on purchase mortgages, using the dynamic border-pair-by-month PPML specification described in Section 3.5. HMDA assigns a purchase loan to the property bought, not the borrower's prior residence. Advertising assigned by the new property's DMA is therefore generally not the advertising the household received before choosing the property. The pre-exposure purchase coefficients are jointly zero ($p = 0.270$), as are the post-exposure coefficients through month three ($p = 0.744$) and month six ($p = 0.936$). This null result weighs against local credit-supply or housing-market shocks aligned with the DMA boundary.

4.2 Effect of advertising on refinancing

Figure 3 plots the effect of local mortgage advertising on total refinancing. Panel A reports monthly effects. Refinancing begins to rise immediately after advertising increases and remains elevated over the next several months. Panel B reports two cumulative measures. The line sums the separate monthly flow coefficients; the open circles count a property once if it has refinanced by the stated horizon. The measures answer slightly different questions, but they give similar answers over the first six months.

Table 3 gives the estimates. An additional \$0.01 of local mortgage television advertising per DMA resident causes 0.678 additional properties per 10,000 eligible properties to refinance within three months (standard error 0.263). The six-month effect is 0.816 (0.373). At twelve months the point estimate remains positive, at 0.919, but the standard error rises to 0.635. Summing the monthly coefficients gives 0.707, 0.926, and 1.295 at the same horizons.

The magnitude can be read directly. Suppose a DMA with one million residents receives \$10,000 more mortgage advertising, which is one cent per resident. Among 100,000 eligible properties near the relevant borders, the estimate implies roughly 6.8 additional refinances over the next three months. This is a small response for any one household, but mortgage advertising is frequent and reaches a large stock of borrowers.

The estimate is stable across the width of the border band. Appendix Table 12 reports the design at eight, ten, twelve, and fourteen miles. The three-month response is 0.644, 0.678, 0.681, and 0.650 across those four windows, and it is significant at the 5 percent level in each. The six-month response follows the same pattern.

The same table varies the spatial controls at each bandwidth. At ten miles and three

months, adding pooled side slopes gives 0.679 (0.263) and adding persistent border-pair side slopes gives 0.709 (0.269), both close to the headline estimate.

4.3 Effect of advertising on lender choice

The deeds data establish that advertising expands refinancing; HMDA identifies where the additional business goes. Figure 5 pools the lender-specific border assignments for display. Crossing to the high-advertising side raises the focal lender's advertising by 1.473 cents per resident and its share of local refinance originations by 0.189 percentage points.

Panel A of Table 4 holds the 2,993,083 observations in the main lender-choice sample fixed. The benchmark estimate is 0.129 percentage points for an additional cent of focal-lender advertising per resident, 0.138 with ZIP-by-year fixed effects, and 0.133 after controlling for rival advertising. Pooled fixed-geographic-side slopes give 0.177 and persistent lender–border side slopes give 0.110. Appendix Table 15 reports the same specifications at five, seven-and-a-half, ten, and fifteen miles. The benchmark estimate stays between 0.125 and 0.131 across the four windows, and the persistent-slope estimate is similarly stable.

Panel B separates a second issue. The estimate in the larger active-lender sample is 0.152 percentage points and remains 0.152 after ZIP-by-year fixed effects are added. When lender-by-ZIP fixed effects are added, with or without ZIP-by-year fixed effects, the estimate falls to 0.058. All four columns use the same 195.4 million observations. The fixed effects change what the regression is asking. The cross-sectional border comparison is dominated by cases in which a lender is on television on one side and absent or barely present on the other. Among assignments with unequal spending, the lower-exposure side has zero measured focal-lender television advertising in 88.6 percent of cases, and 85.3 percent of the population-weighted advertising gap comes from these zero-lower-side comparisons. The lender-by-ZIP specification instead follows changes in advertising by the same lender in the same place over time. Households there may already know the lender from earlier campaigns, branches, or other media.

The estimates describe two economically different margins. Introducing current television exposure has a large effect on lender choice; additional advertising within an established lender–place relationship also works, but the response is smaller. We use the cross-border estimate in the benchmark because it matches the observed low-versus-zero exposure con-

trast.

4.4 Who responds, whose advertisements work, and when advertisements appear

An additional refinance is more valuable when the household has more to gain. Figure 6 first divides the eligible mortgage stock by its predetermined rate-saving opportunity. For properties with less than 50 basis points to gain, an additional cent of advertising per resident produces 0.295 refinances within three months (0.242). For properties with at least 50 basis points to gain, the estimate is 0.658 (0.337). The high-opportunity estimate is positive and statistically significant, although the difference between the two groups is imprecise. A dollar measure that also accounts for estimated remaining balance gives a response of 0.502 at the 25th percentile of annual savings and 0.714 at the 75th percentile. These estimates enter the valuation below: they allow an advertising dollar to generate more value when it reaches a mortgage with a larger available saving, and they allow those mortgages to respond more strongly.

Panel A of Table 5 asks whether the total-refinancing response differs across places. The low-income-place contrast is imprecise. The response is much larger in ZIP codes with a higher predetermined nonwhite borrower share: 0.069 at one standard deviation below the mean and 1.330 at one standard deviation above it. The difference is 1.261 (0.263). This place-level response combines audience composition, advertising placement, the eligible mortgage stock, and household responsiveness.

Panel B asks whose advertisements shift lender choice. Using official HMDA lender types, a cent of advertising per resident raises the refinance share of a bank by 0.126 percentage points, the share of an independent mortgage company by 0.047 percentage points, and the share of a credit union by 0.211 percentage points. The independent-mortgage-company minus bank difference is -0.078 (0.060); the credit-union minus bank difference is 0.085 (0.063). Credit unions differ statistically from independent mortgage companies. Descriptive regressions using observed advertising amounts preserve the same ordering across lender types.

Panel C allows the total-refinancing effect to vary across banks, independent mortgage

companies, and credit unions. The resulting spending-weighted estimate, 0.572 (0.324), is close to the pooled benchmark of 0.678 (0.263), but is less precise because the separate lender-type effects are difficult to distinguish statistically ($p = 0.667$). We therefore use the more precise pooled estimate as our main estimate and report the separate lender-type estimates in Appendix Table 13.

Figure 6 also reports lender-choice effects by borrower income and race. Every group moves toward the advertiser. The response is similar above and below $50,000 of borrower income. The nonwhite estimate is somewhat smaller than the white estimate, with a difference p-value of 0.057. The race estimates are complementary: Panel A measures place-level market expansion, while Panel B measures lender choice conditional on refinancing.

The interaction between advertising and the lender's relative rate varies across time periods, advertiser–lender mappings, and specifications. The benchmark therefore lets lender rates and fees affect mortgage value while holding the response probability independent of the lender's relative rate.

Table 6 describes when advertising actually appears. Advertising-weighted months have national mortgage rates 6.9 basis points higher than the average month. The mean rate-saving opportunity is 2.8 basis points lower, and the share of eligible mortgages with at least 50 basis points to gain is 1.9 percentage points lower. Advertisers therefore did not concentrate spending in the months with the best aggregate refinancing opportunities. This timing pattern enters the value calculation, not the estimated quantity response.

In 2021, the advertising-dollar-weighted lender offer rate is 0.5 basis point above the contemporaneous national rate. Across 1,467 positive-advertising lender-month cells, the unweighted correlation between log advertising and the lender's same-year-centered relative offer is -0.099. These statistics condition and weight the data differently, so the small negative within-year association is consistent with the slightly positive dollar-weighted level difference. Rates can be attached to 57.2 percent of local advertising spending. Lender steering therefore contributes little to the benchmark mortgage value; the larger component is whether and when the advertisement causes a household to refinance.

4.5 Putting the estimates in common units

The market-expansion and lender-choice designs use different denominators. The first estimates the change in total refinances among eligible properties. The second estimates the change in the advertiser's share among households who refinance. To combine them, let Y denote total refinances per 10,000 eligible properties, s_j the advertiser's share of those refinances, and $y_j = s_j Y$ the advertiser's originations. For a finite advertising change,

$$\Delta y_j = s_{j0}\Delta Y + Y_0 \Delta s_j + \Delta Y \Delta s_j. \tag{5}$$

Combining the two estimates requires an assumption about how a particular lender's advertising affects total refinancing. The deeds regression estimates the average market-expansion effect across all advertisers; our benchmark assumes this effect is homogeneous, so the average also applies to each lender represented in the lender-choice sample. We assess this assumption in two ways. First, allowing the market-expansion effect to vary by lender type produces the similar but less precise estimate reported above. Second, because only advertisers matched to HMDA enter the lender-choice sample, we reweight that sample to match the full advertising sample on advertising intensity, geographic reach, active months, DMA, and year. Entropy balancing changes the lender-share response from 0.124 (0.010) to 0.131 (0.010); stabilized inverse-propensity weighting gives 0.154 (0.016), or 0.152 (0.015) after capping extreme weights. These estimates imply competitor shares between 67.2 and 71.9 percent, close to the benchmark; Appendix Table 14 reports the details.

For the baseline point calibration, we use 141 refinances per 10,000 eligible properties and a 0.97-percent advertising-lender share.[6] Assigning the pooled 0.678 market-expansion response to a focal-lender advertising change and combining it with the 0.124-percentage-point lender-share response gives 0.182 advertiser originations and 0.496 competitor originations, so competitors receive 73.1 percent of the point-estimated increase (95 percent confidence interval: 53.1 to 93.1 percent).

6. The 1.38 percent mean in Table 1 covers the broader reviewed lender-choice panel before fixed-effect singleton removal.

5 A Demand Model of Refinancing and Lender Choice

This section interprets the reduced-form parameters through a nested logit model in which a household decides whether to refinance and, conditional on refinancing, chooses a lender. The parsimonious model separates the two channels and combines the estimates consistently, following the structure in Shapiro (2018).

5.1 Household choice

Let household i choose among refinancing lenders j in market m and period t. Conditional on refinancing, utility from lender j is

$$u_{ijmt} = v_{ijmt} + \varepsilon_{ijmt}, \qquad v_{ijmt} = \xi_{ijmt} + \gamma A_{jmt}, \tag{6}$$

$$s_{ijmt} = \frac{\exp(v_{ijmt}/\lambda)}{\sum_k \exp(v_{ikmt}/\lambda)}. \tag{7}$$

The term A_{jmt} is lender j's advertising, while ξ_{ijmt} includes its rate, fees, reputation, convenience, and other attributes. Advertising raises the lender's relative appeal by γA_{jmt}. This is the lender channel. The conditional share s_{ijmt} is the probability that household i chooses lender j given that it refinances.

The parameter $\lambda \in (0, 1]$ determines how close the lenders are as substitutes. When λ is low, lenders share much of their unobserved appeal, so a borrower drawn toward one of them can readily substitute to another and the attraction of refinancing itself barely moves. When λ is high, lenders are more differentiated, and making one of them more attractive does more to raise the value of refinancing as a whole.

The attractiveness of the refinancing alternatives is summarized by their inclusive value,

$$IV_{imt} = \log\left(\sum_k \exp(v_{ikmt}/\lambda)\right). \tag{8}$$

The probability of refinancing is

$$q_{ihmt} = \Lambda(w_{ihmt} + \kappa_h A_{mt} + \lambda IV_{imt}), \tag{9}$$

where A_{mt} is total local mortgage advertising, h indexes the household's predetermined refinancing opportunity, and Λ is the logistic function. The term $\kappa_h A_{mt}$ is the direct channel of Section 2.1. An advertisement may remind a household to check its mortgage or communicate that rates have fallen — anything that nudges households to refinance who otherwise would not have done so. Writing the coefficient as κ_h allows the response to be larger when the household has more to gain. In the calibration below, however, we fit a common κ across opportunity groups; the estimated opportunity gradient enters when we value induced refinances in Section 6.

The lender channel can also expand refinancing. When an advertisement makes one lender more appealing, refinancing as a whole becomes more attractive relative to doing nothing. This effect operates through IV_{imt}. It is different from the direct channel: an advertisement can bring a household into the market without affecting which lender it chooses, whereas the lender channel changes the relative attractiveness of a particular lender and may also pull the household in.

The unconditional probability of refinancing with lender j is

$$p_{ijhmt} = q_{ihmt} s_{ijmt}. \tag{10}$$

The deeds design identifies the change in q. The HMDA design identifies the change in s_j. Their product determines how the increase in refinancing is divided between the advertiser and other lenders. Equation (10) is the model version of the expression in equation (5).

5.2 Mapping the estimates into the model

The mapping can be written directly in terms of the two observed changes. Let q_0 and q_1 denote the probabilities of refinancing before and after the advertising change, and let s_0 and s_1 denote the advertiser's shares among refinancers. Define the corresponding changes in log odds as

$$m_q = \text{logit}(q_1) - \text{logit}(q_0), \qquad m_s = \text{logit}(s_1) - \text{logit}(s_0). \tag{11}$$

If only the focal lender's utility changes, the lender-choice effect satisfies

$$m_s = \frac{\gamma \Delta A_j}{\lambda}. \tag{12}$$

The same utility change raises the inclusive value of refinancing. The total refinancing effect therefore satisfies

$$m_q = \kappa \Delta A^{\text{mkt}} + \lambda \log[1 + s_0\{\exp(m_s) - 1\}]. \tag{13}$$

The first term is the direct channel. The second is the market expansion that comes through the lender channel, as making the advertiser more attractive makes refinancing itself a better proposition. For the pooled point calibration, we assign the average total-advertising market-expansion response to a focal lender and evaluate both ΔA_j and ΔA^{mkt} at \$0.01 per resident.

The baseline inputs are the 0.678 increase in total refinancing and the 0.124-percentage-point increase in the advertiser's conditional share. Conditional on λ, these moments and the baseline refinancing probability and advertiser share identify γ and κ. As a functional-form check, Appendix Table 16 estimates a joint all-lender conditional MNL/PPML system with an explicit all-other-lenders alternative. Its fitted shares add to one within each ZIP-year; the linear fuzzy-border estimate remains the causal lender-choice input.

We use $\lambda = 0.75$ as the benchmark, close to estimates from retail banking in Dick (2008), and report values from 0.25 to 1 in Appendix Table 17. What the parameter governs is how much of the lender channel spills over into market expansion. If lenders are very close substitutes, the lender channel mostly moves a borrower from one lender to another and adds little to the attraction of refinancing itself. The direct channel must then explain almost all market expansion. If lenders are more differentiated, making the advertised lender attractive also improves the household's refinancing choice set, and more of the observed entry into refinancing can be attributed to the lender channel. The fitted total response and lender-share response are the same in either case. What changes is the interpretation of how the advertisement produced them.

5.3 What the model says about the two channels

Table 7 reports the results. Panels A and B summarize the pooled point calibration and accounting bridge from Section 4.5; Panel C decomposes the calibrated response into the two channels.

In Panel C we consider the effects of each channel in isolation. When $\lambda = 0.75$, the direct channel alone produces 0.547 additional refinances per 10,000 eligible properties and the lender channel alone produces 0.130. With both channels active the model reproduces the calibrated 0.678 effect. The direct channel therefore accounts for about four-fifths of market expansion at the benchmark. The lender channel remains essential to the advertiser's private return, because it shifts the conditional lender choice, even though it explains less of the increase in the total number of refinances.

Across λ values from 0.25 to 1, the direct channel generates 0.503–0.634 additional refinances and accounts for at least roughly three-quarters of the calibrated market expansion. The advertiser gains mainly because households move toward it, while households gain mainly because advertising prompts additional refinancing. These are model decompositions of point estimates.

The smaller lender-by-ZIP estimate describes additional advertising within an established lender–place relationship. Holding the outer response fixed is a separate calibration: its 0.058-percentage-point lender-share response would send more of the expanded market to competitors than the cross-border response does, but it is not a direct estimate of market expansion for that margin.

6 Borrower Value and Advertiser Returns

Valuing the reduced form requires a counterfactual for when induced households would otherwise have refinanced. We construct that mortgage path, calculate borrower mortgage value and advertiser revenue, and then describe the scope of each measure.

6.1 The two sources of borrower value

Let G_{ij}^E denote the mortgage gain when advertising induces household i to refinance with lender j, net of refinancing costs and relative to the household's expected mortgage path without the advertisement. Let G_{ij}^R denote the difference in mortgage value when a household that refinances either way is directed to lender j rather than another lender. Borrower value from a change in advertising can be written as

$$\frac{dW}{dA} = \sum_i \omega_i \left[\underbrace{\frac{dq_i}{dA} \sum_j s_{ij} G_{ij}^E}_{\text{additional refinancing}} + \underbrace{q_i \sum_j G_{ij}^R \frac{ds_{ij}}{dA}}_{\text{change in lender}} \right]. \tag{14}$$

The first term comes from the households brought into refinancing at the time of the advertisement, and the superscript E denotes this expansion margin. The second comes from the change in rates and fees caused by sending refinancing households to a different lender, and the superscript R denotes reallocation. The weights ω_i are chosen so that the calculation reflects the households and places actually exposed to the observed advertising.

Market expansion can save a household years of unnecessarily high mortgage payments, while lender reallocation matters only through the difference between the terms offered by the advertiser and those offered by the lender the household would otherwise have chosen. In the data, the first component is much larger.

6.2 Substitution over time

Because the twelve-month estimates are imprecise and the eligible stock evolves as properties refinance, move, or leave the data, we construct the later-refinancing path using an external attention estimate rather than extrapolating the local projection.

Instead, the benchmark treats attention to refinancing as arriving at random, with a constant probability. We use the annual attention intensity of 0.234 estimated in Berger et al. (2025), which implies an average of 4.3 years between attention events and a 1.93 percent chance of an attention event in any given month. When attention next arrives, the household compares the mortgage it still has with the rate then available and refinances if the

saving clears the decision threshold implied by refinancing costs, which is 29.9 basis points at the benchmark. Under the benchmark, 46.5 percent of households refinance without the advertisement during the following five years.

The realized rate path is important. Consider two households with the same current mortgage. For the first, rates rise immediately after the advertisement and remain high. Prompting it to refinance today can preserve a valuable opportunity that would otherwise disappear. For the second, rates fall sharply next year. An advertisement can induce it to pay a refinancing cost now and miss a better opportunity later. The value of the nudge depends on this sequence, not only on the rate gap on the day the advertisement appears.

For each mortgage and each month, we use the national mortgage rate when the preceding mortgage was recorded, the national rate when advertising occurs, the estimated remaining balance, and the national rates that subsequently occurred. To convert the rate gap into dollars we use a common balance, as described below. The five-year rate path is available for advertising from January 2007 through March 2021, using realized rates through March 2026. These 171 exposure months contain 93.6 percent of the local television spending in the main 2007–2021 sample. Within each market-month, the estimated opportunity-response gradient determines which mortgages are most likely to be induced.

This approach separates two ideas that are easy to conflate. The reduced-form estimate tells us how many households refinance soon after advertising. The attention calculation tells us what those households would probably have done later. The first is identified by the border design. The second is a calibrated counterfactual, and we report how the answer changes when future attention is more or less frequent.

6.3 Borrower mortgage value

The average household induced to refinance has a gross rate-saving opportunity of 97.1 basis points. This quantity already incorporates the observed timing and geography of advertising and the larger response among households with more to gain. It is lower than it would be if advertisers concentrated spending in the highest-opportunity months, but higher than the opportunity of a randomly selected eligible mortgage because response rises with potential savings.

To convert the rate gap into a dollar value, we assume a $300,000 mortgage and refinanc-

ing costs equal to 1.25 percent of that balance. We count the interest saved over the five years following the advertisement rather than over the full remaining life of the loan, and we discount those savings at the current mortgage rate. For each induced refinance, we compare immediate refinancing with the expected no-advertising path described above. The expected timing value is $5,003 per induced refinance. The estimate of 0.366 additional refinances per $1,000 of advertising therefore produces about $1.83 of value per advertising dollar through additional refinancing.

Changing the lender adds about 0.7 cent per advertising dollar. The destination effect is small because advertiser and alternative-lender terms are close on average; the benchmark holds the response probability independent of the lender's relative rate because the estimated rate interaction varies across samples and mappings. Adding the two components gives $1.84 of borrower mortgage value per advertising dollar. A border-pair bootstrap that re-estimates the market-expansion effect gives a 90 percent confidence interval of [$0.79, $3.08]. Table 8 reports the benchmark.

The calculation also shows why the heterogeneity and placement results matter. Starting from advertising spread uniformly per resident across market-months and a flat household response across refinancing opportunities yields $1.686 per advertising dollar. Allowing households with larger gains to respond more strongly adds $0.637. Restoring the actual timing and geography of advertising subtracts $0.485, producing the benchmark value of $1.84. Because the two effects interact, we average their contributions across the two possible orders.

The positive response gradient therefore helps households: advertisements are more likely to move mortgages for which refinancing is valuable. Actual placement partly works in the opposite direction. Table 6 showed that advertising was not concentrated in the months with the largest aggregate opportunities. To illustrate how much the placement of advertising matters, we consider the following exercise. Spreading the same dollars uniformly across the market-months that already have advertising raises the value for households to $2.379 per dollar. Allocating them to the highest-value quarter of resident-months raises it to $6.979, while allocating them to the lowest-value quarter of resident-months produces −$0.663, so the same advertising budget can be worth nearly four times the benchmark or can destroy value outright depending only on when and where it is spent.

How often households would have refinanced on their own is the single most important assumption in the calculation. If future attention arrives less frequently, once every 8.5 years on average, the value rises to $2.48 per advertising dollar. If it arrives every 3.0 years on average, the value falls to $1.44. If induced households would never refinance later within the five-year window, the value is $3.38. Using the 100.6-basis-point decision threshold from Agarwal, Driscoll, and Laibson (2013) rather than the benchmark 29.9 raises the value to $1.92. Appendix Table 18 reports these assumptions and the allocation decomposition.

6.4 Returns to the advertising lender

Applying the registered valuation-sample conversion N/E from the pooled all-local-spot placement ledger to the baseline point calibration, $10,000 of advertising produces 0.982 additional originations for the advertiser. Equivalently, the advertiser spends about $10,187 for each additional origination it receives. This quantity includes both households brought into refinancing and households who would have refinanced with another lender.

We translate the quantity into a revenue benchmark using the Mortgage Bankers Association's 2021 industry-wide production revenue of $11,003 per originated loan (Mortgage Bankers Association, 2022). The baseline point calibration gives $1.08 of gross production revenue per advertising dollar. This is gross revenue, not profit. Marginal origination costs lower private returns, while servicing, repeat business, and cross-selling can raise the value of an acquired borrower; Jin, Liebersohn, and Wu (2026) provide evidence that mortgage relationships generate broader banking business.

The established-market estimate implies fewer advertiser originations per dollar when market expansion is held fixed, but that exercise is also a calibration rather than a direct market-expansion estimate for established lender–place relationships.

The private and household returns arise from different channels. The lender channel accounts for most of the advertiser's gain, because it moves borrowers toward the focal lender. At the point estimates, the direct channel accounts for most of the increase in refinancing and nearly all measured borrower value, while the advertiser captures a minority of the additional refinances.

6.5 Scope of the calculation

The $1.84 estimate is a local, partial-equilibrium measure of mortgage payments and refinancing fees under the observed historical rate path. It uses the pooled response to all local mortgage advertising, including the residual component. The $1.08 advertiser result is a pooled point calibration; both apply the registered pooled all-local-spot N/E conversion. The quantities therefore do not form a single fully matched welfare ledger. A full welfare measure would additionally require household application costs and constraints, lender costs and relationship value, and market-equilibrium responses. Following Shapiro (2022), we report the components tied to the causal estimates and identify these additional objects separately.

7 Conclusion

Mortgage advertising changes both whether households refinance and which lender they choose. Using discontinuities in local television advertising at media-market borders, we find that an additional cent of advertising per resident produces 0.68 refinances per 10,000 eligible properties within three months; the point estimate is larger among households with more to gain, although the difference is imprecise. Advertising by a particular lender also raises that lender's share among refinancing households. Under the pooled point calibration, the advertiser receives 0.18 additional mortgages and competitors receive another 0.50.

Market expansion and lender choice pay off to different parties. A lender can gain by persuading borrowers to select it even when the advertisement creates little new refinancing, while households gain mainly when advertising prompts a worthwhile refinance that would otherwise have happened later or not at all. In the pooled demand calibration, the direct channel explains most market expansion over the full range of substitution parameters we consider, while the lender channel explains most of the advertiser's gain. The lender channel is strongest where a lender has little or no current local television exposure, and credit-union advertising shifts conditional lender choice more than independent-mortgage-company advertising. The total-refinancing effect is also larger in places with a higher predetermined nonwhite borrower share.

To value the additional refinancing, we allow induced households to refinance later, when they next pay attention and when realized rates make refinancing worthwhile. Under the

benchmark, an average dollar across all local mortgage advertising creates $1.84 of borrower mortgage value. Some advertising accelerates refinancing rather than creating it, so the estimate varies with how long households would otherwise take to notice the opportunity. Under the pooled point calibration, $10,000 of advertising produces 0.98 additional originations for the advertiser, or $1.08 of gross production revenue per advertising dollar at the 2021 industry average.

Mortgage advertising is neither a nuisance nor a public service. It brings inattentive households into refinancing, with point estimates largest where households have the most to gain. The reported calibrations place borrower mortgage value above advertiser gross revenue, although the two quantities do not form a matched welfare ledger. But those firms choose when and where to spend, and they choose to acquire customers rather than to find the households with the largest unexercised opportunities. The private market already has a reason to correct a well-documented household mistake; what it does not have is a reason to correct it in the places, or at the times, where correcting it is worth the most. The size and even the sign of the competitor spillover remain uncertain.

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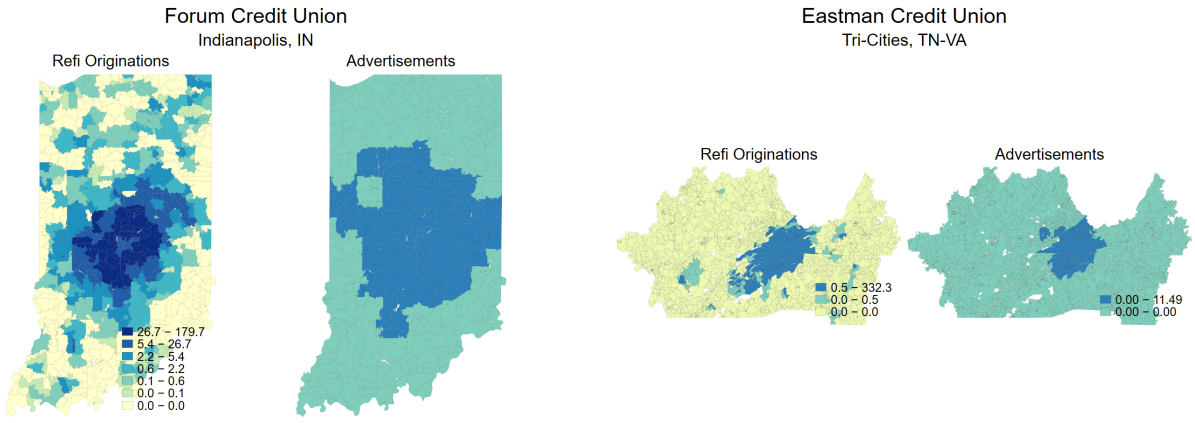
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Table 1: Summary Statistics

Variable	Mean	Std. dev.	10th pct.	Median	90th pct.	*N*
Panel A. Deeds market-expansion sample						
Eligible properties per border-pair month	26,108.8	49,011.2	1,259.0	11,858.0	58,676.4	79,345
Monthly refinances per 10,000 eligible properties	43.67	51.47	0.00	35.45	90.62	158,690
Local mortgage advertising (cents per resident)	0.98	1.66	0.00	0.31	2.79	158,690
Panel B. HMDA lender-choice sample						
Advertising lender refinance share (percent)	1.38	3.72	0.00	0.00	4.39	4,008,314
Advertising-lender spending (cents per resident)	0.61	2.56	0.00	0.00	1.45	4,008,314

Notes: Panel A describes the ten-mile deeds sample used for the aggregate market-expansion estimates. Panel B describes the reviewed ten-mile HMDA lender-choice panel before fixed-effect singleton removal. Deeds moments are unweighted across border-side months except for eligible properties, which are measured by border-pair month. Advertising is displayed in cents per resident. The lender-share mean is weighted by 2010 ZIP population; lender advertising is unweighted. A zero in the distribution is an observed zero, not a missing value. Appendix Table 9 reports sample coverage.



(a) Forum Credit Union **(b)** Eastman Credit Union

Figure 1: Examples of Local Television Advertising at Media-Market Borders

Notes: The maps illustrate local television advertising by two mortgage advertisers and nearby ZIP codes on opposite sides of Designated Market Area boundaries. Shading denotes advertising exposure in the media market; lines mark DMA borders. The empirical analysis uses all qualifying borders and advertisers rather than the two examples shown.

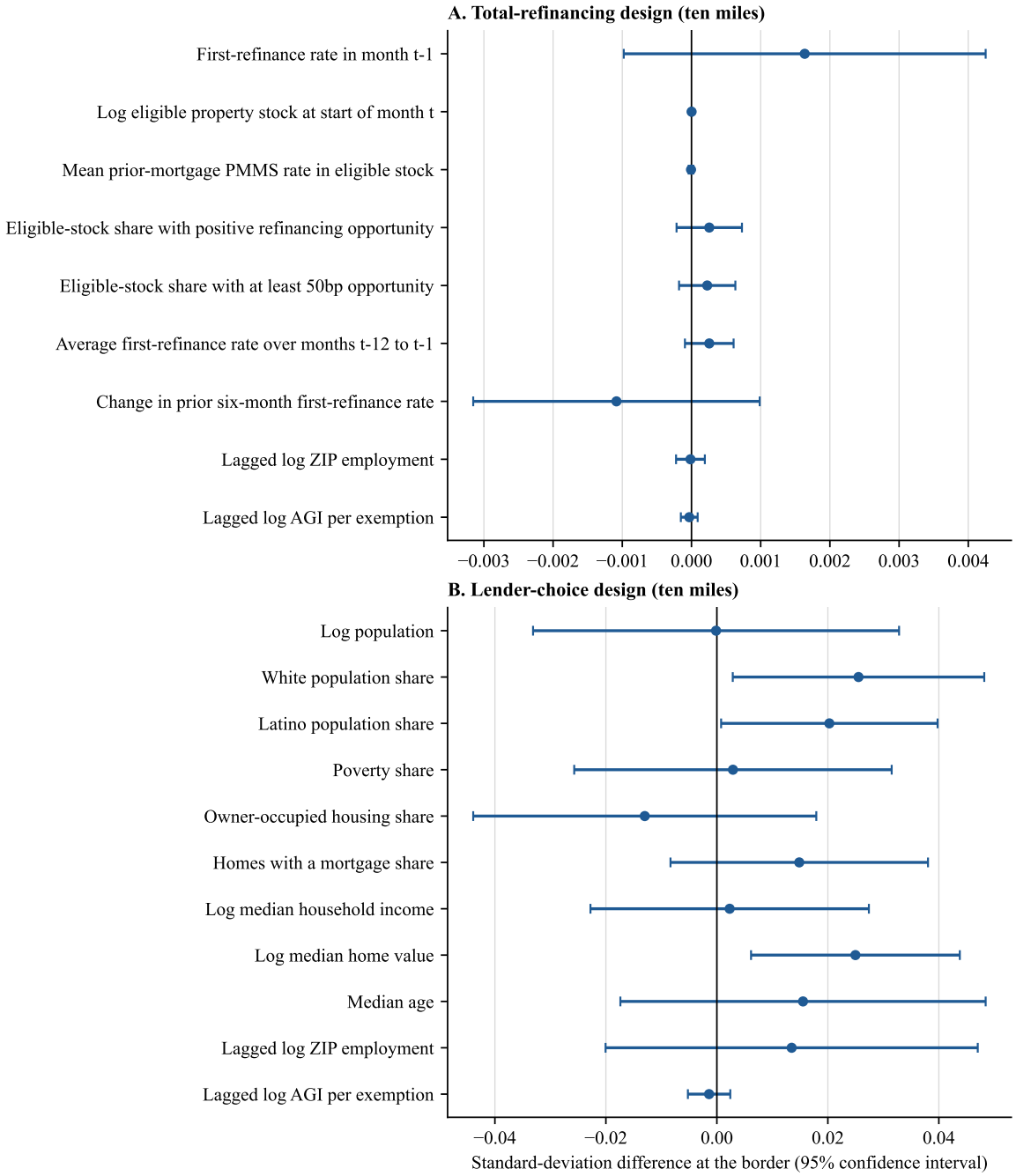


Figure 2: Covariate Balance at Media-Market Borders

Notes: Points are standardized discontinuities in predetermined variables at media-market borders; bars are pointwise 95 percent confidence intervals. Panel A uses the exact three-month total-refinancing specification. Panel B uses the ten-mile lender-choice specification. The full set of coefficients, standard errors, and p-values appears in Table 2.

Table 2: Covariate Balance at Media-Market Borders

Predetermined variable	Comparison mean	Std. difference	Std. error	p-value
Panel A. Total-refinancing design (thousandths of a standard deviation; ten miles)				
First-refinance rate in month $t-1$	53.386	1.6	(1.3)	0.222
Log eligible property stock at start of month t	7.844	0.0	(0.0)	0.796
Mean prior-mortgage PMMS rate in eligible stock	5.011	0.0	(0.0)	0.706
Eligible-stock share with positive refinancing opportunity	0.784	0.3	(0.2)	0.288
Eligible-stock share with at least 50 bp opportunity	0.583	0.2	(0.2)	0.275
Average first-refinance rate over months $t-12$ to $t-1$	52.913	0.3	(0.2)	0.154
Change in prior six-month first-refinance rate	0.251	-1.1	(1.1)	0.306
Lagged log ZIP employment	8.213	0.0	(0.1)	0.889
Lagged log AGI per exemption	3.964	0.0	(0.1)	0.605
Joint test of all nine variables				0.937
Panel B. Lender-choice design (standard deviations; ten miles)				
Log population	9.572	0.000	(0.017)	0.993
White population share	0.832	0.026	(0.012)	0.027
Latino population share	0.079	0.020	(0.010)	0.042
Poverty share	0.145	0.003	(0.015)	0.843
Owner-occupied housing share	0.720	-0.013	(0.016)	0.410
Homes with a mortgage share	0.627	0.015	(0.012)	0.210
Log median household income	10.113	0.002	(0.013)	0.857
Log median home value	11.901	0.025	(0.010)	0.009
Median age	39.380	0.016	(0.017)	0.355
Lagged log ZIP employment	8.169	0.014	(0.017)	0.431
Lagged log AGI per exemption	4.112	-0.001	(0.002)	0.472
Joint test of all eleven variables				< 0.001

Notes: Each row reports the discontinuity in a predetermined variable at a media-market border, divided by that variable's standard deviation. Panel A displays these standardized differences and standard errors in thousandths of a standard deviation; Panel B displays them in standard deviations. Both panels use ZIP codes within ten miles of a border. Panel A uses the exact three-month total-refinancing specification and reports the mean in the estimation sample. Panel B uses the 2007–2021 lender-choice specification and reports the lower-advertising-side mean. Its regressions include lender–border–year fixed effects and separate assignment-specific linear distance slopes on each side, use 2010 ZIP-population weights, and cluster by ZIP and lender–border–year assignment. IRS and ZIP Business Patterns variables are lagged one year. Individual p-values and joint tests are reported directly.

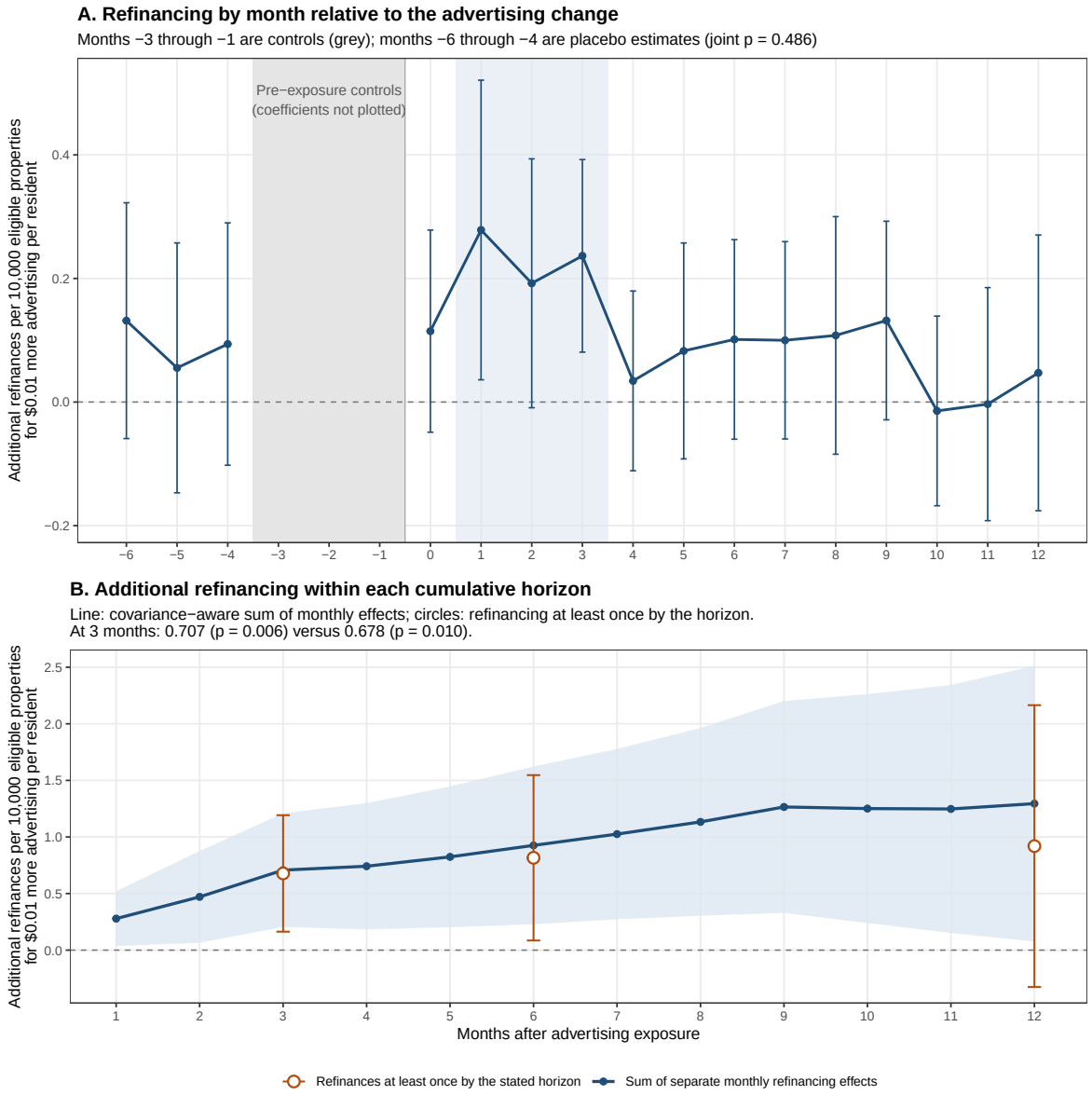


Figure 3: Effect of Local Mortgage Advertising on Total Refinancing

Notes: Panel A reports monthly changes in first qualifying refinances per 10,000 eligible properties caused by an additional $0.01 of local mortgage television advertising per DMA resident. Months −3 through −1 enter as outcome-history controls and are not plotted. Panel B reports cumulative effects. The line sums the separate monthly flow estimates; open circles count each property at most once by the stated horizon. All monthly horizons are estimated jointly in one stacked border-side regression, and the three unique-refinancing points are estimated jointly in one stacked ZIP-level regression. Both use the ten-mile sample, eligible-property-stock weights, horizon-specific border-pair-by-fixed-side and border-pair-by-month fixed effects, three advertising lags, three lagged refinancing outcomes, and two-way clustering by constituent DMA and calendar month. Bars and shaded regions are pointwise 95 percent confidence intervals.

Table 3: Effect of Local Mortgage Advertising on Total Refinancing

	Months after advertising		
	3	6	12
Refinanced at least once	0.678**	0.816**	0.919
	(0.263)	(0.373)	(0.635)
Sum of monthly refinancing responses	0.707***	0.926***	1.295**
	(0.256)	(0.355)	(0.621)
Border-pair months	79,345	79,345	79,345
Border pairs	454	454	454

Notes: Each coefficient is the number of additional refinances per 10,000 eligible properties caused by an additional $0.01 of local mortgage television advertising per media-market resident. The first row counts a property at most once by each horizon on one registered common cohort with complete follow-up through all reported horizons. The second row sums the monthly flow coefficients through that horizon and uses their full covariance matrix. The three direct horizons are estimated jointly in one stacked ZIP-level regression; all monthly horizons are estimated jointly in one stacked border-side regression. Both use 2007–2021 advertising exposure, eligible-property-stock weights, horizon-specific border-pair-by-fixed-side and border-pair-by-month fixed effects, three advertising lags, three lagged refinancing outcomes, and two-way clustering by constituent DMA and calendar month. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

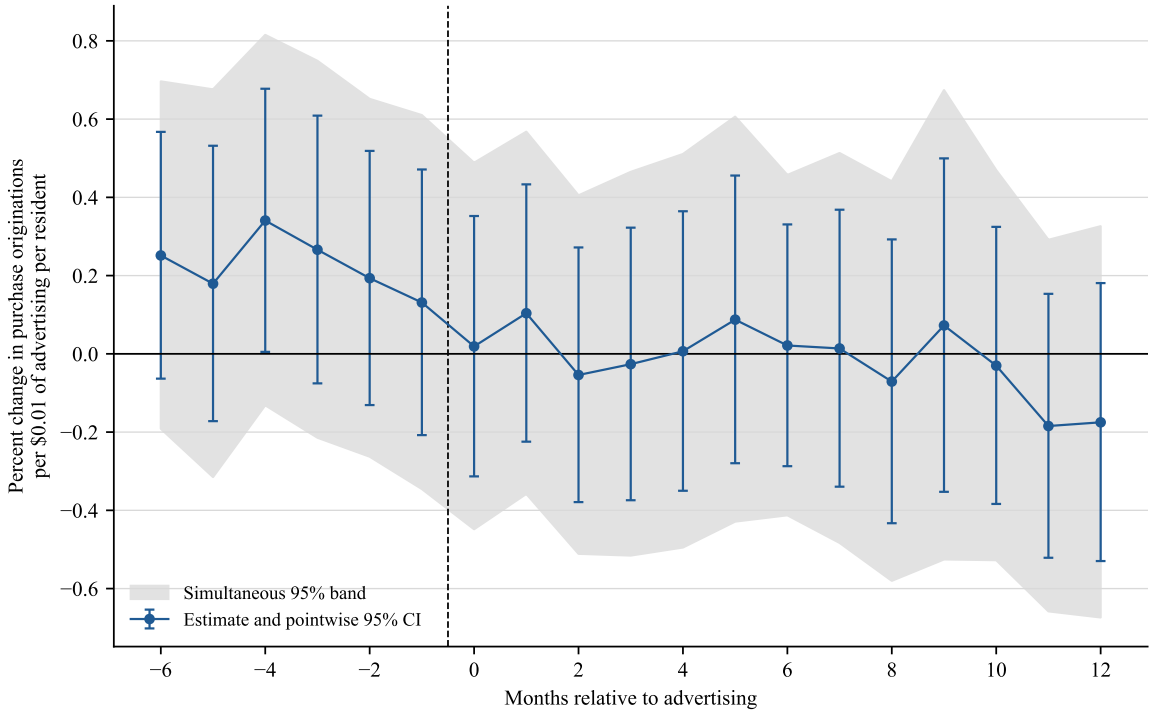


Figure 4: Purchase-Mortgage Originations Do Not Respond to Local Mortgage Advertising
Notes: The figure estimates the percent change in purchase-mortgage originations caused by an additional $0.01 of local mortgage television advertising per media-market resident. It uses the ten-mile border-pair-by-month PPML specification. Points and bars are estimates and pointwise 95 percent confidence intervals; the gray region is a simultaneous 95 percent band. The negative-month coefficients are jointly zero ($p = 0.270$). The post-advertising coefficients are jointly zero through month 3 ($p = 0.744$) and month 6 ($p = 0.936$). Standard errors are clustered by border pair and calendar month.

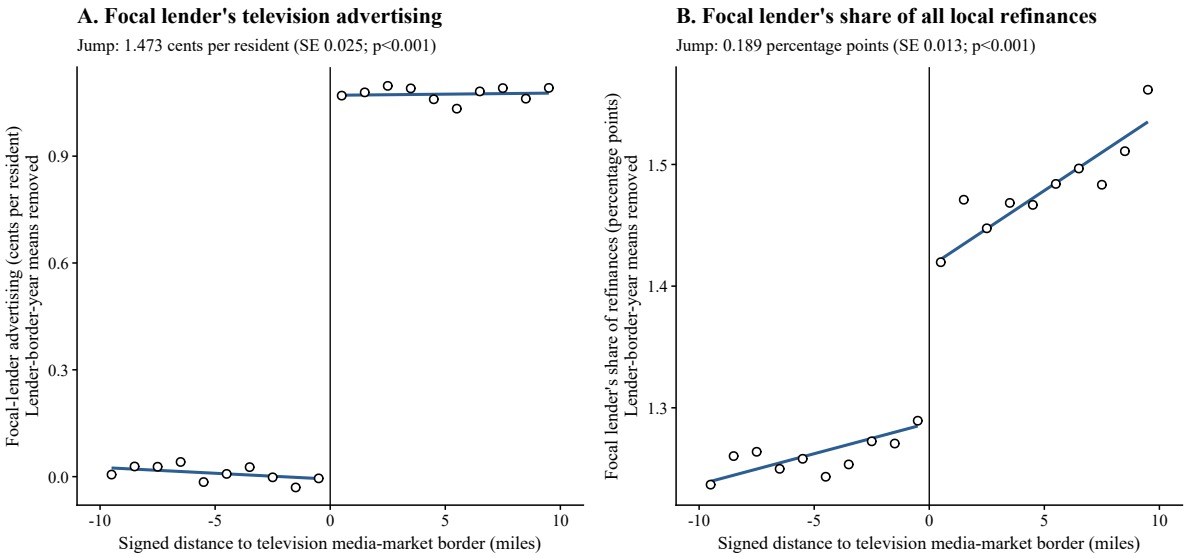


Figure 5: Lender Advertising and Lender Choice at Media-Market Borders

Notes: The figure pools lender–border–year assignments within ten miles of a DMA boundary. Distance is signed so that the side receiving more advertising from the focal lender is positive. Panel A shows focal-lender television advertising in cents per resident. Panel B shows the focal lender's percentage share of local HMDA refinance originations. Lender–border–year means are removed for the display. The reported jumps are reduced-form discontinuities; Table 4 reports the corresponding fuzzy-RD estimates using the underlying ZIP observations, separate distance slopes, population weights, fixed effects, and two-way clustered standard errors.

Table 4: Effect of Lender Advertising on Its Share of Local Refinances

Panel A. Main lender-choice sample, identical 2007–2021 observations

	Primary (1)	ZIP–year FE (2)	Rival advertising (3)	Pooled slopes (4)	Persistent slopes (5)
First stage: focal-lender advertising (cents per resident)	1.473***	1.451***	1.458***	1.483***	1.360***
	(0.025)	(0.026)	(0.025)	(0.025)	(0.022)
High-advertising-side effect on focal-lender refinance share	0.002***	0.002***	0.002***	0.003***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2SLS effect on focal-lender refinance share	0.129***	0.138***	0.133***	0.177***	0.110***
	(0.009)	(0.010)	(0.009)	(0.009)	(0.008)
ZIP × year fixed effects	No	Yes	No	No	No
Other represented lenders' advertising	No	Absorbed	Yes	No	No
Assignment-specific side slopes	Yes	Yes	Yes	No	No
Pooled fixed-geographic-side slopes	No	No	No	Yes	No
Persistent lender–border side slopes	No	No	No	No	Yes
Bandwidth (miles)	10	10	10	10	10
Observations	2,993,083	2,993,083	2,993,083	2,993,083	2,993,083
Lender–border–year assignments	86,560	86,560	86,560	86,560	86,560
Lenders	1,223	1,223	1,223	1,223	1,223
First-stage F-statistic	3562.8	3229.5	3500.4	3588.7	3700.6

Panel B. Larger active-lender sample, identical 2000–2021 observations

	Baseline (6)	ZIP × year FE (7)	Lender × ZIP FE (8)	Both sets of FE (9)
First stage: focal-lender advertising (cents per resident)	1.555***	1.554***	1.351***	1.350***
	(0.074)	(0.074)	(0.047)	(0.047)
High-advertising-side effect on focal-lender refinance share	0.002***	0.002***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
2SLS effect on focal-lender refinance share	0.152***	0.152***	0.058***	0.058***
	(0.017)	(0.017)	(0.009)	(0.009)
ZIP × year fixed effects	No	Yes	No	Yes
Lender × ZIP fixed effects	No	No	Yes	Yes
Bandwidth (miles)	10	10	10	10
Observations	195,360,459	195,360,459	195,360,459	195,360,459
Lender identities	763	763	763	763
First-stage F-statistic	436.7	438.6	824.2	827.7

Notes: The outcome is the focal lender's share of HMDA refinance originations in a ZIP and year, expressed as a fraction in estimation. The first-stage rows display focal-lender advertising in cents per media-market resident; the 2SLS rows report percentage-point changes in lender share per additional one cent of focal-lender advertising per resident. All estimates use ZIP codes within ten miles of a DMA boundary, lender–border–year fixed effects, 2010 ZIP-population weights, and two-way clustering by ZIP and lender–border–year assignment. Columns (1)–(3) use assignment-specific side slopes; columns (4) and (5) respectively use pooled fixed-geographic-side slopes and persistent lender–border side slopes. Panel A holds observations fixed while adding annual local conditions shared across lenders or other represented lenders' advertising. Because represented total advertising equals own plus rival advertising, ZIP-by-year fixed effects absorb that local represented-advertising environment. Panel B crosses each included lender-year with every eligible ZIP code and codes zero refinance originations and zero advertising where appropriate. A lender-year is included when its exact dated base-filer identity or reviewed advertiser-family identity is present for that year and all of its linked base filers have verified filer-year support. Missing local outcomes and identity-DMA advertising are coded zero only within that verified support. It locks one common sample across all four specifications, and its lender-by-ZIP specifications compare the same lender in the same place over time. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

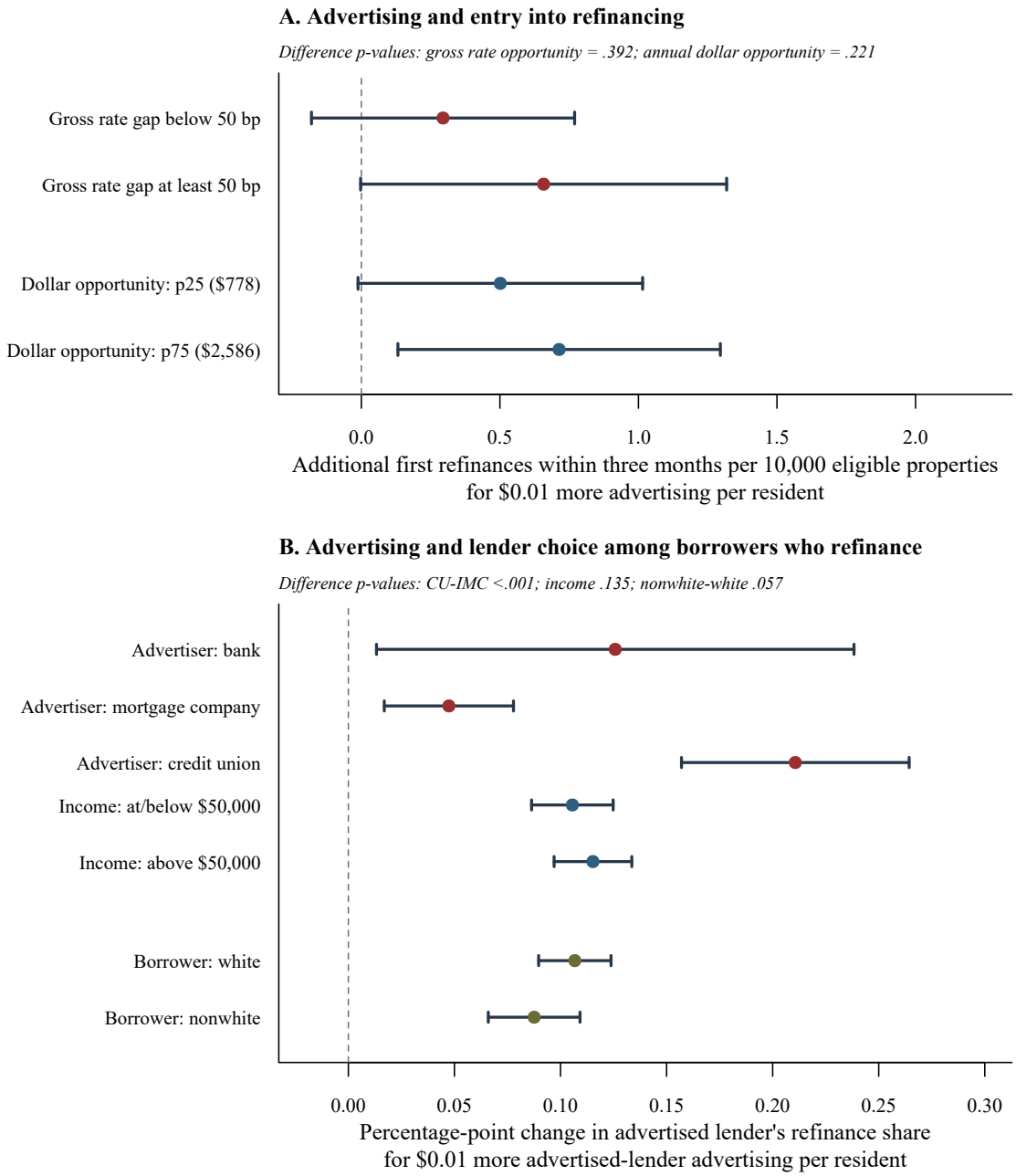


Figure 6: Who Responds to Mortgage Advertising and Whose Advertisements Are Effective
Notes: Panel A reports the three-month market-expansion effect across predetermined refinancing opportunities. The gross rate gap is the national mortgage rate when the preceding mortgage was recorded minus the national rate one month before advertising. Annual dollar opportunity also uses estimated remaining balance. Panel B reports percentage-point changes in the advertiser's share among refinancing households by advertiser type and borrower group. Market-expansion estimates use the ten-mile monthly deeds design; lender-choice estimates use the ten-mile annual HMDA design. Bars are pointwise 95 percent confidence intervals. The group-difference p-values are printed in the figure.

Table 5: Who Responds to Mortgage Advertising and Whose Advertisements Are Effective

	One s.d. below mean	One s.d. above mean	Difference
Panel A. Additional refinances within three months			
Prior-year low-income borrower share	0.895	0.473	-0.422
	(0.614)	(0.307)	(0.819)
Prior-year nonwhite borrower share	0.069	1.330***	1.261***
	(0.219)	(0.290)	(0.263)

	Bank	Independent mortgage company	Credit union
Panel B. Effect on the advertising lender's refinance share			
Fuzzy border estimate	0.126**	0.047***	0.211***
	(0.057)	(0.016)	(0.027)
Direct advertising-amount association	0.073	0.017***	0.174***
	(0.055)	(0.004)	(0.037)
First-stage F-statistic	269.8	110.8	224.4
IMC minus bank		−0.078 (0.060)	
Credit union minus bank		0.085 (0.063)	
Credit union minus IMC		0.163*** (0.031)	
Panel C. Lender-type market-expansion robustness within three months		($p = .667$)	
Strict named-type estimates	0.474	0.830	0.066
	(0.374)	(0.607)	(0.500)
Named-spend weighted average		0.572* (0.324)	

Notes: Panel A reports additional unique refinances per 10,000 eligible properties caused by an additional $0.01 of local mortgage advertising per resident. Its modifiers are predetermined, lagged place characteristics; differences can reflect which households are exposed to the channels and times when advertisements air as well as differential household responsiveness. Panel B reports percentage-point changes in the focal lender's share among refinancing households per $0.01 of its advertising per resident. It uses the ten-mile 2019–2021 sample and classifies advertisers using official lagged-HMDA reporter type aggregated to the parent-year. IMC denotes independent mortgage company. The fuzzy-border row instruments advertising and its lender-type interactions with high-side assignment and the corresponding interactions. The direct advertising-amount row uses observed spending on the same exact 417,896-observation support and is descriptive because lenders choose their advertising. Panel B standard errors are two-way clustered by ZIP and lender–border–year assignment. Panel C reports current-month effects from the ten-mile monthly border design over January 2007–December 2021. Effects are additional unique properties refinancing within three months per 10,000 at-risk properties for $0.01 more advertising per resident. The strict decomposition assigns spending to a named lender type only when the advertiser identity is eligible for the lender-choice analysis; the residual category is not shown. The named-spend weighted average uses fixed spending shares of 0.386 for banks, 0.457 for independent mortgage companies, and 0.157 for credit unions and retains the covariance among the three estimates. Panel C standard errors are two-way clustered by constituent DMA and calendar month. The equality test compares the three type-specific Panel C coefficients. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 6: When Mortgage Advertising Occurs and the Rates Advertisers Offer

	Calendar-month mean	Ad-dollar-weighted mean	Difference
Panel A. National advertising timing, 2007–2021			
National mortgage rate (percent)	4.294	4.363	6.9 bp
Eligible mortgages with at least 50 bp to gain (percent)	55.8	53.9	-1.9 pp
Mean rate-saving opportunity (basis points)	85.0	82.3	-2.8 bp

Panel B. Lender rates attached to advertising, 2021	
Advertising-weighted lender offer rate	2.954%
Advertising-weighted national mortgage rate	2.949%
Advertising-weighted lender offer minus national rate	0.5 bp
Unweighted lender offer minus same-year advertiser mean	3.2 bp
Correlation of log advertising with same-year relative offer rate	-0.099***
Share of local advertising spending with an attached lender rate	57.2%

Notes: Panel A compares an ordinary average across the 180 months from 2007 through 2021 with an average weighted by local mortgage television spending in each month. Refinancing opportunity is the prior mortgage's national rate minus the current national mortgage rate, evaluated over the eligible ZTRAX mortgage stock. Total local advertising spending is $918.6 million. Panel B uses the 2021 advertiser–lender crosswalk and HMDA-based offer-rate layer. The first three rows are weighted by attached local advertising dollars across parent–DMA–month cells. The relative-offer mean is unweighted across all 1,535 linked parent-months; the correlation is unweighted across the 1,467 linked parent-months with positive local spot spending and uses log local spot dollars and the lender offer centered by its HMDA-volume-weighted same-year mean. Attached cells contain $44.9 million of $78.5 million in local spot spending. The counterfactual values each induced refinance in the month and place where advertising occurred, using the contemporaneous opportunity distribution and the estimated response by opportunity; lender-specific terms are attached only when the advertising parent is linked to a lender. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 7: Reduced-Form Moments and Demand-Model Decomposition

	Estimate	Std. error	95% CI
Panel A. Reduced-form inputs for the pooled point calibration			
Additional refinances per 10,000 eligible properties	0.678	0.263	$[0.163, 1.193]$
Increase in advertising lender's refinance share (percentage points)	0.124	0.010	$[0.104, 0.144]$
Panel B. Pooled calibration per 10,000 eligible properties			
Originations with the advertising lender	0.182	0.014	$[0.154, 0.211]$
Originations with competing lenders	0.496	0.261	$[-0.015, 1.006]$
Total additional refinances	0.678	0.263	$[0.163, 1.193]$
Share of additional refinances going to competitors	73.1%	10.2 pp	$[53.1\%, 93.1\%]$
Panel C. Model channels, benchmark within-refinancing parameter $\lambda = 0.75$			
Refinancing generated by direct channel	0.547		
Refinancing generated by lender channel	0.130		
Model prediction with both channels	0.678		

Notes: Panel A reports the two reduced-form inputs used in the pooled point calibration. Panel B assigns the average total-advertising market-expansion response to a focal lender and applies equation (5). Its standard errors and normal confidence intervals treat the two reduced-form estimates as independent and hold baseline refinances and the initial lender share fixed. The allocation is a calibration rather than a directly estimated causal ratio. Panel C shows the pooled model decomposition at $\lambda = 0.75$, near an existing retail-banking estimate. Alternative λ values and the established lender–ZIP margin appear in the appendix.

Table 8: Economic Magnitudes per Dollar of Mortgage Advertising

Quantity	Estimate
Panel A. Benchmark	
Additional refinances per $1,000 of advertising	0.366
Average rate-saving opportunity among induced refinances	97.1 bp
Borrower mortgage value created by $1 of advertising	$1.84
90% confidence interval	[$0.79, $3.08]
Additional advertiser originations per $10,000 of advertising	0.982
Advertiser gross production revenue per $1 of advertising	$1.08
Panel B. Alternative refinancing timing without the advertisement	
Less frequent future attention: average 8.5 years between attention events	$2.48
More frequent future attention: average 3.0 years between attention events	$1.44

Notes: The borrower-value rows combine the pooled causal response to all local mortgage advertising with a $300,000 balance, a 1.25-percent refinancing cost, national mortgage rates subsequently realized, the estimated refinancing-opportunity response gradient, and the observed timing and geography of advertising. Their confidence interval uses a border-pair bootstrap while holding the financial inputs fixed. The advertiser rows apply the registered valuation-sample N/E conversion from the pooled all-local-spot placement ledger to the pooled point calibration in Table 7. Gross production revenue uses the Mortgage Bankers Association's 2021 industry-wide production-revenue measure; it is revenue, not profit. Panel B changes only the assumed arrival rate of future refinancing attention. The no-later-refinancing upper reference and the full duration, fee, rate-assignment, opportunity-response, placement, and model-parameter grids appear in the appendix.

A Data Appendix

This appendix groups the supporting material on sample coverage, DMA geography, advertising measurement, lender matching, rates and fees, and validation of the deeds-based refinancing measure. Figure 8 shows the DMA geography. Figures 7 and 10 place mortgage advertising in the broader television market and show its evolution alongside mortgage originations. Figure 9 and Table 11 compare the deeds measure with HMDA.

A.1 Estimation samples and coverage

Appendix Table 9 reports the geographic and temporal coverage of the deeds and HMDA estimation samples, along with the advertising spending represented in the data.

A.2 Construction of lender rates and fees

We construct the standardized lender rate separately in 2019, 2020, and 2021. In each year, the rate sample consists of originated 360-month, conventional, first-lien mortgages on site-built one-to-four-family properties, excluding open-end and business-purpose loans. We winsorize the reported interest rate at the first and ninety-ninth percentiles and estimate

$$r^{w}_{i\ell t} = \alpha_{\ell t} + \beta_{1t} \log V_i + \beta_{2t} \log Y_i + \beta_{3t} \log L_i + \beta_{4t} \, \mathrm{CLTV}_i + \beta_{5t} \, \mathrm{DTI}_i + \varepsilon_{i\ell t}, \tag{15}$$

where V_i is property value, Y_i is borrower income, L_i is loan amount, CLTV is the combined loan-to-value ratio, and DTI is the debt-to-income ratio. The fixed effect $\alpha_{\ell t}$ is the standardized rate term for legal lending entity ℓ. Because equation (15) is estimated separately by year, its normalization compares lenders within the same annual rate environment. When an advertising parent is linked to more than one legal entity in a year, we retain the entity with the largest number of loans in the rate file.

The fee term is constructed differently. For each legal entity and year, we average total loan costs divided by loan amount over covered originations with non-missing fields. The benchmark uses the 2021 average because the lender-offer comparison used in the valuation is evaluated in 2021. Thus the rate term adjusts for the observed borrower and loan characteristics in equation (15), while the fee term is the lender's observed average cost share

rather than a borrower-adjusted fixed effect. The valuation ledger attaches usable rate and fee terms to 57.2 percent of local advertising spending. Terms are unavailable when the advertiser cannot be linked to HMDA, when the dated crosswalk supplies no usable legal entity, or when the retained entity has no qualifying rate sample or non-missing cost fields. For those advertisements, the benchmark uses the national mortgage rate from the Freddie Mac Primary Mortgage Market Survey.

A.3 Which advertisements are unmatched

Table 10 describes which Kantar observations can be linked to an HMDA lender. The unweighted match rate is 51.2 percent across cells defined by advertiser, DMA, and month, while the advertising dollar-weighted rate is 61.9 percent. The spending-weighted specification indicates that larger advertising cells are more likely to be matched. These comparisons are descriptive: the Kantar extracts reveal where, when, and how much an advertiser spends, but little else about advertisers that cannot be linked to HMDA.

B Additional Empirical Evidence

B.1 Bandwidth and spatial controls

Appendix Table 12 reports the total-refinancing design at four displayed bandwidths and under three spatial-control specifications; the replication files also report six- and seven-and-a-half-mile windows. Every column is estimated in ZIP-month levels with eligible-property-stock weights, border-pair-by-fixed-side and border-pair-by-month fixed effects, and constituent-DMA-by-calendar-month clustered inference. The columns respectively use no distance slopes, pooled fixed-side slopes, or persistent border-pair side slopes. The persistent border-pair specification requires at least two distinct ZIP distances on each side and therefore uses restricted support.

Appendix Table 15 reports lender-choice estimates across bandwidths and slope specifications. Its primary columns use assignment-specific slopes; the alternatives pool side slopes by fixed geographic orientation or by lender–border. Sections 4.2 and 4.3 summarize the estimates, and the table notes report weights, clustering, and exact sample construction.

Table 9: Estimation Sample Coverage

Sample coverage	Number
Panel A. Deeds market-expansion sample, 2007–2021	
DMA-border pairs	454
ZIP codes within 10 miles	13,276
Border-pair months	79,345
Border-side months	158,690
Panel B. HMDA lender-choice sample, 2000–2021	
Lender–border–year assignments	117,637
ZIP codes within 10 miles	12,661
Lenders	1,455
Lender–ZIP–year observations	4,008,314
Total local mortgage television spending, 2007–2021	$918.6 million
Spending linked to a lender	$568.6 million
Share of spending linked to a lender	61.9%

Notes: Panel A describes the ten-mile deeds sample used for the market-expansion estimates. Panel B describes the reviewed ten-mile HMDA lender-choice panel before fixed-effect singleton removal. Advertising totals cover the 2007–2021 period common to the principal quantity and value calculations.

Table 10: Characteristics of Advertising Matched to HMDA Lenders

	(1) Unweighted	(2) Spending weighted
Log advertising spending	0.022	0.041**
	(0.016)	(0.017)
Number of DMAs	0.000	-0.001
	(0.002)	(0.002)
Active months in year	-0.019**	-0.017**
	(0.007)	(0.007)
DMA fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	99,783	99,783
R^2	0.120	0.234

Notes: The unit of observation is a parent-advertiser–DMA–month with positive local mortgage television advertising in 2007–2021. The dependent variable equals one when the dated advertiser parent appears in the HMDA lender crosswalk. Log spending is the natural log of advertising dollars in that cell. The number of DMAs and active months are calculated within advertiser-year. Both columns include DMA and year fixed effects. Column (1) is unweighted; column (2) uses advertising spending as weights. Standard errors, clustered by advertiser parent, are in parentheses. Media type does not vary because the sample contains only local television advertising, and the Kantar extracts do not report daypart. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

B.2 All-lender adding-up check

Appendix Table 16 reports a functional-form check for conditional lender choice. The joint conditional MNL/PPML system contains every represented advertiser parent and an explicit composite alternative for all remaining lenders. ZIP-by-year fixed effects normalize fitted counts to the observed all-lender total, and the fitted shares add to one within each retained choice set. The linear fuzzy-border estimate remains the paper's causal lender-choice input.

B.3 Additional heterogeneity and influence diagnostics

Figure 11 shows the refinancing-opportunity split and the unstable lender-rate response gradient. Figure 12 reports market-expansion estimates across prior loan age, recorded loan amount, estimated balance, and annual dollar opportunity. Figure 13 reports the corresponding monthly interaction paths. These measures are constructed from information recorded before the advertising exposure.

Figures 14 and 15 report lender-choice heterogeneity by advertiser size and type and by borrower income and race. Figure 16 reports leave-one-lender-out influence estimates for the largest lenders.

C Demand and Value Sensitivity

Appendix Table 17 varies the within-refinancing substitution parameter λ while holding the pooled point-calibration inputs fixed. Lower values make lenders closer substitutes and assign less market expansion to the lender channel; higher values allow the advertised lender's improved appeal to raise the value of refinancing by more. The direct channel remains the larger calibrated expansion channel throughout the reported range.

Appendix Table 18 varies the assumed arrival of future refinancing attention and reports the placement decomposition. Less frequent future attention raises the value of advertising because the no-advertising household waits longer to reconsider its mortgage. More frequent attention lowers it. The table also shows the no-later-refinancing reference, the order-neutral decomposition of response heterogeneity and placement, and illustrative reallocations of the observed advertising budget. These are partial-equilibrium calibration exercises that hold

the causal response schedule fixed.

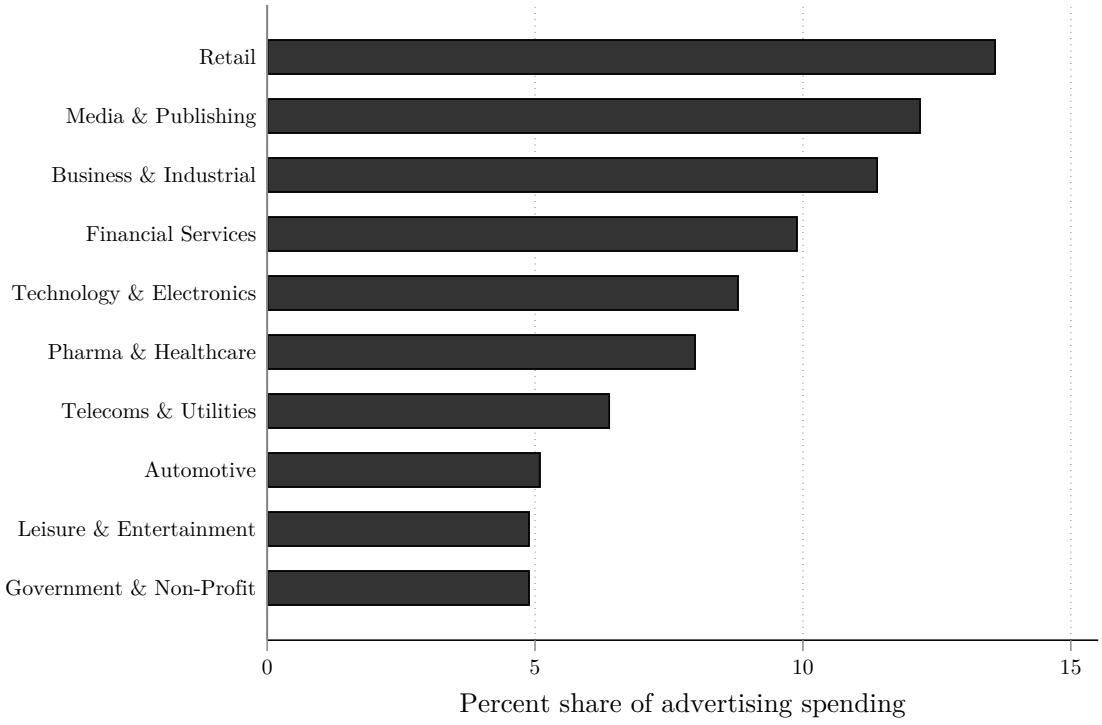


Figure 7: Television Advertising Spending by Industry

Notes: Bars report industry shares of measured television advertising spending. Financial services includes mortgage advertising and other financial products.

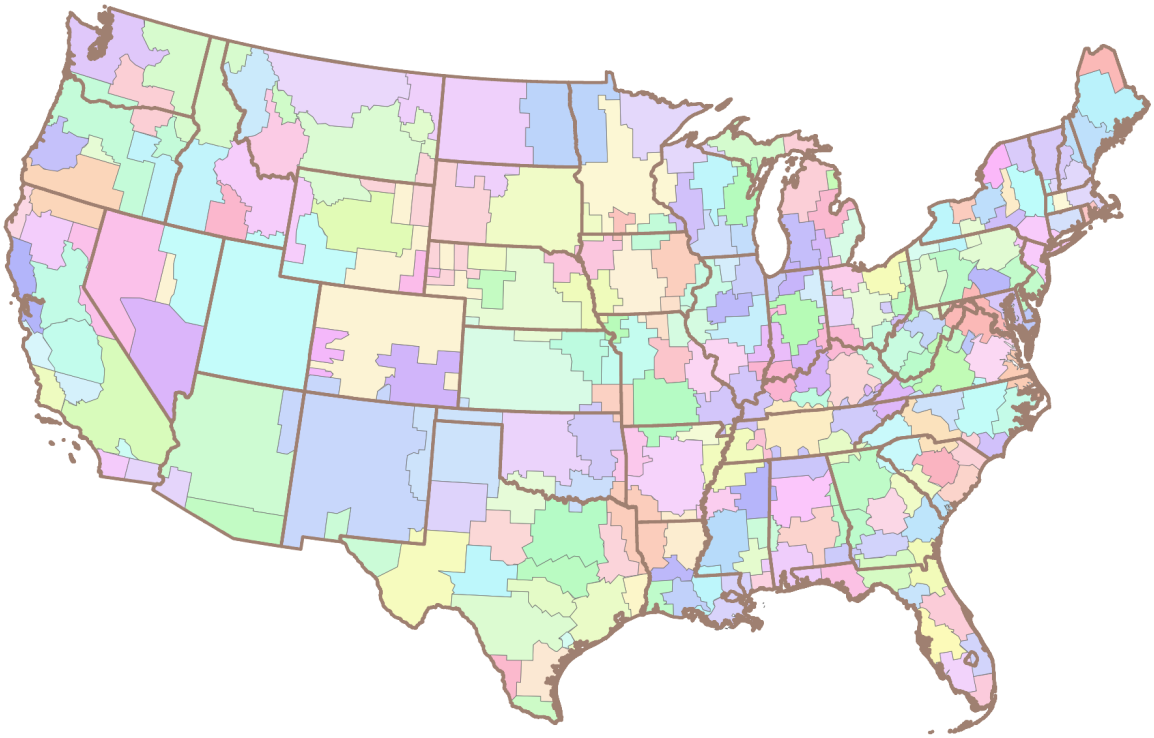
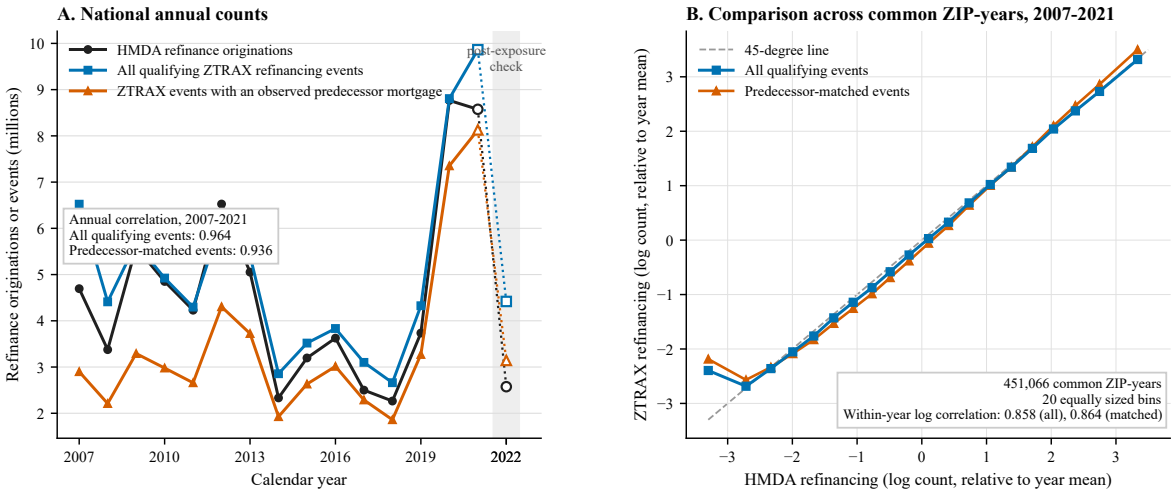


Figure 8: Designated Market Areas and Their Borders

Notes: The map shows U.S. Designated Market Areas and the boundaries used to form adjacent media-market pairs. The empirical samples additionally impose the stated ZIP-distance, data-coverage, and border-support requirements.



Notes: HMDA measures refinance originations allocated to 2010 ZCTAs. A qualifying ZTRAX event is a recorded mortgage of at least $10,000, excluding loan-type codes CL, CM, FA, and RM and records within 30 days of a deed; duplicates are removed. The matched series additionally requires an earlier classified mortgage on the same property. Panel B uses common ZIP-years after stable ZTRAX coverage begins. The shaded 2022 observations are a post-exposure check and are excluded from reported fit statistics.

Figure 9: Validation of the Deeds-Based Refinancing Measure

Notes: Panel A compares national annual HMDA refinance originations with qualifying refinancing events in the deeds data, both for all events and for events with a preceding recorded mortgage. Panel B compares within-year ZIP variation on the common support. The shaded 2022 observations are a post-exposure check and are excluded from the reported correlations.

Table 11: Validation of the Deeds-Based Refinancing Measure

Validation statistic	All qualifying ZTRAX events	Events with an observed predecessor mortgage
Correlation of national annual counts, 2007–2021	0.964	0.936
ZTRAX events divided by HMDA originations, 2007–2021	1.102	0.758
Correlation of common county-year counts, 2007–2021	0.966	0.966
Correlation of common ZIP-year counts, 2007–2021	0.928	0.930
Within-year log correlation across common ZIP-years, 2007–2021	0.858	0.864
Common ZIP-years, 2007–2021	451,066	451,066
2022 events divided by HMDA originations (post-exposure check)	1.716	1.220
2022 log correlation across common ZIPs (post-exposure check)	0.872	0.891

Notes: HMDA measures refinance originations allocated to 2010 ZCTAs. A qualifying ZTRAX refinancing event is a mortgage record of at least $10,000 that is not within 30 days of a deed and excludes construction, commercial, FHA, and reverse-mortgage loan types; duplicate records are removed. The predecessor-matched measure additionally requires an earlier classified mortgage on the same property and is therefore expected to contain fewer events. ZIP-year and county-year comparisons use common geographic support after the dominant county reaches stable ZTRAX coverage. The 2007–2021 window matches the causal advertising analysis. Calendar year 2022 is a post-exposure check and is excluded from the principal fit statistics.

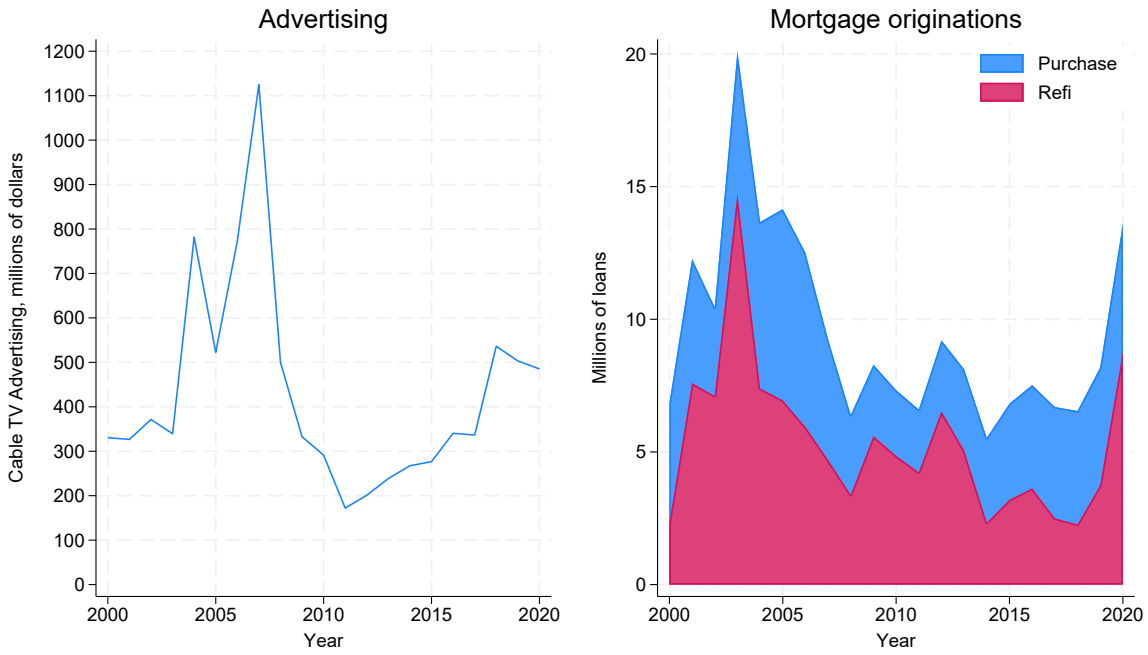


Figure 10: Mortgage Advertising and Mortgage Originations over Time

Notes: The left panel reports annual mortgage television advertising. The right panel reports annual purchase and refinance originations. The figure is descriptive and does not supply the identifying variation, which comes from differential advertising at DMA borders.

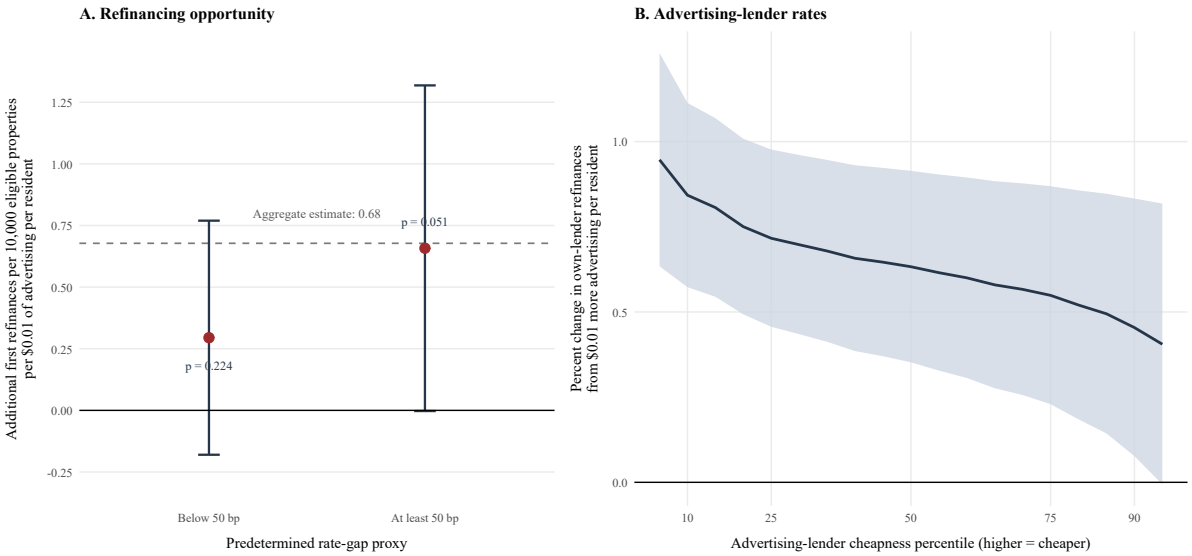


Figure 11: Additional Response Heterogeneity

Notes: Panel A reports three-month market-expansion effects below and above a 50-basis-point predetermined refinancing opportunity. The p-value printed above the high-opportunity estimate tests that estimate against zero; the difference between the two groups is not statistically significant. Panel B plots the lender-choice response across percentiles of the advertising lender's standardized relative mortgage rate. The lender-rate gradient is unstable across samples and mappings, so it is not used as a causal heterogeneity parameter in the benchmark valuation. Bars are pointwise 95 percent confidence intervals.

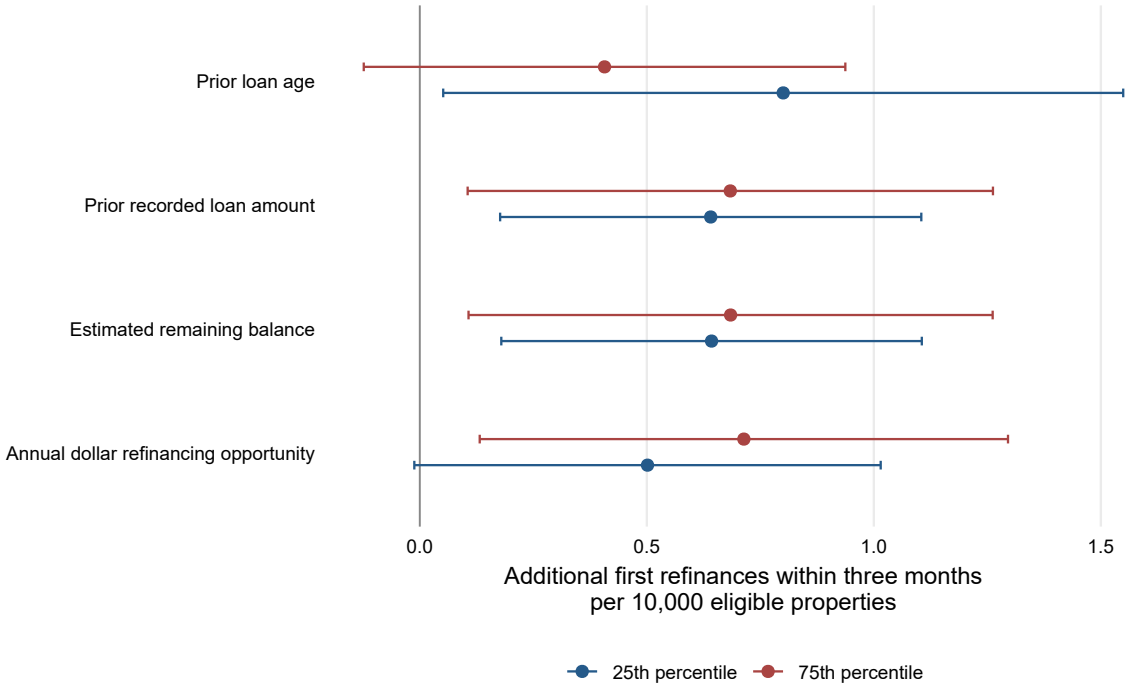


Figure 12: Market-Expansion Effects across Predetermined Loan Characteristics
Notes: Points report three-month market-expansion effects evaluated at the 25th and 75th percentiles of each predetermined characteristic. Estimated remaining balance amortizes the preceding recorded loan amount. Annual dollar opportunity multiplies the balance by the national rate gap. Bars are pointwise 95 percent confidence intervals clustered by border pair and calendar month.

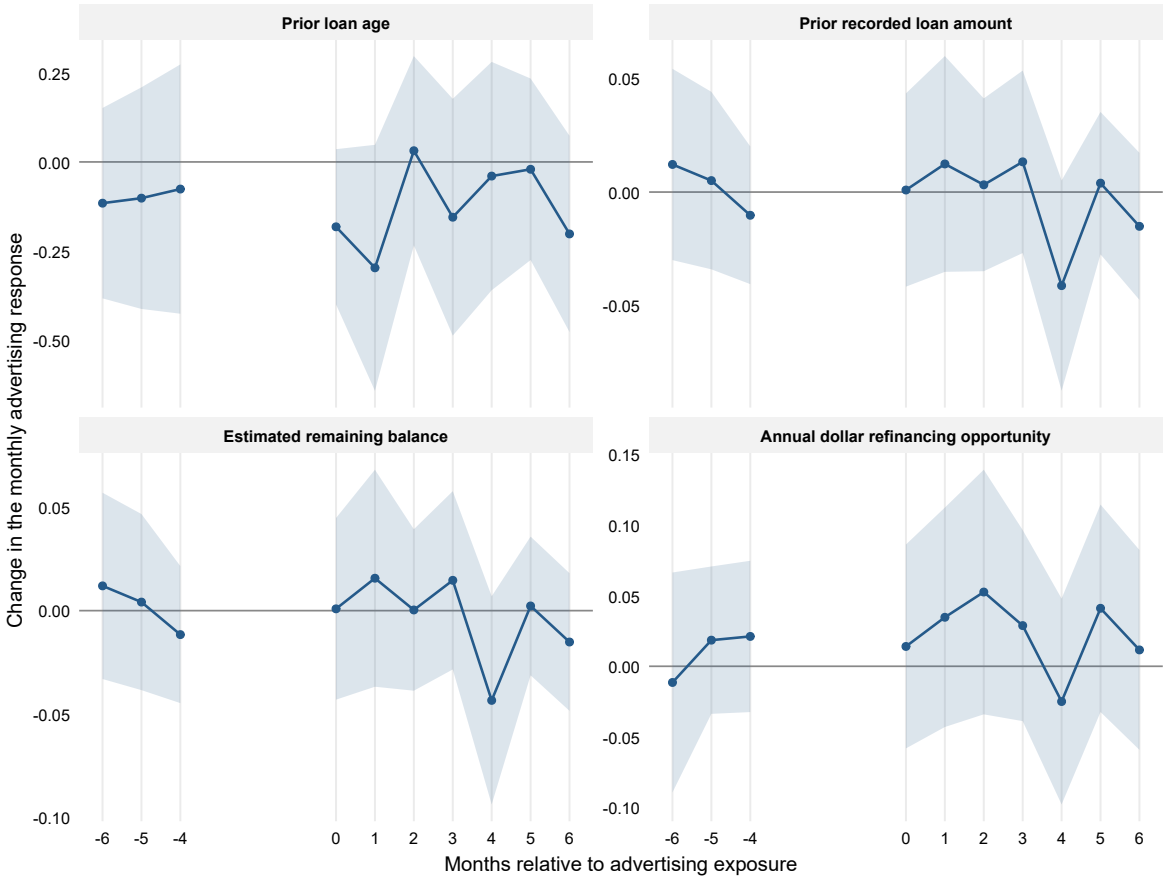


Figure 13: Monthly Diagnostics for Market-Expansion Heterogeneity

Notes: The panels report changes in the monthly advertising response associated with prior loan age, prior recorded loan amount, estimated remaining balance, and annual dollar refinancing opportunity. Months −6 through −4 are placebo coefficients; months −3 through −1 enter as outcome-history controls and are not plotted. Shaded regions are pointwise 95 percent confidence intervals.

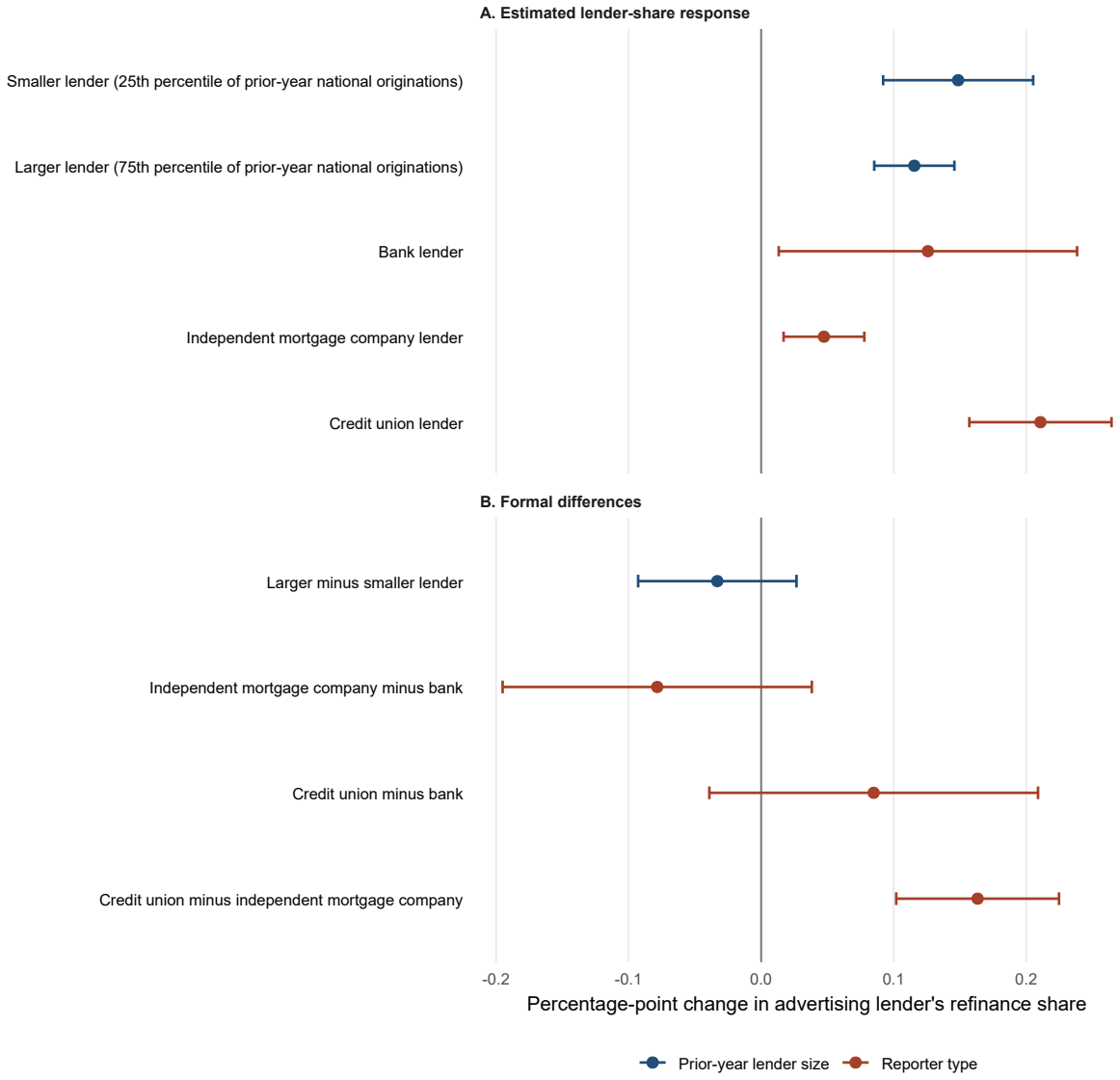


Figure 14: Advertiser Effectiveness by Lender Size and Type

Notes: Points report the percentage-point effect of an additional cent of focal-lender advertising per resident on that lender's share of local refinance originations, conditional on refinancing. Size is prior-year national refinance originations. Reporter type compares banks, independent mortgage companies, and credit unions. Panel B reports direct differences. Bars are 95 percent confidence intervals using the clustering convention of the lender-choice design.

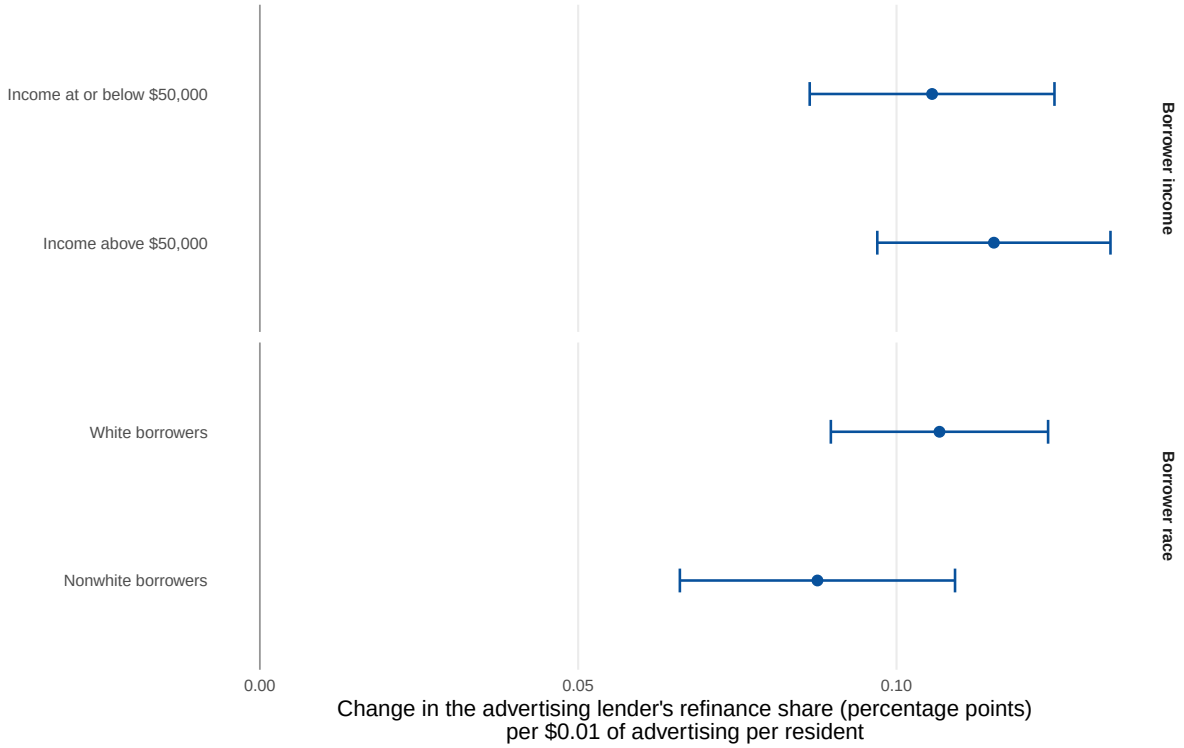


Figure 15: Lender-Choice Effects across Borrower Income and Race Groups

Notes: Points report the percentage-point effect of an additional cent of focal-lender advertising per resident on that lender's share of refinance originations within each borrower group. The estimates describe lender choice among households who refinance and do not identify group-specific entry into refinancing. Bars are 95 percent confidence intervals.

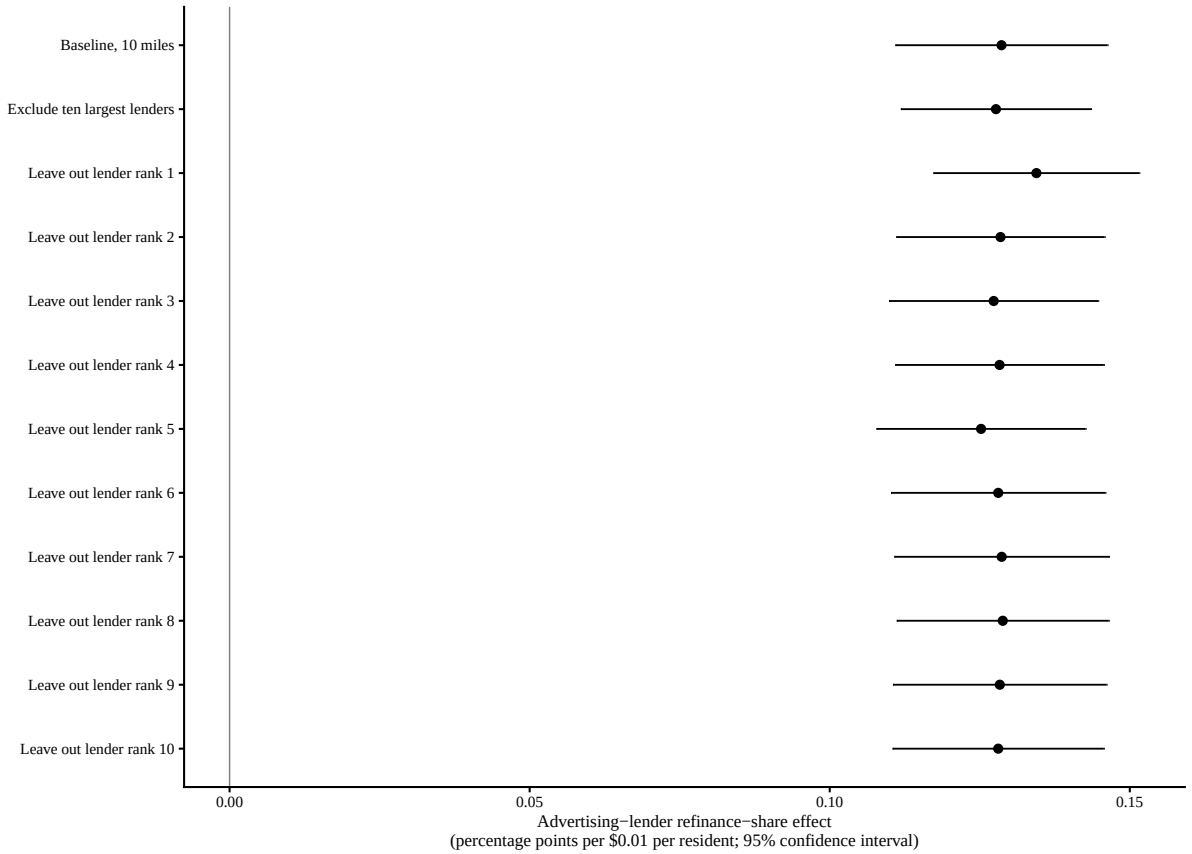


Figure 16: Influence Diagnostics for the Lender-Choice Estimate

Notes: The figure reports the focal-lender share effect in the full 2007–2021 main lender-choice sample at the ten-mile bandwidth, after excluding the ten largest lenders, and after omitting each of those lenders one at a time. Bars are 95 percent confidence intervals.

Table 12: Bandwidth and Spatial-Control Robustness in the Total-Refinancing Design

	No spatial slopes	Pooled slopes	Border-pair slopes
Eight miles			
3 months	0.644**	0.645**	0.699**
	(0.264)	(0.264)	(0.270)
6 months	0.722*	0.724*	0.775**
	(0.396)	(0.396)	(0.404)
12 months	0.677	0.680	0.671
	(0.667)	(0.667)	(0.682)
Border-pair months	79,267	79,267	63,435
Underlying ZIP-month rows	2,029,225	2,029,225	1,925,243
Ten miles			
3 months	0.678**	0.679**	0.709***
	(0.263)	(0.263)	(0.269)
6 months	0.816**	0.818**	0.835**
	(0.373)	(0.373)	(0.376)
12 months	0.919	0.923	0.835
	(0.635)	(0.636)	(0.627)
Border-pair months	79,345	79,345	64,787
Underlying ZIP-month rows	2,250,148	2,250,148	2,152,261
Twelve miles			
3 months	0.681***	0.683***	0.692***
	(0.259)	(0.260)	(0.263)
6 months	0.832**	0.834**	0.844**
	(0.381)	(0.381)	(0.385)
12 months	0.977	0.983	1.002
	(0.651)	(0.652)	(0.650)
Border-pair months	79,377	79,377	66,233
Underlying ZIP-month rows	2,471,554	2,471,554	2,383,344
Fourteen miles			
3 months	0.650***	0.652***	0.658***
	(0.240)	(0.241)	(0.242)
6 months	0.709*	0.712**	0.720**
	(0.360)	(0.361)	(0.362)
12 months	0.749	0.756	0.777
	(0.635)	(0.636)	(0.636)
Border-pair months	79,521	79,521	66,677
Underlying ZIP-month rows	2,681,849	2,681,849	2,592,296

Notes: The outcome is additional unique refinancing properties per 10,000 eligible properties for an additional \$0.01 of advertising per resident. Every column is a ZIP-by-month regression weighted by the eligible-property stock in the exposure month and absorbs border-pair-by-fixed-side and border-pair-by-month fixed effects. The first column has no distance slopes. The second adds pooled fixed-geographic-side slopes. The third uses the subset on which both sides identify persistent border-pair slopes. The standardized bandwidth grid is 6, 8, 10, 12, and 14 miles. At 6 miles, the three-month no-slope estimate is 0.502 (0.230), directionally consistent with the displayed windows. The replication package reports all five bandwidths and exact support diagnostics. Standard errors are two-way clustered by constituent DMA and calendar month. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 13: Lender-Type Robustness: Market Expansion and Spillover Accounting

	H3	H6	H12
Panel A. Additional unique refinances per 10,000 eligible properties			
Bank advertising	0.474	0.301	−0.301
	(0.374)	(0.640)	(1.152)
Independent mortgage company advertising	0.830	1.207	1.107
	(0.607)	(0.868)	(1.435)
Credit-union advertising	0.066	0.229	3.120
	(0.500)	(1.028)	(2.067)
Canonical remainder (residual)	0.850*	1.134	1.107
	(0.443)	(0.770)	(1.207)
Strict named-lender spending mix	0.572*	0.704	0.879
	(0.324)	(0.462)	(0.838)
Broader advertiser-identity named mix	0.554*	0.612	0.737
	(0.314)	(0.459)	(0.830)
All-dollar canonical spending mix	0.727**	0.942**	1.006
	(0.307)	(0.476)	(0.747)
Wald p-value: bank = IMC = credit union	0.667	0.656	0.386
Wald p-value: all four components equal	0.643	0.770	0.592

Panel B. H3 accounting for the strict named-lender spending mix

	Point effect	Delta-method 90% level interval	90% simultaneous Bonferroni set
Total additional refinances	0.572	$[0.040, 1.105]$	$[-0.625, 1.769]$
Originations with the advertising lender	0.154	$[0.099, 0.210]$	$[0.025, 0.286]$
Originations with competing lenders	0.418	$[-0.109, 0.945]$	$[-0.875, 1.713]$

Notes: Effects are for an additional \$0.01 of advertising per resident; H3, H6, and H12 count refinancing at least once within three, six, and twelve months. The strict decomposition assigns exposure to a named type only when the dated advertiser is supported, the advertisement satisfies the mortgage-lender eligibility rule used by the lender-choice design, and official HMDA records identify its type. The residual is the canonical local spot exposure not assigned to an eligible named lender and is not interpreted as national advertising. The broader row classifies every supported advertiser identity with an unambiguous official identity-year type regardless of product scope. The four current components and three lags of each enter jointly in the full 2007–2021 ten-mile design. Estimates use eligible-property weights, horizon-specific border-pair-by-side and border-pair-by-month fixed effects, and two-way clustering by constituent DMA and month. The strict named weights are 0.386, 0.457, and 0.157 for banks, independent mortgage companies, and credit unions; the all-dollar weights are 0.172, 0.204, 0.070, and 0.555 including the residual.

Panel B combines the strict outer estimates with corrected type-specific lender-share effects, 141 baseline refinances per 10,000 properties, and type-specific low-side shares. Delta-method intervals retain covariance across types within each design and set outer–inner covariance to zero. The simultaneous set is a 90 percent Bonferroni rectangle over the six primitive type effects. The implied competitor share is 73.0 percent as a point calibration; no ratio interval is reported because the simultaneous set for total expansion includes zero. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 14: Lender-Choice Robustness to Advertiser-Match Reweighting

	Original	Entropy balance	Stabilized IPW	Capped IPW
Panel A. Lender-choice estimates and diagnostics				
Lender-share effect (percentage points)	0.124***	0.131***	0.154***	0.152***
	(0.010)	(0.010)	(0.016)	(0.015)
First-stage coefficient	0.0148***	0.0126***	0.0098***	0.0102***
	(0.0003)	(0.0002)	(0.0002)	(0.0002)
First-stage F-statistic	3,059.4	3,407.3	2,685.6	3,093.1
Observations	2,029,229	2,029,229	2,029,229	2,029,229
Maximum absolute standardized difference	0.167	0.080	0.142	0.045
Maximum parent–year weight	1.00	14.14	83.34	19.83
Panel B. Spillover accounting				
Weighted initial lender share	0.97%	0.77%	0.63%	0.73%
Advertiser originations	0.182	0.191	0.222	0.220
Competitor originations	0.496	0.487	0.456	0.458
Competitor share	73.1%	71.9%	67.2%	67.5%
95% confidence interval	[53.1, 93.1]	[50.7, 93.0]	[42.0, 92.4]	[42.8, 92.3]

Notes: The target is the complete sample of positive local mortgage television advertising by canonical advertiser parent, DMA, and month during 2007–2021. Advertisers that can be linked to HMDA account for 65.8 percent of target spending. Entropy balance matches the spending-weighted distributions of log advertising, advertiser–year geographic reach and active months, DMA, and year. Stabilized inverse-propensity weights use the same variables; the capped version limits the cell factors at their first and 99th percentiles. Each factor is collapsed to advertiser-parent–year and applied uniformly to every ZIP and both sides of the corresponding lender-border-year comparison. All columns use the same exact-common ten-mile support, original population weights, fixed effects, spatial slopes, and two-way clustering by ZIP and lender–border–year assignment. The common-support restriction excludes 0.018 percent of target spending.

Panel B holds the market-expansion response at 0.678 (0.263) and baseline refinancing at 141 per 10,000 eligible properties; weighted columns use their weighted initial lender share. Normal delta-method intervals treat the market-expansion and lender-choice estimates as independent and hold baseline refinancing, the initial lender share, and estimated selection factors fixed. Confidence intervals are in percentage points. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 15: Bandwidth and Spatial-Control Robustness in the Lender-Choice Design

Panel A. Main lender-choice sample	Primary	ZIP–year FE	Rival advertising	Pooled slopes	Persistent slopes
Five miles	0.126***	0.134***	0.130***	0.148***	0.114***
	(0.010)	(0.011)	(0.010)	(0.009)	(0.009)
Observations	2,139,229	2,139,229	2,139,229	2,139,229	2,139,229
Seven-and-a-half miles	0.125***	0.135***	0.129***	0.163***	0.110***
	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)
Observations	2,577,610	2,577,610	2,577,610	2,577,610	2,577,610
Ten miles	0.129***	0.138***	0.133***	0.177***	0.110***
	(0.009)	(0.010)	(0.009)	(0.009)	(0.008)
Observations	2,993,083	2,993,083	2,993,083	2,993,083	2,993,083
Fifteen miles	0.131***	0.140***	0.134***	0.210***	0.106***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)
Observations	3,854,289	3,854,289	3,854,289	3,854,289	3,854,289
ZIP × year fixed effects	No	Yes	No	No	No
Other represented lenders' advertising	No	Absorbed	Yes	No	No
Assignment-specific side slopes	Yes	Yes	Yes	No	No
Pooled fixed-geographic-side slopes	No	No	No	Yes	No
Persistent lender–border side slopes	No	No	No	No	Yes

Panel B. Larger active-lender sample	Baseline	ZIP × year FE	Lender × ZIP FE	Both sets of FE
Five miles	0.149***	0.149***	0.055***	0.055***
	(0.018)	(0.018)	(0.010)	(0.010)
Observations	142,799,832	142,799,832	142,799,832	142,799,832
Seven-and-a-half miles	0.148***	0.148***	0.054***	0.054***
	(0.017)	(0.017)	(0.009)	(0.009)
Observations	171,320,226	171,320,226	171,320,226	171,320,226
Ten miles	0.152***	0.152***	0.058***	0.058***
	(0.017)	(0.017)	(0.009)	(0.009)
Observations	195,360,459	195,360,459	195,360,459	195,360,459
Fifteen miles	Not available; panel constructed at ten miles			
ZIP × year fixed effects	No	Yes	No	Yes
Lender × ZIP fixed effects	No	No	Yes	Yes

Notes: The unit of observation is a lender–border–ZIP–year cell. The outcome is the focal lender's refinance-origination share, stored as a fraction in the source panel; coefficients are percentage-point changes for an additional \$0.01 of focal-lender advertising per resident. Panel A uses 2010 ZIP-population weights, lender–border–year fixed effects, and two-way clustering by ZIP and lender–border–year assignment. Every Panel A specification at a given bandwidth uses one exact common support. Panel B crosses each included lender-year with every eligible ZIP. A lender-year is included when its exact dated base-filer identity or reviewed advertiser-family identity is present for that year and all of its linked base filers have verified filer-year support. Missing local outcomes and identity-DMA advertising are coded zero only within that verified support. Panel B uses one common saturated-D support for specifications A–D and clusters by ZIP and lender–border. The larger active-lender panel is built on a fixed ten-mile geography and cannot be extended beyond it. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 16: Joint All-Lender Conditional Choice: Functional-Form and Adding-Up Check

	Joint all-lender MNL/PPML
High-advertising-side assignment	0.086***
	(0.009)
ZIP–year choice sets used	199,981
Model rows used	1,718,573
Represented advertiser parents	852
Weighted share of refinances at represented advertisers	19.2%
Explicit all-other-lenders alternative	Yes
Maximum fitted-share adding-up error	4.44×10^{-16}
Maximum fitted-count total error	5.23×10^{-5}

Notes: The coefficient is the effect of high-advertising-side assignment on the focal advertiser's log conditional lender utility. The 2000–2021 model contains each advertiser parent represented in the reviewed panel and a composite alternative containing all other lenders. ZIP-by-year fixed effects make PPML numerically equivalent to a conditional multinomial logit and normalize fitted counts to the observed all-lender total in each retained choice set. The system also includes alternative-by-year and focal-assignment controls. The standard error is two-way clustered by ZIP and focal assignment. High-dimensional fixed-effect and perfect-zero handling retains 199,981 of 200,115 choice sets and 1,718,573 of 3,024,378 rows; the residual alternative preserves the all-lender market total. All registered adding-up and nonnegativity checks pass. This coefficient is a functional-form/model-fit companion and does not replace the paper's linear fuzzy-border causal estimate. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 17: Demand-Model Parameter and Advertising-Margin Sensitivity

λ	Lender utility shift	Direct channel	Lender channel	Both channels
Panel A. Within-refinancing substitution				
0.25	0.030	0.634	0.043	0.678
0.50	0.061	0.591	0.087	0.678
0.75	0.091	0.547	0.130	0.678
1.00	0.121	0.503	0.174	0.678

Advertising margin	Share effect	Advertiser	Competitors
Panel B. Implied originations per 10,000 eligible properties			
Cross-market benchmark (ten-mile common support)	0.124 pp	0.182	0.496
Established lender–ZIP margin (ten-mile active-lender sample)	0.058 pp	0.088	0.590

Notes: Panel A holds the pooled point-calibration inputs fixed and varies the within-refinancing substitution parameter. Lower λ means lenders are closer substitutes. The main text reports $\lambda = 0.75$; the model fits the calibrated total effect in every row. Panel B holds the 0.678 total-refinancing effect fixed and changes only the conditional lender-share response. The cross-market row uses the 2007–2021 exact-common ten-mile estimate used in the counterfactual calculations. The established-relationship row uses specification D from the larger 2000–2021 ten-mile active-lender panel, which adds both ZIP-by-year and lender-by-ZIP fixed effects. That row illustrates how the established-relationship margin changes the destination of the expanded market rather than estimating a separate total market-expansion effect.

Table 18: Borrower-Value Calibration and Placement Sensitivities

Timing assumption	Attention intensity	Threshold (bp)	Refinance by 60m	Value per ad dollar
Panel A. Refinancing without the advertisement				
Berger attention-arrival benchmark	0.234	29.9	0.465	$1.84
Lower attention estimate	0.118	26.2	0.281	$2.48
More frequent attention	0.330	32.6	0.571	$1.44
Agarwal–Driscoll–Laibson threshold	0.234	100.6	0.377	$1.92
No later refinancing within five years	–	–	0.000	$3.38

Component	Value per ad dollar
Panel B. Order-neutral decomposition	
Uniform placement and flat response across opportunities	$1.686
Larger response among households with more to gain	+$0.637
Actual timing and market geography	−$0.485
Observed allocation and estimated response gradient	$1.839

Advertising allocation	Refis per $1,000	Value per ad dollar
Panel C. Reallocation of the observed advertising budget		
Actual advertising timing and geography	0.366	$1.839
Same dollars spread equally per resident across market-months	0.456	$2.379
Same dollars placed in the highest-value quarter of resident-months	0.875	$6.979
Same dollars placed in the lowest-value quarter of resident-months	0.211	−$0.663

Notes: Panel A changes future-attention or decision-threshold assumptions one at a time. The attention intensity is annual. The 100.6-basis-point sensitivity uses the optimal-refinancing rule in Agarwal, Driscoll, and Laibson (2013). Panel B decomposes the benchmark by averaging over the order in which the response gradient and observed placement are introduced. Components are rounded and may not sum exactly at the displayed precision. Panel C reallocates the same advertising dollars across supported market-months while holding the causal response schedule fixed. These are calibration and allocation counterfactuals, not separate causal estimates. The observed benchmark and Panel A totals incorporate the ten-mile lender-choice destination value. The other allocation counterfactuals retain the validated July calculations because the lender-destination adjustment is less than one-tenth of a cent per advertising dollar and does not change any displayed entry. Additional duration, fee, opportunity-tail, and rate-path sensitivities remain in the replication package.