Mortgage Lock-In and Housing Investment*

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Abstract

Homeowners with below-market mortgage rates are less likely to move, which increases the expected tenure in the homes they keep. Using a quarterly panel linking property records, mortgage originations, and building permits, we find that mortgage lock-in increases residential fixed investment in the form of maintenance, renovations, and expansions. An accounting exercise indicates that additional permitting by incumbent homeowners more than offsets the reduction associated with fewer sales. Maintenance is prevalent among homes of intermediate age, while permits for homes over 50 years old address functional obsolescence. We show that the response is driven by higher income households, rather than by those with more depreciated homes (and higher investment needs).

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1 Introduction

Homeowners with below-market fixed-rate mortgages are less likely to move (Batzer et al., 2026; Fonseca and Liu, 2024; Liebersohn and Rothstein, 2025). Given that improvement spending is closely tied to housing transactions (Benmelech et al., 2023), this is an additional channel through which higher interest rates reduce residential fixed investment, which in total accounts for about 4% of U.S. GDP.[1] Locked-in owners, however, also expect to stay in their homes longer, and much less is known about how they invest in the properties they keep. The sharp rise in mortgage rates since 2022 has resulted in millions of mortgage-locked homeowners, making this question particularly salient today. In this paper, we investigate how mortgage lock-in affects investment by homeowners who expect to stay in their homes due to lock-in.

The effect of higher interest rates on homeowners' investment decisions is theoretically ambiguous (Potepan, 1989; Schwab, 1985). On the one hand, higher rates reduce the net present value of home improvements, making homeowners less likely to invest. On the other hand, homeowners who expect to remain in their properties longer may invest more, especially in improvements whose private benefits are not fully capitalized into house prices (Billings, 2015; Gyourko and Saiz, 2004). At the same time, lock-in may also discourage investment if homeowners who would prefer to move are reluctant to invest in properties they hope to leave. Whether these homeowners invest more or less as they become increasingly locked in is ultimately an empirical question.

We begin our analysis by constructing a quarterly panel of single-family homes that links property records and mortgage originations. These data allow us to measure the extent to which each homeowner is locked in. We supplement these records with building permits that are originally sourced from local permitting authorities and then standardized and matched to individual properties by Cotality. Building permits are generally required for work that affects a property's structure, safety, major building systems, or floor area. The permit records also include detailed textual descriptions of the proposed work. We use these descriptions to distinguish between maintenance projects (e.g., roofing, plumbing, and HVAC work), discretionary improvements (such as kitchen and bathroom renovations), and expansions (e.g., additions and accessory dwelling units). Our primary measure of

[1] In 2025, spending on improvements to existing homes totaled approximately $435 billion, compared with $418 billion for new single-family construction (U.S. Bureau of Economic Analysis, National Income and Product Accounts, Tables 1.1.5 and 5.4.5). Together, the two components account for about two-thirds of residential fixed investment.

investment is whether a homeowner obtains a permit for any of these projects in a given quarter.

To estimate the effect of mortgage lock-in on residential investment, we follow the approach used in recent studies of mortgage lock-in and homeowner mobility (Fonseca and Liu, 2024; Liebersohn and Rothstein, 2025). We measure mortgage lock-in as the difference between mortgage rates in a given quarter and the rate available when each homeowner originated their existing mortgage; the larger the gap, the greater the lock-in. In our preferred specification, we compare homeowners within the same ZIP code and quarter, controlling for mortgage origination year and a range of property, homeowner, and mortgage characteristics. This approach holds constant prevailing mortgage rates and local housing market conditions, allowing us to compare otherwise similar homeowners who differ in how locked-in they are.

We first confirm that mortgage lock-in reduces homeowner mobility, consistent with existing research. A 100-basis-point increase in the mortgage-rate gap reduces the probability of selling a home in the following quarter by 0.083 percentage points, or approximately 6% relative to the sample mean. In addition, and consistent with (Benmelech et al., 2023), we show that home transactions are strongly associated with permitting in the quarters following a transaction, so the reduction in sales naturally leads to a reduction in this source of improvement spending.

We then turn to our building permit data to investigate how the same mortgage lock-in that discourages home sales affects investment in existing properties by homeowners who do not move. We find that greater mortgage lock-in increases the probability of obtaining permits across all three categories of investment. Specifically, a 100-basis-point increase in the mortgage-rate gap raises the probability of obtaining a maintenance permit by 6.1% relative to the sample mean. Locked-in homeowners are also more likely to undertake discretionary renovations and expansions.

We supplement our permit-based analysis with data from the Panel Study of Income Dynamics (PSID), which reports homeowners' annual spending on repairs and maintenance, to study the intensive margin of residential investment. Our mortgage and permit dataset provides an excellent measure of the extensive margin of residential investment, but it has two important limitations. First, reported project values are often missing or unreliable, limiting what the data tell us about the intensive margin of investment. Second, smaller repairs and cosmetic improvements often do not require permits. Using the PSID data and instrumenting for household-specific mortgage-rate gaps with aggregate market rates as in Fonseca and Liu (2024), we find that a 100-basis-point increase

in mortgage lock-in increases annual repair spending by approximately $427, or 13% relative to the sample mean.

Taken together, our findings suggest that mortgage lock-in reduces residential investment by discouraging transactions, but homeowners who are more locked in are also more likely to undertake capital improvement projects. To assess the relative importance of these two effects, we conduct a simple accounting exercise using our property-level data. We combine the estimates of the increase in permitting due to home purchases with our estimated effect of mortgage lock-in on home sales to calculate the reduction in permitting associated with fewer transactions. We then compare this reduction with the additional permitting undertaken by locked-in homeowners. Combining these two margins, we find that the estimated increase in permitting among incumbent homeowners more than offsets the estimated reduction associated with fewer home sales.

To interpret these responses, we view home improvement as an investment whose return includes both the consumption value of additional housing services and any increase in resale value. The consumption benefits depend on the gap between the home's current condition and the quality or configuration the homeowner desires. Mortgage lock-in extends the expected period over which homeowners incur the utility losses associated with this gap, potentially making investment more attractive, particularly when private benefits are not fully capitalized into resale prices. These benefits must be weighed against the opportunity cost of committing funds to the home. Limited liquid resources raise this opportunity cost, discouraging investment even when improvement needs are substantial. This perspective motivates our examination of property condition and homeowners' financial resources as two determinants of the investment response to mortgage lock-in.

We first consider a home's need for maintenance and improvements. Major components of a home, including roofs, heating and cooling systems, and plumbing, deteriorate over time and eventually require replacement. We find that the maintenance response to mortgage lock-in is strongest among homes aged 21 to 50 years, when many of these systems begin to require replacement. In contrast, discretionary renovations and expansions respond most strongly to mortgage lock-in among homes older than 50 years, consistent with homeowners adapting older properties to better meet their needs.

We next examine how the investment response varies with homeowners' financial resources. Using household income reported at mortgage origination, we find that higher-income homeowners

respond more strongly to mortgage lock-in, even when comparing homeowners within the same ZIP code and quarter. We find similar results when comparing higher- and lower-income neighborhoods.[2] This difference does not appear to reflect greater investment needs. Homes in lower-income neighborhoods exhibit larger age-related price discounts, consistent with greater accumulated depreciation. Together, these findings suggest that homeowners' financial resources play an important role in determining whether they respond to lock-in by investing in their properties.

To further study the relative importance of investment need versus the ability to invest in explaining the response of permitting to interest rates, we test how this response varies with previous permitting activity. Homes that have recently undergone improvements likely have fewer remaining maintenance needs, in which case we would expect a weaker response to lock-in. At the same time, the presence of recent permitting activity is evidence that the household is interested and able to invest in their home. We find that homes with recent permits respond more strongly to mortgage lock-in, particularly for discretionary renovations and expansions. This relationship is driven by properties where the current homeowner undertook the previous work, rather than improvements completed by a prior owner.

Together, these findings help shed light on why mortgage lock-in affects residential investment. The stronger maintenance response among middle-aged homes is consistent with homeowners becoming more willing to undertake costly repairs when they expect to remain in their properties longer. At the same time, the results on neighborhood income and previous investment activity suggest that the ability and willingness to undertake improvements is potentially even more important. This implies that mortgage lock-in exacerbates geographic inequality in housing quality and in consumption of housing services. Homeowners in higher-income neighborhoods respond to lock-in by maintaining and improving their properties, while those in lower-income neighborhoods, whose homes were already lower quality, face the double burden of being less able to move and less able to improve the homes they remain in.

Our paper contributes to several strands of literature. First, we contribute to research on households' decisions to move or improve their existing homes. Schwab (1985) and Potepan (1989) study how mortgage financing and interest rates influence these decisions, while Shear (1983), Seek (1983), and Montgomery (1992) examine the tradeoff between moving and undertaking improvements to the

[2] Gyourko and Tracy (2006) show a substantial elasticity of home maintenance and repairs to income shocks.

current home. We provide new empirical evidence on this tradeoff by linking homeowners' existing mortgages to subsequent investment in their properties. Our data allow us to examine not only whether homeowners invest, but also the types of improvements they undertake, and how these decisions respond to interest rate movements.

Second, we contribute to the growing literature on the consequences of mortgage lock-in. Existing studies establish that homeowners with below-market mortgage rates are less likely to move and examine the implications for housing and labor markets (Batzer et al., 2026; Ferreira et al., 2010; Fonseca and Liu, 2024; Liebersohn and Rothstein, 2025; Quigley, 1987). More recently, Katz and Minton (2026) and Fonseca et al. (2026) study the effects of mortgage lock-in on equilibrium house prices.[3] We identify another consequence of mortgage lock-in: homeowners who remain in their properties are more likely to invest in maintaining and improving them. By linking mortgage originations, ownership histories, and building permits at the property level, we measure this investment response directly and compare it with the reduction in investment associated with fewer home sales.

Finally, our paper contributes to research on residential capital expenditures and the maintenance of the existing housing stock. Previous work examines how the private returns to improvements, financing constraints, and housing depreciation affect investment decisions (Francke and van de Minne, 2017; Gyourko and Saiz, 2004; Harding et al., 2007; Knight and Sirmans, 1996; Lopez and Yoshida, 2022; Melzer, 2017). More recently, Benmelech et al. (2023) documents substantial spending on home improvements surrounding housing transactions. We complement this research by examining investment undertaken by homeowners who remain in their properties, and by studying how this investment varies with property age, previous improvements, and neighborhood income. We show that mortgage lock-in arising from changes in interest rates is associated with increased investment by homeowners who stay in their properties. Our findings suggest that interest rates can influence residential capital expenditures not only through the cost of financing, but also through their effects on homeowners' incentives to move.

[3] Katz and Minton (2026) also examine renovation permitting at the ZIP-code level. They find weak evidence that mortgage lock-in reduces renovation activity, although their estimates are statistically insignificant and do not distinguish investment by incumbent homeowners from investment associated with home sales.

2 Conceptual framework

We build on the mortgage lock-in framework of Fonseca and Liu (2024) and the model of Fazio et al. (2025) to consider how mortgage lock-in affects homeowners' decisions to invest in their existing properties. Our empirical strategy compares homeowners facing the same prevailing market interest rate but with different rates on their existing mortgages. We therefore focus our model's attention on how differences in existing mortgage rates affect investment incentives, holding fixed the market interest rate and the cost of financing improvements at prevailing rates. Broadly, our model is characterized by the following features. First, mortgage terms influence whether a household moves and therefore how long it expects to enjoy the services from an improvement. Second, investment depends on the gap between actual and desired housing quality and on the consumption forgone to finance it. Third, because many repairs and renovations require a substantial indivisible outlay, we model investment as a discrete project. This introduces a financing threshold: a household must be able to cover the outlay before its expected return can influence the investment decision.

2.1 Model

Household i owns a home of quality q_i and has an interest-only mortgage of balance B_i and fixed rate $\bar{r}_i$. Moving requires repaying that loan and financing a home of quality $q_i^M > q_i$ with a new balance B_i^M at market rate r. Define the rate gap $g_i = r - \bar{r}_i$. Moving changes mortgage payments by $g_i B_i + r(B_i^M - B_i)$. For $g_i > 0$, the household gives up below-market financing when it moves and faces a mortgage lock-in incentive. Our predictions focus on $g_i > 0$, so we ignore the possibility of refinancing for the purposes of this exposition.

There are two periods. In period zero, the household chooses whether to undertake one improvement, $d_i \in \{0,1\}$, with outlay $K_i > 0$. The project raises current-home quality by $\Delta q_i > 0$ and adds $\Delta V_i = v_i(q_i + \Delta q_i) - v_i(q_i) > 0$ to per-period housing utility. In period one, the household observes a moving opportunity ε_i with continuous distribution F_i, then chooses whether to stay or move. Improvements are assumed to provide owner-specific services but not to increase resale proceeds (an extreme version of the evidence in Gyourko and Saiz (2004) and Billings (2015)). With period-one

income y_{i1}, utility $u_i(c)+v_i(q)$, and moving cost κ_i in utility units, the continuation payoffs are

$$\begin{aligned} S_i(d_i) &= u_i(y_{i1} - \bar{r}_i B_i) + v_i(q_i + d_i \Delta q_i), \\ M_i(\varepsilon_i) &= u_i(y_{i1} - r B_i^M) + v_i(q_i^M) + \varepsilon_i - \kappa_i. \end{aligned} \tag{1}$$

The household stays if $S_i(d_i) \geq M_i(\varepsilon_i)$. The project raises the attractiveness of staying, and mortgage lock-in also raises its probability by making a move more costly.

Let a_i denote liquid assets, y_{i0} current income, and $w_i = a_i + y_{i0} - \bar{r}_i B_i$ cash on hand after the existing mortgage payment. The period-zero budget is $c_{i0} + d_i K_i \leq w_i$. To capture an indivisible project's financing requirement without adding a borrowing problem, suppose a minimum amount $\underline{c}_i > 0$ must remain for current consumption. The project is feasible only if $K_i \leq w_i - \underline{c}_i$; otherwise $d_i = 0$. The baseline thus considers projects funded from available liquid resources rather than new debt.

When the project is feasible, the household compares its value with and without investment. Define $s_i(d)$ as the probability of staying conditional on project choice d, and $\widetilde{s}_i$ as the average probability of staying as the project's utility gain is introduced, so $s_i(0) \leq \widetilde{s}_i \leq s_i(1)$. Appendix B defines this average precisely. The household undertakes the project if and only if

$$\left[1 + \beta \widetilde{s}_i\right] \Delta V_i \;\geq\; u_i(w_i) - u_i(w_i - K_i), \tag{2}$$

where $0 < \beta < 1$. The left side is the immediate housing benefit plus its expected discounted continuation value. The right side is the exact utility cost of reducing current consumption by the fixed outlay. This also accounts for the project's effect on the moving decision itself, since staying becomes more attractive when the household invests because the house provides better housing services.

2.2 Model Implications

The model provides four implications for how mortgage lock-in affects residential investment. First, mortgage lock-in increases investment by incumbent homeowners. An increase in the mortgage-rate gap g_i makes moving more expensive and increases the probability that the homeowner remains in the property. This increases the expected benefit of undertaking an improvement, since the homeowner is more likely to enjoy the additional housing services ΔV_i in the following period. As shown

in Appendix B, holding the existing mortgage rate $\bar{r}_i$ fixed, an increase in the market rate r weakly increases the net benefit of investing. Our empirical setting compares homeowners facing the same market interest rate r but with different existing mortgage rates $\bar{r}_i$. In the model, a lower $\bar{r}_i$ increases the incentive to invest through two channels. First, it increases expected tenure by making moving more expensive. Second, it increases cash available for investment, w_i, by reducing existing mortgage payments. Both channels increase the net benefit of investing, so the model predicts a nonnegative relationship between g_i and investment. However, this does not imply that every homeowner responds. Investment increases only for households whose projects become financially feasible or whose net benefits from investing become positive.

Second, the aggregate effect of mortgage lock-in on residential investment is ambiguous. The model predicts that a larger mortgage-rate gap reduces the probability of moving while increasing the incentive to invest in the current property. These effects have competing implications for aggregate residential investment. As documented in Benmelech et al. (2023), home purchases generate substantial spending on improvements. By reducing housing transactions, mortgage lock-in may therefore reduce investment associated with home purchases, even as it encourages incumbent homeowners to invest more in their existing properties.

Third, the investment response depends on the need for improvements. In the model, the benefit of investment is $\Delta V_i = v_i(q_i + \Delta q_i) - v_i(q_i)$, which depends on the home's initial quality q_i and the additional quality Δq_i provided by the improvement. Suppose housing utility is increasing and concave in quality below the homeowner's preferred level q_i^*, and an improvement raises quality without exceeding that level. Holding project size and preferences fixed, a lower q_i increases ΔV_i, making investment more attractive. Homeowners with greater improvement needs may therefore have stronger incentives to invest when mortgage lock-in increases their expected tenure. Note that a larger ΔV_i does not necessarily imply a greater response to lock-in, since homeowners with sufficiently large investment benefits may undertake the project regardless of their expected tenure.

Fourth, the investment response depends on the homeowner's financial resources. In the model, an improvement is feasible only if its cost K_i does not exceed available resources $w_i - \underline{c}_i$, where $w_i = a_i + y_{i0} - \bar{r}_i B_i$. Homeowners with insufficient resources cannot undertake an improvement, even when mortgage lock-in increases its expected benefits. Among homeowners who can afford the project, greater resources also reduce the utility cost of investment, $u_i(w_i) - u_i(w_i - K_i)$, when

consumption utility is concave. Homeowners with more financial resources may therefore be better positioned to respond to mortgage lock-in.

3 Data, Measurement, and Research Design

3.1 Data Sources

3.1.1 Property and Mortgage Records

Our main analysis uses property and mortgage records originally collected by county assessors and recorders' offices. These publicly available records contain each property's precise street address and building characteristics, its history of ownership transfers, and all mortgage originations secured by the property, including purchase mortgages and subsequent refinancing activity. We obtain these data from Cotality (formerly CoreLogic), which collects, cleans, and standardizes the underlying public records. We use these data to construct a quarterly property-level panel that tracks ownership tenure and the age, original amount, and purpose of the most recent mortgage.

We observe all mortgages and deeds of trust, which are recorded with the county to establish the lender's security interest in the property and are thus a matter of public record. The promissory notes specifying the contractual interest rates, however, are generally not publicly available. Following Fonseca and Liu (2024) and Liebersohn and Rothstein (2025), we proxy for each mortgage's contractual interest rate using the average 30-year fixed mortgage rate prevailing at the time of origination, obtained from Freddie Mac's Primary Mortgage Market Survey (PMMS). Using market rates rather than actual contractual rates has the additional advantage in our setting of excluding borrower-specific differences in mortgage pricing that may be correlated with unobserved borrower characteristics. To account for the fact that borrowers often lock in their rates before closing, we assign each mortgage the prevailing weekly rate 45 days before closing for purchase mortgages and 30 days before closing for refinancings.

We then use these rates to construct a quarterly measure of the mortgage rate gap, defined as the difference between the current market rate and the rate on the homeowner's most recent mortgage. Specifically, for each quarter, we calculate the difference between the lowest weekly 30-year fixed mortgage rate during that quarter and the rate assigned to the homeowner's existing mortgage. The

rate gap thus changes each quarter as market rates fluctuate. A positive gap indicates that market rates have risen since origination. For example, a homeowner whose most recent mortgage has a 3% rate would have a positive rate gap of three percentage points in a quarter when prevailing rates are 6%. At those rates, the homeowner would face a substantial increase in their monthly payment if they sold their home and purchased a similarly priced one. For this reason, we say that this homeowner is "locked in" to their current mortgage.

3.1.2 Building Permits and Residential Investment

Our next data requirement is a measure of homeowners' investments in their properties. We measure this residential fixed investment using building permit data. The underlying records are collected by local permitting authorities, which issue permits to ensure that proposed construction complies with building codes and other applicable requirements. Permits are required for many types of work on existing homes, including additions, structural alterations, and certain plumbing, electrical, and heating and cooling projects.[4] These publicly available records typically include the property's address, the dates the permit was filed and approved, and a textual description of the proposed work. Cotality collects permit records from these agencies, standardizes the descriptions of the work, and links each record to the same property identifier used in its deeds and assessor files. We can therefore observe permitting activity at individual properties and identify the mortgage and owner associated with each property at the time of the activity.[5]

We use Cotality's standardized project types, together with the textual descriptions of the proposed work, to classify permits into three categories. Maintenance includes work on existing systems and components, such as roofs, plumbing, electrical systems, HVAC, siding, and windows. Discretionary renovations include kitchen and bathroom remodeling, other interior renovations, and projects such as decks, patios, swimming pools, and solar installations. Expansions include additions, garages, accessory dwelling units, and conversions of existing space into living area.

A single improvement project can generate multiple permits. For example, a kitchen renovation may require a separate permit for plumbing work, while a larger project might expand the home's footprint while also renovating bathrooms and replacing ductwork. We account for this in two ways.

[4] North Carolina has a statewide building code, but some permitting requirements and the administration of permits vary across local jurisdictions. See North Carolina General Statutes, Section 160D-1110, accessed November 9, 2026.

[5] See Cotality's Building Permits product description.

First, for each property-quarter, we construct indicators for any permitted work and for each of the three categories. Because a property can have permits in multiple categories, anywhere from zero to four of these indicators can equal one in a given quarter. Second, we construct a project-scope index ranging from zero for no permitted activity to three for expansions and other large projects. When a property has several types of work in a quarter, we assign the highest scope.

Building permits are an incomplete measure of residential investment. Smaller repairs and cosmetic improvements often do not require permits, some projects may be undertaken without the legally required permits, and permits typically record proposed work, which may not ultimately be completed. Nevertheless, these data have some real strengths that make them well suited to our analysis. Most larger investments in residential properties, including major renovations and expansions, require permits. And in North Carolina, building codes also require permits for many maintenance projects regardless of size, including repairs to structural components and work on plumbing, electrical, and HVAC systems. The records therefore capture an economically important component of residential capital expenditures. Furthermore, because permits are recorded at the property level, we can observe the timing and nature of these investments and link them to the homeowner's mortgage, allowing us to study how investment decisions respond to changes in mortgage lock-in.

3.1.3 Panel Study of Income Dynamics

A second limitation of the permit data is that these records do not consistently report project costs, either estimated or realized. To examine how mortgage lock-in affects investment spending in dollars, we turn to data from the Panel Study of Income Dynamics (PSID), a longitudinal survey that tracks homeownership, residential moves, mortgage characteristics, and household spending, including information on household repair and maintenance expenditures.

3.1.4 Household and Neighborhood Income

We use two measures of income to study how homeowners' financial resources affect their investment decisions. First, we obtain household income reported under the Home Mortgage Disclosure Act (HMDA). Using the algorithm published in Bayer et al. (2025), we match HMDA mortgage originations to our property and mortgage records allowing us to observe the income reported by borrowers when obtaining their mortgages. Second, we measure neighborhood income using average adjusted

gross income from IRS ZIP-code data for 2005. We use this measure to classify ZIP codes into higher- and lower-income neighborhoods. Measuring neighborhood income before our sample period ensures that the classification predates the mortgage-rate changes we study.

3.2 Sample Construction and Summary Statistics

Our main sample covers homeowners with mortgages originated between 2010 and 2021 and matches these properties to permitting activity between 2014 and 2024. We restrict the analysis to counties with non-missing deeds, assessor, and permit data throughout this period. Incomplete coverage of deeds and assessor records, particularly in smaller and more rural counties, is well documented (Adelino et al., 2026). We therefore pay particular attention to the quality and consistency of the permit data across counties. To minimize the risk that changes in reporting coverage are mistaken for changes in investment activity, we take a conservative approach and impose two additional county-level requirements. First, we require that counties report at least one permit in three quarters of every year and have no two consecutive quarters without permitting activity. Second, we examine annual permit counts and the number of property-quarters with permits, both countywide and for the major reporting agencies within each county. We exclude counties with large breaks in these series that suggest changes in reporting coverage. Seventeen North Carolina counties, which together account for 48% of the state's 2020 population, meet these requirements and enter our analysis.

Within these counties, we focus on single-family homes with valid property identifiers and street addresses. We exclude properties built before 1900, those with more than 6,000 square feet of living space, and those with an original mortgage amount below $10,000 or above $15 million. We further restrict the sample to just those where the homeowner's existing mortgage is at least five quarters old. This restriction serves two purposes. First, as first documented by Benmelech et al. (2023) and confirmed in Figure 1, home sales are associated with substantial residential investment. Because buyers typically originate a new mortgage when purchasing a home, their mortgage rate gaps are mechanically close to zero, even as they undertake substantial renovations. Including these observations would therefore introduce a relationship between rate gaps and permitting that reflects the timing of home purchases rather than the effect of mortgage lock-in.

Second, refinancing decisions can themselves be related to planned investments. Our event stud-

ies, presented in Appendix Figure A1, show that permitting activity increases around cash-out refinancing, consistent with homeowners using mortgage proceeds to finance improvements. Because refinancing also resets the mortgage rate gap to approximately zero, including these transactions presents a potential reverse causality problem. A homeowner planning a major renovation might obtain a cash-out refinance to finance the project, resetting their rate gap to approximately zero just as permitting activity increases. Requiring mortgages to be at least five quarters old addresses both concerns. It removes the period immediately surrounding purchases and refinancings, when permitting activity is high and the mortgage rate gap is mechanically close to zero. It also allows time for market interest rates to change after origination, so that variation in the rate gap is more plausibly driven by subsequent movements in market rates rather than mortgage decisions made in anticipation of investment.

Our main analysis asks how mortgage lock-in in quarter t effect the probability of obtaining a building permit in quarter $t+1$. We impose one additional restriction on the timing of permitted activity. We exclude property-quarter observations with a qualifying permit in quarter t, so that permitting in quarter $t+1$ is less likely to reflect work already underway. In practice, permits associated with a property are overwhelmingly concentrated within a single quarter, and it is uncommon for the same property to receive permits in consecutive quarters.

[Table 1 around here]

Table 1 reports summary statistics for our full sample, covering 2014 through 2024, and our post-hike sample, covering 2022 through 2024. In some of our analysis we focus on the post-hike period. The sharp increase in mortgage rates beginning in 2022 generated substantial variation in mortgage lock-in among homeowners who had originated their mortgages before the increase. Furthermore, the post-hike sample reduces concerns about selection into refinancing. During periods of falling interest rates, Keys et al. (2016) suggest that homeowners who retain mortgages with rates substantially above prevailing market rates may be financially constrained or inattentive. These characteristics may also affect their propensity to invest in their homes. By focusing on the post-hike period, we study homeowners whose rate gaps largely reflect the increase in market rates after their mortgages were originated.

The table also reports separate observation counts for our permit and sale regressions, reflecting

an additional sample restriction imposed on the former. Because we are interested in how mortgage lock-in affects investment by incumbent homeowners, we require that the same homeowner retain ownership of the property through quarter $t+1$. Without this restriction, a permit obtained by a new buyer could be incorrectly attributed to the previous homeowner's mortgage rate gap. We do not impose this restriction in the sale regressions, where the outcome of interest is precisely whether the homeowner sells the property. Instead, we define a sale as a transfer to a new owner in quarter $t+1$ with a reported transaction price. The sale sample therefore includes observations excluded from the permit sample and consequently has slightly more observations.

3.3 Empirical Strategy

To estimate the relationship between mortgage lock-in and housing investment, we compare homeowners within the same ZIP code and quarter who obtained their existing mortgages at different interest rates. These homeowners face the same prevailing market interest rates and local housing market conditions, but differ in the extent to which they are locked into their current mortgages. Specifically, for each permit category k, we estimate

$$Y^k_{i,t+1} = \beta_k g_{it} + X'_{it}\gamma_k + \alpha^k_{z(i),t} + \lambda^k_{o(i)} + \varepsilon^k_{it}, \tag{3}$$

where $Y^k_{i,t+1}$ indicates whether property i receives a permit in quarter $t+1$, and g_{it} is the mortgage-rate gap in quarter t. The vector X_{it} includes bins for construction year, building area, ownership tenure, and mortgage age, along with the log original mortgage amount. ZIP-code-by-quarter fixed effects, $\alpha^k_{z(i),t}$, absorb prevailing interest rates and local housing market conditions, while mortgage-origination-year fixed effects, $\lambda^k_{o(i)}$, account for differences across mortgage vintages. Standard errors are two-way clustered by mortgage-origination month and mortgage identifier.

We estimate this specification separately for any permitted work, maintenance, discretionary renovations, and expansions. We also estimate the same regression using home sales as the outcome. All outcomes are multiplied by 100, so β_k measures the percentage-point change in next-quarter permitting associated with a 100-basis-point increase in the mortgage-rate gap.

Our identifying variation comes from differences in mortgage rates at origination, primarily within origination years. Mortgage rates fluctuate considerably over the course of a year, so home-

owners who originated mortgages in different months, or even different weeks, can face meaningfully different rates. These differences are especially relevant following the sharp increase in market rates beginning in 2022. Because all mortgages in our sample were originated before the increase, homeowners entered the high-rate period with different existing mortgage rates and consequently different degrees of lock-in.

4 Results: Mortgage Lock-In and Housing Investment

4.1 Extensive Margin: Permitting and Sales

Table 2 presents our main results. We begin by confirming that our measure of mortgage lock-in predicts the reduction in homeowner mobility documented in previous research. Column 5 of Panel A shows that a 100-basis-point increase in the mortgage-rate gap is associated with a 0.083-percentage-point reduction in the probability of selling in the following quarter, or approximately 6% of the sample mean. This finding is consistent with Fonseca and Liu (2024) and Liebersohn and Rothstein (2025).

[Table 2 around here]

The first four columns of Table 2 show that greater mortgage lock-in is also associated with more investment among homeowners who remain in their properties. A 100-basis-point increase in the rate gap raises the probability of obtaining a building permit by 0.109 percentage points, or approximately 7% relative to the sample mean. Much of this increase comes from maintenance, which accounts for the majority of permitted projects. However, we also find significant increases in discretionary renovations and expansions. Although these projects are less common, their proportional responses to lock-in are also sizable.

The positive effect of lock-in on maintenance permitting is consistent with homeowners becoming more willing to undertake costly repairs when they expect to remain in their properties longer. A homeowner who plans to move in the near future might postpone replacing an aging roof or electrical system, relying instead on smaller repairs until the property is sold. Mortgage lock-in thus increases the likelihood that the homeowner will ultimately bear the costs of these deferred capital expenditures, encouraging more maintenance. The increase in home expansions reflects a related in-

centive. Homeowners who might otherwise have moved to a larger house may instead expand their existing homes to obtain additional space without giving up their low mortgage rates. Discretionary renovations fall somewhere between these two cases. Updating an outdated kitchen, for example, may address functional obsolescence while also better meeting the owner's preferences. Taken together, Table 2 shows that mortgage lock-in has economically significant effects across a wide range of residential capital expenditures. Homeowners who might otherwise have moved to avoid costly repairs or find a property better suited to their needs instead invest in maintaining and improving the homes they already own.[6]

Panel B repeats the analysis for 2022Q2–2024Q4, focusing on the period during and following the sharp rise in mortgage rates. During this period nearly all homeowners in our sample had mortgages with rates below prevailing market rates, so almost all of the variation in the mortgage-rate gap reflects differences in the degree of lock-in. In the full sample, variation also comes from borrowers who retained above-market mortgages despite opportunities to refinance. The similarity of the estimates across the two samples suggests that our results are not driven by selection among homeowners who failed to refinance during periods of low interest rates.

[Figure 2 around here]

In Figure 2, we relax the assumption of a linear relationship between mortgage lock-in and permitting. We focus on the post-hike sample and replace the continuous mortgage-rate gap with indicators for 50-basis-point intervals. Across all four categories, permitting generally increases with the size of the mortgage-rate gap before leveling off at gaps of approximately 250–300 basis points. This pattern is consistent with mortgage lock-in operating, at least in part, through expected tenure. As the mortgage-rate gap increases, moving becomes increasingly costly, making homeowners more willing to invest in their existing properties. At some point, however, the cost of moving may already be sufficiently high that a further increase in the rate gap has little effect on expected tenure and, consequently, on the incentive to invest.

[6]The main results are robust to omitting origination-year fixed effects and adding a control for current loan-to-value controls, see Appendix Tables A1 and A2.

4.2 Intensive Margin: Repair Spending and Project Scope

Building permits allow us to observe whether homeowners undertake improvements, but not how much they spend. To examine spending directly, we turn to the Panel Study of Income Dynamics (PSID), which reports homeowners' annual expenditures on repairs and maintenance. We use the 2015–2025 survey waves and restrict the sample to homeowners with fixed-rate mortgages originated before 2022. Unlike our property records, the PSID reports homeowners' actual mortgage interest rates. We therefore measure mortgage lock-in as the difference between prevailing market rates and the homeowner's reported mortgage rate. Because actual mortgage rates may reflect borrower characteristics that also affect investment, we instrument for this gap using the difference between prevailing market rates and average market rates in the year of origination or refinancing. This instrument follows the same approach used to measure lock-in in our main analysis.

[Table 3 around here]

Table 3 reports the relationship between mortgage lock-in and annual repair spending. Column 1 presents the OLS estimate, which is small and statistically insignificant. One possible explanation is that homeowners' reported mortgage rates reflect not only market conditions at origination, but also borrower characteristics that may independently affect their ability or willingness to invest. Measurement error in survey responses may further attenuate the estimated relationship. To address these concerns, we instrument for mortgage lock-in using market lock-in, which is based on prevailing interest rates in the year of mortgage origination or refinancing. Column 2 shows a strong first stage, with an F-statistic of 198. Our preferred 2SLS estimate in Column 3 implies that a 100-basis-point increase in Mortgage Lock-In raises annual Repair Spending by approximately $427, or 13% relative to the sample mean. Column 4 reports the corresponding reduced-form estimate, which is also positive and statistically significant. These results complement our permit findings by showing that mortgage lock-in increases spending on home repairs and maintenance, including work that may not require a building permit.

Finally, we return to the permit data to examine whether lock-in affects the scope of projects undertaken. Table 4 uses an index ranging from zero for no permitted work to three for expansions and other major projects.

[Table 4 around here]

A 100-basis-point increase in the mortgage-rate gap raises this index by approximately 8% relative to its mean. The result is similar using Poisson estimation. Conditional on obtaining a permit, the increase is smaller, at approximately 1.4%. These results suggest that the increase in residential investment comes from homeowners undertaking larger projects and, especially, more projects.

4.3 Aggregate Implications for Residential Fixed Investment

Our results so far show that mortgage lock-in increases investment by homeowners who remain in their properties. However, lock-in also reduces home sales, and previous research has shown that housing transactions generate substantial spending on improvements (Benmelech et al., 2023). The aggregate implications of mortgage lock-in therefore depend on the relative magnitude of these two effects. Does the additional investment by incumbent homeowners outweigh the investment lost from fewer housing transactions?

We begin by examining the relationship between home sales and permitting in our own data. Figure 1 plots permitting activity in the eight quarters before and after a home purchase. Consistent with Benmelech et al. (2023), permitting increases substantially around transactions. Maintenance permitting peaks in the quarter of the sale, while discretionary renovations and expansions peak in the following quarter. Permitting remains elevated for several quarters afterward. These patterns suggest that fewer home sales could reduce the number of permitted improvement projects.

[Figure 1 around here]

To compare the two effects, we conduct a simple accounting exercise. For each permit category, we calculate the reduction in permitting associated with fewer sales by multiplying our estimated effect of lock-in on home sales by the additional permitting observed in the four quarters before and after a transaction. We then compare this reduction with the increase in permitting among incumbent homeowners. Specifically, we calculate

$$\widehat{B}_k = \frac{\widehat{\beta}^S}{100}\widehat{A}_k, \qquad \widehat{N}_k = \widehat{\beta}^I_k + \widehat{B}_k, \tag{4}$$

where $\widehat{\beta}^S$ is the sale coefficient from Table 2, $\widehat{A}_k$ is the sum of the transaction-related permitting

coefficients from quarters −4 through +4, and $\widehat{\beta}_k^I$ is the estimated increase in incumbent permitting. Thus, $\widehat{B}_k$ measures the reduction in permitting associated with fewer sales, while $\widehat{N}_k$ measures the net change in permitting.[7]

[Table 5 around here]

Table 5 shows that the increase in permitting among incumbent homeowners is substantially larger than the reduction associated with fewer sales. For maintenance, a 100-basis-point increase in the mortgage-rate gap raises incumbent permitting by 0.084 percentage points, while the reduction in sales lowers permitting by just 0.006 percentage points. The increase among incumbent homeowners is therefore as much as 15 times as large as the reduction associated with fewer transactions. We find similarly large differences for discretionary renovations and expansions.

These results suggest that the additional permitting undertaken by locked-in homeowners more than offsets the reduction associated with fewer home sales. Although this accounting exercise does not establish the net effect of mortgage lock-in on aggregate investment expenditures, it shows that the response among incumbent homeowners is large relative to the transaction-related decline. Focusing exclusively on the reduction in housing transactions would therefore miss an important part of how mortgage lock-in affects residential investment.

5 Household Income and Home Depreciation

Our results show that homeowners with greater mortgage lock-in are more likely to invest in their existing properties. In Section 2, we show that the decision to undertake an improvement depends on both the benefits it provides and the resources available to finance it. We now examine how the investment response varies with property age, household and neighborhood income, and previous permitting activity to assess the relative importance of investment needs and homeowners' ability to undertake improvements.

[7] The accounting calculation uses the unnormalized transaction-event coefficients. Figure 1 normalizes these coefficients to the average over quarters −8 through −5 for presentation.

5.1 Property Age

The need for maintenance changes over the life of a home. Relatively new homes have few major systems in need of replacement, while middle-aged homes begin to experience failures of roofs, plumbing, HVAC systems, and other components. Of course, as discussed earlier in the paper, fixes can be pushed down the road and patches can buy a few years. At older ages, however, properties have likely either fallen into complete disrepair and left the market or have settled into relatively steady cycles of maintenance and replacement.

[Figure 3 around here]

We investigate this pattern in Figure 3, which shows the relationship between a home's age and its sale price per square foot, controlling for property characteristics and ZIP-code-by-year fixed effects. Several features are worth noting. First, property values decline immediately after construction, consistent with buyers paying a premium for a new home. Beyond this initial decline, however, values remain relatively stable until approximately age 20. At this point, major building systems begin reaching the end of their useful lives, and property values decline more rapidly through approximately age 40. Importantly, this figure reflects depreciation net of homeowners' investments in maintaining and improving their properties. The steeper decline among middle-aged homes is therefore consistent with a period when major systems begin to fail and homeowners do not fully offset their deterioration through maintenance. Finally, the relationship flattens again among older homes. Although these properties sell at a substantial discount relative to newer homes, the flattening is consistent with our prediction that sufficiently old homes reach a relatively steady state in which ongoing capital expenditures largely offset further depreciation.

Appendix Figure A2 provides additional evidence, showing that maintenance permitting increases sharply as homes enter their teens and again around age 40. Together, these patterns motivate our decision to divide homes into three age groups: 0–20, 21–50, and over 50 years old.

This life-cycle pattern has implications for how maintenance decisions respond to mortgage lock-in. Owners of relatively new homes have little need for major repairs, while owners of much older homes may already be accustomed to a steady stream of maintenance expenses. It is among middle-aged homes, where major systems are beginning to reach the end of their useful lives, that the decision to repair or replace may be most sensitive to expected tenure. Homeowners who might

otherwise have deferred these investments in anticipation of moving may instead undertake them when mortgage lock-in makes moving more costly.

[Table 6 around here]

As expected, older homes require more maintenance than younger ones, as reflected in the positive age coefficients in Table 6. Of particular interest, however, is how mortgage lock-in affects these investment decisions. For older homes, where owners may have already settled into a relatively steady cycle of maintenance and replacement, the response to lock-in is no greater than for the youngest homes. It is precisely among middle-aged homes, where major systems are beginning to fail but homeowners may still have considerable flexibility over whether to repair or replace them, that the response to lock-in is strongest. The interaction for homes aged 21–50 is positive and statistically significant, consistent with mortgage lock-in encouraging homeowners to undertake investments they might otherwise have deferred until moving.

We look next to how the lock-in effects on discretionary renovations and expansions vary with home age. Older homes are more likely to have outdated kitchens, less desirable floor plans, or insufficient living space relative to the modern homeowners' preferences. In the absence of lock-in, homeowners dissatisfied with these features might simply move to a more suitable property. When moving becomes more costly, however, renovating or expanding the existing home becomes a more attractive alternative. Consistent with this interpretation, Table 6 shows that the renovations and expansion responses to mortgage lock-in are strongest among homes older than 50 years.

5.2 Household and Neighborhood Income

We next investigate whether the response to mortgage lock-in differs with homeowners' financial resources. Even if two homeowners have similar maintenance needs and expect to remain in their properties longer, the homeowner with greater financial resources may be better positioned to undertake costly repairs or improvements. We examine this possibility using both household income reported under HMDA and neighborhood income from IRS data.

We begin with household income, restricting the sample to mortgages matched to HMDA originations with positive reported applicant income. This leaves 15.0 million property-quarter observations, compared with 22.1 million in the full sample. Appendix Table A3 confirms that our main

results are similar in this subsample.

[Table 7 around here]

Table 7 examines how the investment response varies with household income. We divide homeowners into three groups based on their reported income at mortgage origination: below $60,000, $60,000–$99,999, and at least $100,000. We find that higher-income homeowners respond more strongly to mortgage lock-in. A 100-basis-point increase in the mortgage-rate gap raises the probability of obtaining any permit by 0.077 percentage points among homeowners earning less than $60,000, compared with 0.108 percentage points among those earning at least $100,000. This difference is statistically significant. We find similar patterns for maintenance and discretionary renovations. The response of expansions also tends to increase with income, although the differences are less precisely estimated.

We next examine whether the investment response also varies across neighborhoods. We divide ZIP codes into higher- and lower-income groups using average adjusted gross income from 2005 IRS data, with $50,000 as the cutoff.

[Table 8 around here]

Table 8 shows that the response to mortgage lock-in is substantially larger in higher-income neighborhoods. For maintenance, a 100-basis-point increase in the mortgage-rate gap raises permitting by 0.109 percentage points in higher-income ZIP codes, compared with 0.061 percentage points in lower-income ZIP codes. The differences are even larger for discretionary renovations and expansions, where the responses in higher-income neighborhoods are several times those in lower-income neighborhoods. All four interactions are statistically significant.

One possible explanation is that homes in higher-income neighborhoods have greater maintenance and improvement needs. However, Panel B of Figure 3 suggests otherwise. The relationship between property age and sale prices is substantially more negative in lower-income neighborhoods. Older homes sell at much larger discounts relative to newer homes in these neighborhoods, consistent with greater accumulated depreciation. Thus, the stronger investment response in higher-income neighborhoods does not appear to reflect greater underlying maintenance needs.

The household- and neighborhood-income results are both consistent with higher-income homeowners responding more strongly to mortgage lock-in. Together with the larger investment response among homeowners with a history of undertaking improvements, these findings suggest that the ability to undertake investment matters alongside the need for it.

These differences have implications for housing inequality. Higher-income homeowners respond to mortgage lock-in by maintaining and improving their properties, while lower-income homeowners are less responsive despite potentially greater investment needs. Mortgage lock-in may therefore widen differences in housing quality across households and neighborhoods, even as it increases residential investment overall.

5.3 Previous Permitted Investment

One way to evaluate the relative importance of household financial ability to perform improvements versus the need for those improvements is to consider the recent history of permitting in the home. Homes that have recently undergone major repairs may have less remaining maintenance to undertake but we have direct evidence that the household is able and interested in performing renovations, while those without recent investment may have accumulated greater needs. We compare the response to lock-in across properties with and without permitted investment between 2018 and 2021. We focus on the post-hike period, so that previous permitting is measured before the increase in mortgage rates.

[Table 9 around here]

Interestingly, Table 9 shows that properties with previous permits have a larger response to lock-in across all four categories. However, the differences across categories are revealing. For maintenance, the response is approximately one-third larger among properties with prior permits, a difference significant only at the 10% level. Previous investment may have already addressed some of the property's maintenance needs, leaving fewer repairs to undertake when lock-in increases. For discretionary renovations, however, the response more than doubles, while for expansions it increases by approximately 70%. These projects are less likely to be driven by the failure of aging building systems. Instead, previous permitting may indicate that the homeowner has the financial resources, relationships with contractors, or experience necessary to undertake additional improvements. When

mortgage lock-in increases the incentive to invest, these homeowners may be particularly well positioned to respond.

We can investigate this explanation further by distinguishing between previous investment undertaken by the current homeowner and investment undertaken by a previous owner. Both provide information about the property's maintenance history, but only the former tells us about the current homeowner's experience undertaking improvements. Appendix Table A4 shows that the larger response to lock-in is concentrated among properties where the current homeowner also undertook the previous investment. The interaction between lock-in and previous investment by the same owner is positive and statistically significant across all four permit categories. In contrast, the interactions for investment by previous owners are small and statistically insignificant, although less precisely estimated.

Together, these results suggest that previous permitting captures more than the condition of the property. The relatively modest additional maintenance response is consistent with prior investment having already addressed some repair needs. For renovations and expansions, however, previous permitting appears to be more informative about the homeowner's ability or willingness to undertake projects. Thus, while our property-age results suggest that the need for investment matters, the permitting-history results point toward an important role for homeowners' capacity to respond when mortgage lock-in changes their incentives.

6 Conclusion

Mortgage lock-in affects not only whether homeowners move, but also how they invest in the properties they keep. Using property-level data linking mortgage originations, ownership transfers, and building permits, we find that homeowners with greater mortgage lock-in are less likely to sell their homes but more likely to undertake maintenance, discretionary renovations, and expansions. These results are consistent with homeowners responding to a longer expected stay by addressing repairs they might otherwise have deferred and adapting their properties to better meet their needs. We find similar evidence in household survey data, where greater mortgage lock-in is associated with higher annual spending on repairs and maintenance.

These findings also have implications for aggregate residential investment. Previous research

has established that housing transactions generate substantial improvement spending, suggesting that mortgage lock-in could reduce residential investment by discouraging home sales. Our results identify an important countervailing effect. In a simple accounting exercise, we find that the additional permitting undertaken by incumbent homeowners is substantially larger than the reduction associated with fewer transactions. Although we cannot establish the net effect on aggregate dollar expenditures, our findings suggest that the decline in housing turnover may be a poor guide to how residential investment responds to mortgage lock-in.

Finally, our heterogeneity results help explain which homeowners respond to these changing incentives. The response of maintenance to lock-in is strongest among middle-aged homes, where major building systems are beginning to require replacement and homeowners have greater flexibility over when to undertake repairs. However, the need for investment does not fully explain the response. Homeowners with a history of undertaking improvements are particularly responsive, as are those in higher-income neighborhoods, even though age-related price depreciation is greater in lower-income neighborhoods. These findings suggest that the ability to finance and undertake improvements matters alongside the need for them.

More broadly, our results highlight an important consequence of mortgage lock-in for the existing housing stock. Homeowners who can afford to improve their properties may be able to accommodate a longer stay through maintenance, renovations, and expansions. Those with fewer resources face the same disincentives to move but may have less ability to adjust their housing consumption. Thus, even as mortgage lock-in encourages additional residential investment, it may also reinforce differences in housing quality across households and neighborhoods.

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Table 1: Summary Statistics

	Full sample		Post-hike sample	
	Mean	SD	Mean	SD
Panel A. Mortgage rates and lock-in				
Mortgage rate gap (percentage points)	0.561	1.573	2.638	0.896
Market mortgage rate (percent)	4.370	1.296	6.126	0.647
Incumbent mortgage rate (percent)	3.809	0.548	3.488	0.594
Panel B. Permit incidence and sale				
Any permit next quarter (percent)	1.636	12.685	1.746	13.099
Maintenance permit next quarter (percent)	1.369	11.619	1.435	11.893
Discretionary permit next quarter (percent)	0.237	4.862	0.282	5.303
Expansion permit next quarter (percent)	0.167	4.089	0.173	4.157
Permit intensity next quarter (0-3)	0.022	0.189	0.023	0.196
Sale next quarter (percent)*	1.415	11.813	0.984	9.869
Panel C. Property, mortgage, and owner characteristics				
Property age (years)	27.930	21.404	30.423	22.050
Building square footage	2194.095	925.255	2205.723	929.238
Original mortgage amount (1000s)	213.349	362.424	237.987	392.488
Owner tenure (years)	8.722	5.254	10.044	6.109
Mortgage age (quarters)	18.854	11.527	22.623	14.320
ZIP average AGI, 2005 (1000s)	58.724	25.761	58.530	25.498
Counts				
Observations	22,088,762		6,768,991	
Sale observations*	22,484,366		6,864,687	

Notes: This table summarizes mortgage financing, permitting, and property characteristics in the full and post-hike estimation samples. The full and post-hike samples use regressor quarters 2014Q1–2024Q4 and 2022Q2–2024Q4, respectively, and mortgages originated in 2010–2021. Mortgages must be more than four quarters old, with no covered permit in the current quarter. Permit statistics condition on continued ownership through the next quarter; starred sale rows use the separate risk set without that condition. The mortgage-rate gap is the current quarter's minimum weekly 30-year PMMS rate minus the origination-week proxy, matched 45 days before purchase-mortgage dates and 30 days before refinance dates. Permit intensity records the largest covered project scope in a quarter, including zero for no covered activity.

Table 2: Mortgage-Rate Gaps, Incumbent Permitting, and Sales

Panel A. Full sample, 2014Q1–2024Q4

	(1) All permits	(2) Maintenance	(3) Discretionary	(4) Expansion	(5) Sale
Rate gap	0.1087***	0.0839***	0.0229***	0.0187***	-0.0828***
	(0.0165)	(0.0149)	(0.0034)	(0.0039)	(0.0178)
Controls	X	X	X	X	X
Fixed Effects					
Zip-Quarter	X	X	X	X	X
Orig-Year	X	X	X	X	X
Counts					
N	22,088,762	22,088,762	22,088,762	22,088,762	22,484,366
Sample Means					
Dependent Variable	1.6358	1.3688	0.2370	0.1675	1.4154

Panel B. Post-hike sample, 2022Q2–2024Q4

	(1) All permits	(2) Maintenance	(3) Discretionary	(4) Expansion	(5) Sale
Rate gap	0.1243***	0.0962***	0.0262***	0.0210***	-0.0834***
	(0.0208)	(0.0186)	(0.0074)	(0.0075)	(0.0194)
Controls	X	X	X	X	X
Fixed Effects					
Zip-Quarter	X	X	X	X	X
Orig-Year	X	X	X	X	X
Counts					
N	6,768,991	6,768,991	6,768,991	6,768,991	6,864,687
Sample Means					
Dependent Variable	1.7464	1.4350	0.2820	0.1731	0.9836

Notes: This table reports the relationship between mortgage lock-in and next-quarter permitting by incumbent owners and home sales. Equation 3 is estimated by OLS. Outcomes are next-quarter indicators scaled by 100; the PMMS-based rate gap is in percentage points. Controls are construction-year, building-area, ownership-tenure, and mortgage-age bins and log original mortgage amount. All columns require mortgages more than four quarters old and no current-quarter covered permit. Permit outcomes additionally condition on continued ownership through the next quarter; sale outcomes do not. Standard errors in parentheses are two-way clustered by origination month and mortgage identifier. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 3: Mortgage Lock-In and Annual Repair Spending in the PSID

Dependent Variable:	Repair Spending	Mortgage Lock-In	Repair Spending	Repair Spending
	OLS	First Stage	2SLS	Reduced Form
	(1)	(2)	(3)	(4)
Mortgage Lock-In	-61.4394		426.8367**	
	(59.6481)		(196.2182)	
Market Lock-In		0.3419***		145.9513**
		(0.0243)		(65.9904)
Controls	X	X	X	X
Fixed Effects				
Survey Wave	X	X	X	X
State	X	X	X	X
First Stage F-Stat			197.98	
Counts				
N	10,790	10,790	10,790	10,790
Sample Means				
Dependent Variable	3,318.1689	0.5186	3,318.1689	3,318.1689

Notes: This table estimates the relationship between mortgage lock-in and annual repair spending using the Panel Study of Income Dynamics. Repair spending is reported in nominal dollars for the calendar year before each interview. The sample uses the 2015–2023 biennial PSID family interviews and the 2025 early release, restricted to fixed-rate mortgages originated or refinanced before 2022 and before the spending year. Mortgage Lock-In is the spending-year average PMMS rate minus the reported mortgage rate. Market Lock-In replaces the reported rate with the average PMMS rate in the origination or refinancing year; both gaps are in percentage points. The 2SLS specification instruments Mortgage Lock-In with Market Lock-In. Controls are log mortgage balance, log house value, log family income, room-count indicators, and reference-person age groups. For the early-release observations, income and age are carried forward from the preceding interview, with two years added to age; house value and rooms use the current interview. Standard errors in parentheses are clustered by PSID household-row identifier. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 4: Mortgage Lock-In and Next-Quarter Permit Intensity

	(1) OLS: all	(2) PPML: all	(3) OLS: intensity > 0
Rate gap	0.0017***	0.0838***	0.0183***
	(0.0002)	(0.0120)	(0.0043)
Controls	X	X	X
Fixed Effects			
Zip-Quarter	X	X	X
Orig-Year	X	X	X
Counts			
N	22,088,762	21,045,323	360,385
Sample Means			
Dependent Variable	0.0218	0.0228	1.3302

Notes: This table examines whether mortgage lock-in is associated with the incidence and scope of permitted home improvements. The outcome is a 0–3 scope index: zero for no covered activity, one for upkeep, two for discretionary renovation, and three for expansion or broad multi-room work. OLS coefficients are index-point changes per percentage-point increase in the rate gap; the PPML coefficient is a semi-elasticity. The positive-intensity regression describes a selected group of investors. Sample restrictions and controls follow Equation 3, including continued ownership and no covered permit in the current quarter. Standard errors in parentheses are two-way clustered by origination month and mortgage identifier. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 5: Additional Incumbent Permitting versus Permitting Lost through Fewer Sales

Category	Components being compared: Additional incumbent permitting (pp)	Components being compared: Permitting lost through fewer sales (pp)	Net permitting (pp)
Any permit	0.1087	-0.0068	0.1019
Maintenance	0.0839	-0.0057	0.0782
Discretionary renovation	0.0229	-0.0013	0.0216
Expansion	0.0187	-0.0008	0.0180

Notes: This table compares additional permitting by incumbent homeowners with permitting associated with home sales forgone following a 100-basis-point increase in the mortgage-rate gap. The calculation follows Equation 4. Additional incumbent permitting is the estimated permit-incidence slope for a one-percentage-point larger rate gap. The corresponding sale-incidence change is -0.0828 percentage points, or $-0.0828/100 = -0.000828$ as a probability. For category k, the sale-window excess, $A_k = \sum_{s=-4}^{4} \widehat{\theta}_{ks}$, accumulates the unnormalized sold-versus-control permit-incidence differences from four quarters before through four quarters after sale, in percentage-point quarters. Permitting lost through fewer sales is the product of the sale-probability change and that excess: $B_k = -0.000828 A_k$. Net permitting adds the two components: $N_k = \widehat{\beta}_k^I + B_k$. Using the displayed maintenance components, $N_M = 0.0839 - 0.0057 = 0.0782$ percentage points. The incumbent-to-lost-permitting ratio is $\widehat{\beta}_k^I / |B_k|$; for maintenance it is approximately $0.0839/0.0057 = 14.7$, equivalent to offsetting about 1,470% of the lost component. Calculations precede rounding. The purchase profiles in Figure 1 use a different normalization from the sale-window inputs. This is an incidence accounting benchmark across different ownership risk sets, without joint standard errors or a dollar-spending interpretation.

Table 6: Mortgage Lock-In by Home Age: Three Groups

	(1) Any permit	(2) Maintenance	(3) Discretionary	(4) Expansion
Rate gap	0.0990***	0.0774***	0.0193***	0.0157***
	(0.0164)	(0.0148)	(0.0035)	(0.0040)
Age 21-50	0.1030***	0.0858***	0.0206***	0.0215***
	(0.0237)	(0.0239)	(0.0048)	(0.0038)
Age 51+	0.1683***	0.1412***	0.0340***	0.0341***
	(0.0319)	(0.0312)	(0.0078)	(0.0062)
Rate gap × age 21-50	0.0207***	0.0191***	0.0023	0.0040***
	(0.0040)	(0.0040)	(0.0017)	(0.0012)
Rate gap × age 51+	0.0144**	-0.0027	0.0178***	0.0099***
	(0.0071)	(0.0067)	(0.0024)	(0.0021)
Controls	X	X	X	X
Fixed Effects				
Zip-Quarter	X	X	X	X
Orig-Year	X	X	X	X
Counts				
N	22,088,762	22,088,762	22,088,762	22,088,762
Sample Means				
Dependent Variable	1.6358	1.3688	0.2370	0.1675

Notes: This table examines how the permitting response to mortgage lock-in varies with property age. Homes aged 0–20 form the reference group. Age indicators enter both in levels and interacted with the rate gap; level coefficients are evaluated at zero gap, and group-specific slopes add the main and interaction coefficients. Outcomes are next-quarter indicators scaled by 100, and rate gaps are in percentage points. Sample restrictions and controls follow Equation 3, including continued ownership and no current-quarter covered permit. Standard errors in parentheses are two-way clustered by origination month and mortgage identifier. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 7: Mortgage Lock-In by Household Income

	(1) Any permit	(2) Maintenance	(3) Discretionary	(4) Expansion
Rate gap	0.0770***	0.0604***	0.0146***	0.0137***
	(0.0190)	(0.0174)	(0.0040)	(0.0041)
Income $60,000–$99,999	0.0903***	0.0843***	-0.0023	0.0114***
	(0.0099)	(0.0091)	(0.0032)	(0.0026)
Income at least $100,000	0.4265***	0.3428***	0.0750***	0.0678***
	(0.0116)	(0.0103)	(0.0041)	(0.0031)
Rate gap × $60,000–$99,999	0.0098*	0.0073	-0.0006	0.0035**
	(0.0050)	(0.0048)	(0.0020)	(0.0016)
Rate gap × At least $100,000	0.0305***	0.0218***	0.0073**	0.0033
	(0.0061)	(0.0055)	(0.0030)	(0.0020)
Controls	X	X	X	X
Fixed Effects				
Zip-Quarter	X	X	X	X
Orig-Year	X	X	X	X
Counts				
N	15,009,515	15,009,515	15,009,515	15,009,515
Sample Means				
Dependent Variable	1.7402	1.4598	0.2484	0.1798

Notes: This table examines how the permitting response to mortgage lock-in varies with household income reported at mortgage origination in HMDA. The sample requires a matched HMDA origination with positive observed applicant income. Income groups use nominal applicant income at origination, with income below $60,000 omitted. Both income-group indicators and their interactions with the rate gap enter the regression. The main rate-gap coefficient is the below-$60,000 slope; adding the relevant interaction gives each higher-income group's slope. Income-group level coefficients are evaluated at a zero rate gap. Reported outcome means pool all three groups. Outcomes are next-quarter indicators scaled by 100, and rate gaps are in percentage points. Other controls and sample restrictions follow Equation 3, including continued ownership and no covered permit in the current quarter. Standard errors in parentheses are two-way clustered by origination month and mortgage identifier. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 8: Mortgage Lock-In by Neighborhood Income

	(1) All permits	(2) Maintenance	(3) Discretionary	(4) Expansion
Rate gap	0.0708***	0.0614***	0.0070*	0.0073*
	(0.0164)	(0.0147)	(0.0041)	(0.0038)
Rate gap × High-income ZIP	0.0796***	0.0472***	0.0336***	0.0242***
	(0.0134)	(0.0115)	(0.0045)	(0.0041)
Controls	X	X	X	X
Fixed Effects				
Zip-Quarter	X	X	X	X
Orig-Year	X	X	X	X
Counts				
N	22,088,086	22,088,086	22,088,086	22,088,086
Sample Means				
Dependent Variable	1.6358	1.3687	0.2370	0.1675

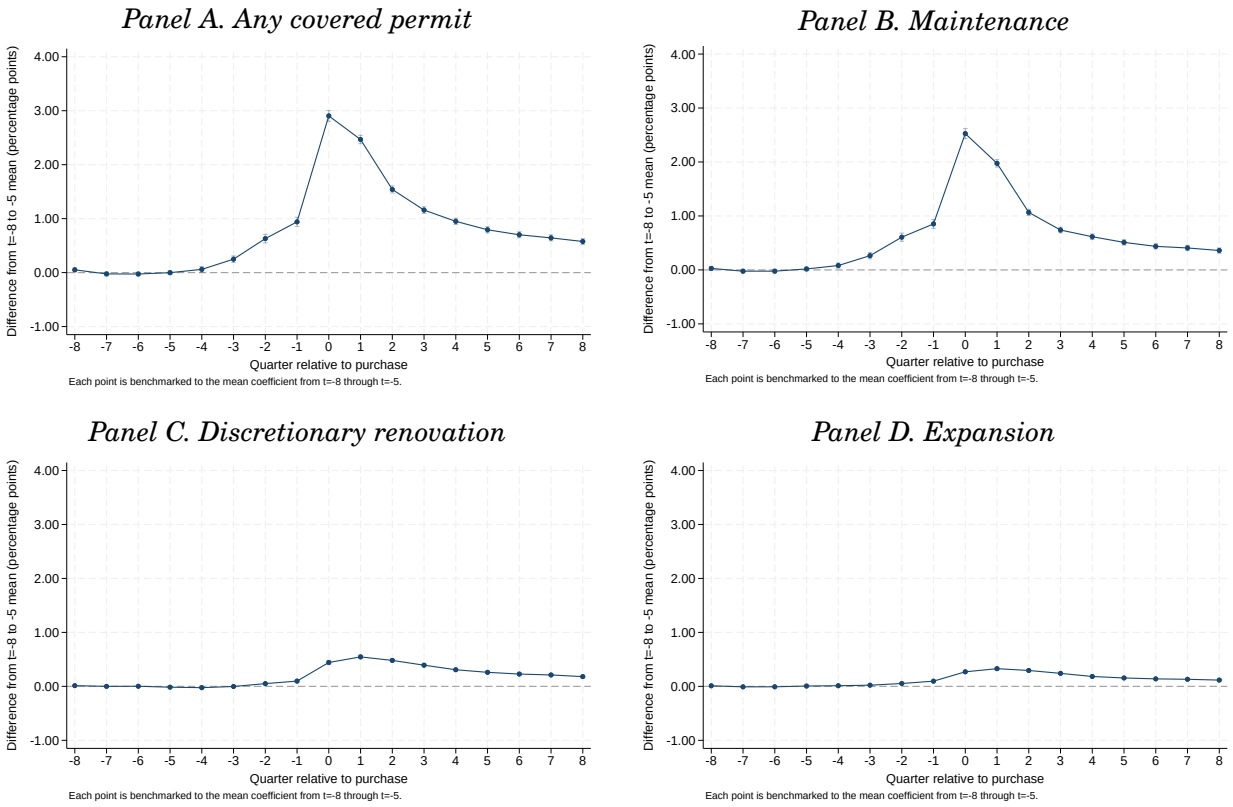
Notes: This table examines how the permitting response to mortgage lock-in differs between higher- and lower-income neighborhoods. High-income ZIP codes have average adjusted gross income above $50,000 in 2005. The main rate-gap coefficient is the lower-income slope; adding the interaction gives the higher-income slope. Reported outcome means pool both groups. Outcomes are next-quarter indicators scaled by 100, and rate gaps are in percentage points. Sample restrictions and controls follow Equation 3, including continued ownership and no covered permit in the current quarter. Standard errors in parentheses are two-way clustered by origination month and mortgage identifier. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 9: Mortgage Lock-In and Fixed 2018–2021 Permit History

	(1) All permits	(2) Maintenance	(3) Discretionary	(4) Expansion
Rate gap	0.1084***	0.0852***	0.0201***	0.0170**
	(0.0216)	(0.0192)	(0.0076)	(0.0073)
Prior permit, 2018–2021	0.4841***	0.3461***	0.1262***	0.0846***
	(0.0435)	(0.0390)	(0.0198)	(0.0158)
Rate gap × prior permit, 2018–2021	0.0519***	0.0268*	0.0278***	0.0117*
	(0.0165)	(0.0151)	(0.0069)	(0.0065)
Controls	X	X	X	X
Fixed Effects				
Zip-Quarter	X	X	X	X
Orig-Year	X	X	X	X
Counts				
N	5,923,670	5,923,670	5,923,670	5,923,670
Sample Means				
Dependent Variable	1.7314	1.4310	0.2716	0.1689

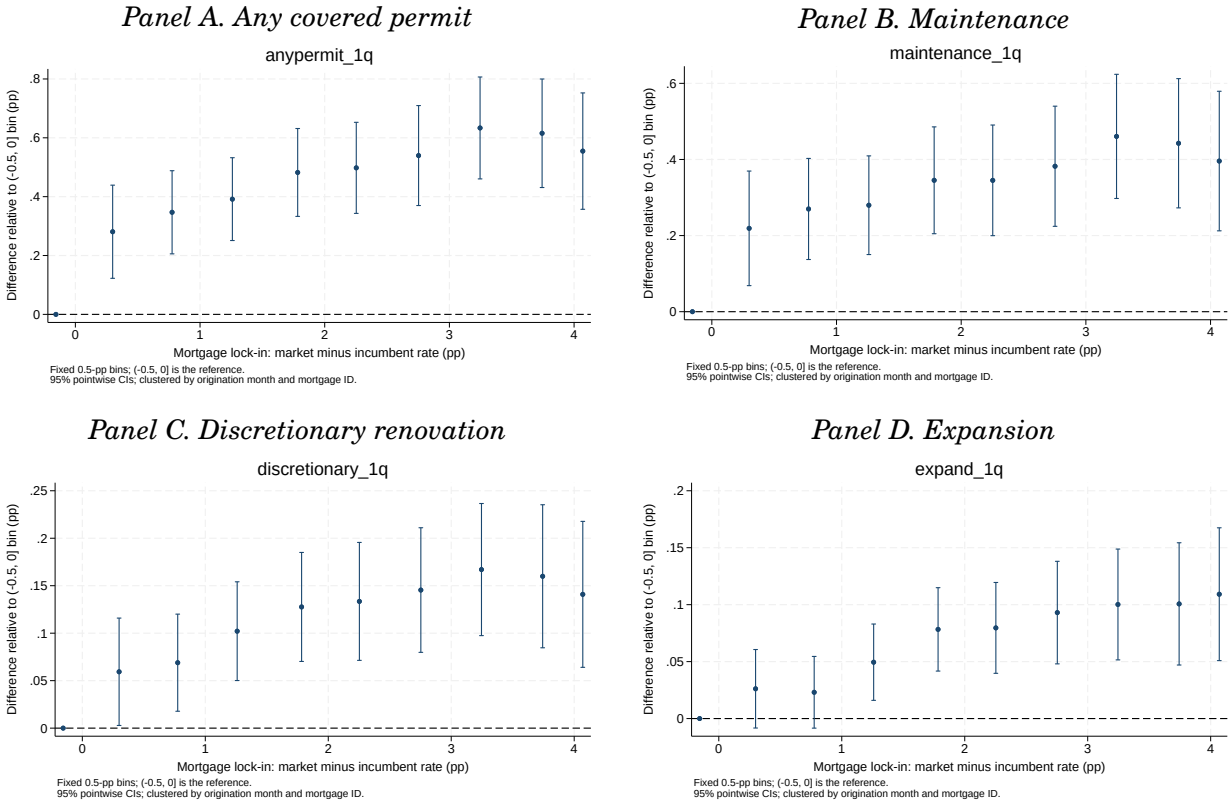
Notes: This table examines whether the post-hike permitting response to mortgage lock-in differs with a property's prior permitted investment. Prior permit indicates recorded maintenance, discretionary, or expansion work in 2018–2021 under any owner. The main rate-gap slope is for properties without that history; the interaction is the difference for properties with prior work. Regressor quarters are 2022Q2–2024Q4, with mortgages originated in 2010Q1–2021Q2 to ensure seasoning at the start of the period. Outcomes are next-quarter indicators scaled by 100, and rate gaps are in percentage points. The sample requires continued ownership and no covered permit in the current quarter. Controls follow Equation 3. Standard errors in parentheses are two-way clustered by origination month and mortgage identifier. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Figure 1: Permitting around Home Purchases



Notes: This figure shows the evolution of permitting around home purchases. Event quarter zero denotes the purchase, and the profiles span eight quarters before through eight quarters after the transaction. The vertical axis reports permit-incidence differences in percentage points, normalized by subtracting the mean coefficient over quarters −8 through −5. The profiles describe transaction-associated activity, which may include work initiated by sellers or buyers, and do not identify a causal effect of purchasing.

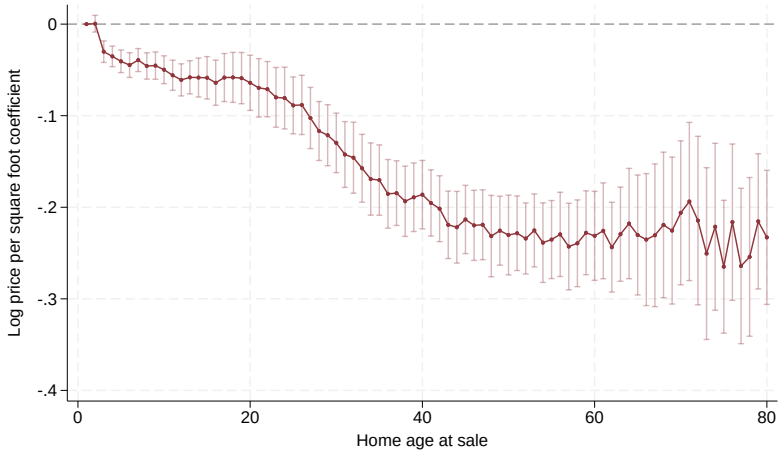
Figure 2: Post-Hike Permitting across Mortgage-Rate-Gap Bins



Notes: This figure shows how next-quarter permitting varies across mortgage-rate-gap bins in the post-hike sample. The specification uses 0.5-percentage-point bins and omits $(-0.5, 0]$ as the reference. The vertical axis reports percentage-point differences in permit incidence relative to that bin. Pointwise 95% confidence intervals use clustering by origination month and mortgage identifier. Intervals for individual bins do not test differences between adjacent bins.

Figure 3: Historical Age–Price Profiles

Panel A. Full historical sample



Panel B. Higher- and lower-income ZIP codes



Notes: This figure describes the historical relationship between a home's age at sale and price per square foot, in the full sample and by neighborhood income. Panel A pools the historical transactions; Panel B allows the age profile to differ by income group. The specification relates log sale price per square foot to age at sale in 2005–2019 transactions, controlling for log building area, bedroom and bathroom bins, and ZIP-by-year fixed effects, with ZIP-clustered standard errors. Higher-income ZIP codes have average adjusted gross income above $50,000 in 2005. Each profile is normalized to age one; Panel B therefore compares age-related price differences within income groups rather than price levels across groups. Intervals are pointwise 95% confidence intervals. Previous investment, construction vintages, land values, and transaction selection can contribute to these descriptive profiles, which are not physical depreciation schedules.

A Supplemental Exhibits

Table A1: Mortgage Lock-In without Origination-Year Fixed Effects

	(1) All permits	(2) Maintenance	(3) Discretionary	(4) Expansion	(5) Sale
Rate gap	0.0990***	0.0677***	0.0276***	0.0205***	-0.1154***
	(0.0097)	(0.0083)	(0.0028)	(0.0023)	(0.0092)
Controls	X	X	X	X	X
Fixed Effects					
Zip-Quarter	X	X	X	X	X
Counts					
N	22,088,762	22,088,762	22,088,762	22,088,762	22,484,366
Sample Means					
Dependent Variable	1.6358	1.3688	0.2370	0.1675	1.4154

Notes: This table assesses the sensitivity of the mortgage lock-in estimates to omitting mortgage-origination-year fixed effects. Outcomes, controls, and sample restrictions follow Table 2, Panel A. Outcomes are next-quarter indicators scaled by 100, and rate gaps are in percentage points. Permit regressions condition on continued ownership; sale regressions do not. Standard errors in parentheses are two-way clustered by origination month and mortgage identifier. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A2: Mortgage Lock-In Controlling for Updated LTV

	(1) All permits	(2) Maintenance	(3) Discretionary	(4) Expansion	(5) Sale
Rate gap	0.0931***	0.0711***	0.0184***	0.0183***	-0.1119***
	(0.0178)	(0.0163)	(0.0045)	(0.0043)	(0.0164)
Controls	X	X	X	X	X
Fixed Effects					
Zip-Quarter	X	X	X	X	X
Orig-Year	X	X	X	X	X
Counts					
N	16,109,644	16,109,644	16,109,644	16,109,644	16,419,103
Sample Means					
Dependent Variable	1.7174	1.4240	0.2623	0.1823	1.5468

Notes: This table examines whether the relationship between mortgage lock-in and permitting or sales persists after controlling for updated loan-to-value ratios. Added end-of-quarter LTV bins are below 70%, 70–80%, 80–90%, and above 90%; their coefficients are suppressed. LTV uses an estimated amortizing mortgage balance and the owner's purchase price updated by the county house-price index. Requiring these inputs changes the available sample, so differences from Table 2 combine added controls and sample selection. Outcomes are next-quarter indicators scaled by 100, and rate gaps are in percentage points. Other controls and restrictions follow Equation 3; permit regressions condition on continued ownership, while sale regressions do not. Standard errors in parentheses are two-way clustered by origination month and mortgage identifier. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A3: Mortgage Lock-In in the HMDA-Matched Income Sample

	(1) Any permit	(2) Maintenance	(3) Discretionary	(4) Expansion
Rate gap	0.0935***	0.0726***	0.0173***	0.0163***
	(0.0196)	(0.0181)	(0.0040)	(0.0042)
Controls	X	X	X	X
Fixed Effects				
Zip-Quarter	X	X	X	X
Orig-Year	X	X	X	X
Counts				
N	15,009,515	15,009,515	15,009,515	15,009,515
Sample Means				
Dependent Variable	1.7402	1.4598	0.2484	0.1798

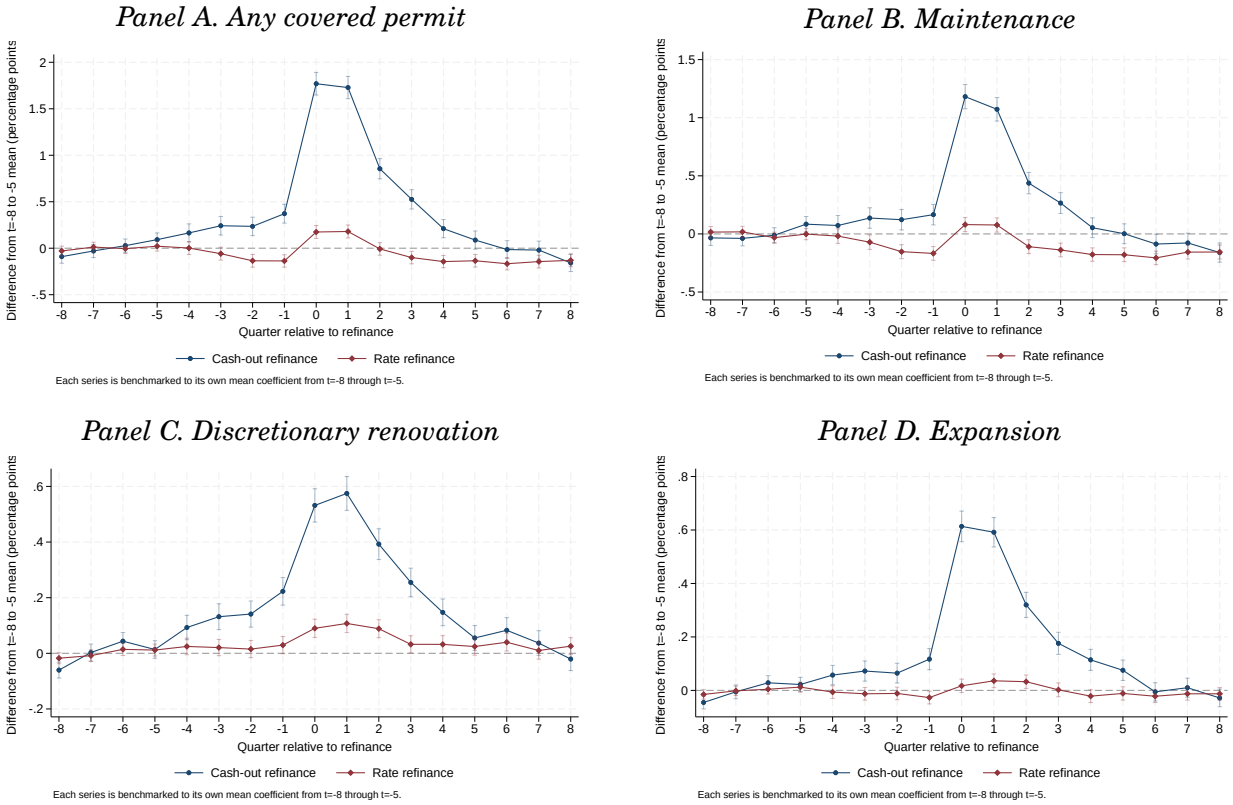
Notes: This table repeats the baseline permitting regressions in the subsample used for the household-income interactions in Table 7. The sample requires positive observed applicant income from a matched HMDA origination. The four columns correspond to the permitting outcomes in Table 2, Panel A; no income-group indicators or interactions are added here. Outcomes are next-quarter indicators scaled by 100, and rate gaps are in percentage points. Controls and other sample restrictions follow Equation 3, including continued ownership through the next quarter and no covered permit in the current quarter. Standard errors in parentheses are two-way clustered by origination month and mortgage identifier. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A4: Mortgage Lock-In and Permit History by Owner

	(1) All permits	(2) Maintenance	(3) Discretionary	(4) Expansion
Rate gap	0.1075***	0.0847***	0.0198**	0.0164**
	(0.0217)	(0.0193)	(0.0077)	(0.0074)
Prior permit: same owner	0.4844***	0.3495***	0.1205***	0.0821***
	(0.0472)	(0.0415)	(0.0205)	(0.0151)
Prior permit: different owner	0.2937	0.1844	0.1707*	0.0187
	(0.2034)	(0.1442)	(0.1012)	(0.0749)
Rate gap × same-owner history	0.0623***	0.0329**	0.0333***	0.0154***
	(0.0181)	(0.0162)	(0.0073)	(0.0059)
Rate gap × different-owner history	0.0065	0.0038	-0.0141	0.0050
	(0.0604)	(0.0435)	(0.0306)	(0.0250)
Controls	X	X	X	X
Fixed Effects				
Zip-Quarter	X	X	X	X
Orig-Year	X	X	X	X
Counts				
N	5,923,670	5,923,670	5,923,670	5,923,670
Sample Means				
Dependent Variable	1.7314	1.4310	0.2716	0.1689

Notes: This table compares the post-hike permitting response to mortgage lock-in across properties with prior permitted work under the same or a different owner. Permit-history indicators distinguish work recorded in 2018–2021 under the current owner and under a different owner. Both indicators and their rate-gap interactions enter together; the main slope is evaluated with both indicators zero. Regressor quarters are 2022Q2–2024Q4 and originations are restricted to 2010Q1–2021Q2. Outcomes are next-quarter indicators scaled by 100, and rate gaps are in percentage points. The sample requires continued ownership and no covered permit in the current quarter. Controls follow Equation 3. Standard errors in parentheses are two-way clustered by origination month and mortgage identifier. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

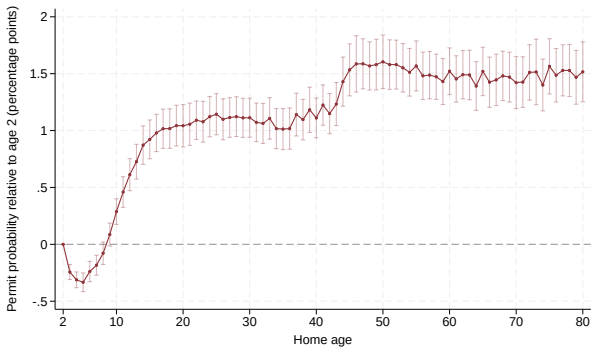
Figure A1: Permitting around Refinancing



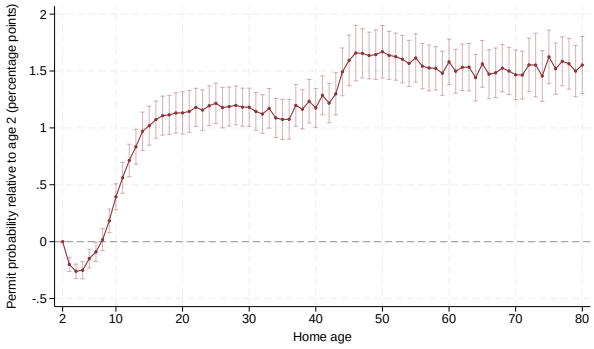
Notes: This figure compares the evolution of permitting around rate and cash-out refinancing. The four panels show separate profiles for the two refinancing types: blue circles denote cash-out refinancing and red diamonds denote rate refinancing. Event quarter zero denotes origination; the window spans eight quarters before through eight quarters after the event. Permit-incidence differences are measured in percentage points relative to each series' mean coefficient over quarters −8 through −5. Intervals are pointwise 95% confidence intervals. Refinancing may be arranged in anticipation of investment, so the profiles are descriptive rather than causal effects of refinancing.

Figure A2: Permitting by House Age

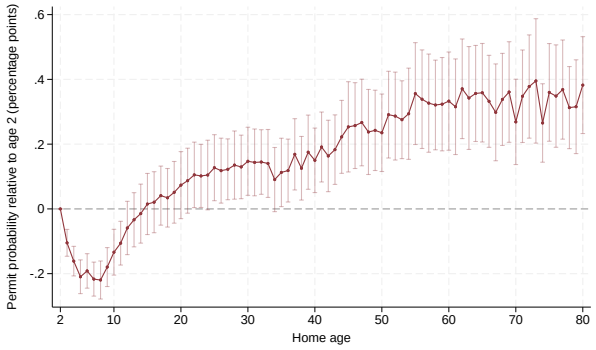
Panel A. Any covered permit



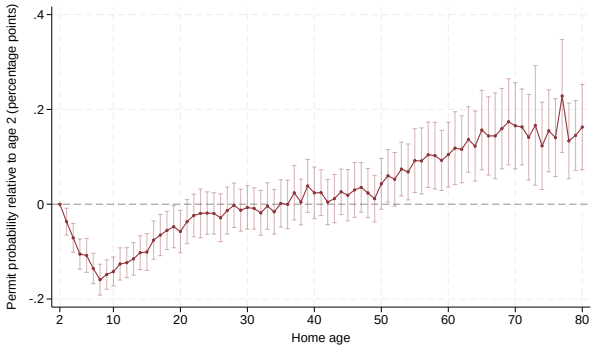
Panel B. Maintenance



Panel C. Discretionary renovation



Panel D. Expansion



Notes: This figure describes how recorded permit incidence varies with property age across the four investment outcomes. The plotted coefficients are percentage-point differences relative to age two, with the confidence intervals from the underlying estimates. They describe permitting levels by age, rather than responses to mortgage lock-in. Category-specific incidence need not sum to any-permit incidence because a property-quarter can contain more than one category of work.

B Derivations and Assumptions

Environment and feasibility. The household chooses whether to undertake a project, $d_i \in \{0,1\}$, before learning its period-one moving opportunity ε_i. The market mortgage rate r is known when investment is chosen; only ε_i is uncertain. A project costs $K_i > 0$, raises housing quality by $\Delta q_i > 0$, and delivers the per-period utility gain $\Delta V_i = v_i(q_i + \Delta q_i) - v_i(q_i) > 0$. It provides services in period zero and in period one if the household stays. Neither resale proceeds nor the moving payoff depend on d_i, although this could be relaxed.

Define cash on hand and consumption conditional on location by

$$\begin{aligned} w_i &= a_i + y_{i0} - \bar{r}_i B_i, \\ c_i^S &= y_{i1} - \bar{r}_i B_i, \\ c_i^M &= y_{i1} - r B_i^M. \end{aligned} \tag{B1}$$

The period-zero budget $c_{i0} + d_i K_i \le w_i$ binds because u_i is increasing and there is no other period-zero saving or borrowing choice. With minimum consumption $\underline{c}_i > 0$, not investing is feasible when $w_i \ge \underline{c}_i$, while investing is feasible precisely when $w_i - K_i \ge \underline{c}_i$. We assume that the project is paid for from available resources, with no new improvement loan.

Assume $B_i, B_i^M > 0$, $0 < \beta < 1$, and $\kappa_i \ge 0$. Consumption c_i^S and c_i^M is positive, as is $w_i - d_i K_i$ for each feasible choice. The function u_i is increasing, concave, and twice continuously differentiable on the relevant range; v_i is increasing on the relevant quality range. The shock has a rate-independent cumulative distribution F_i, continuous density $f_i \ge 0$, and a finite first moment. Except where explicitly varied, assets, incomes, mortgage balances, moving costs, project costs, quality, and the shock distribution are held fixed. The household cannot refinance its existing mortgage without moving. Mortgage balances and house prices are treated as fixed; common terminal wealth can be suppressed, for example if the price difference is financed by the change in mortgage balance and project spending is not capitalized into resale value.

Moving cutoff and its dependence on investment. Let

$$\mu_i = u_i(c_i^S) - u_i(c_i^M) + v_i(q_i) - v_i(q_i^M) + \kappa_i. \tag{B2}$$

From equation (1), the household stays after choosing d_i if and only if

$$\varepsilon_i \le \varepsilon_i^*(d_i) = \mu_i + d_i \Delta V_i. \tag{B3}$$

Consequently, its conditional probability of staying is

$$s_i(d) = F_i(\mu_i + d\Delta V_i), \qquad s_i(1) \ge s_i(0). \tag{B4}$$

For a given project choice, a higher market rate at fixed $\bar{r}_i$ raises μ_i by $B_i^M u_i'(c_i^M) > 0$. At a fixed r, increasing $g_i = r - \bar{r}_i$ by lowering $\bar{r}_i$ raises μ_i by $B_i u_i'(c_i^S) > 0$. Thus both changes weakly increase the probability of staying. The project itself also makes staying more attractive, as indicated by $s_i(1) \ge s_i(0)$.

Exact project decision. For any hypothetical utility gain $z \in [0, \Delta V_i]$, define

$$W_i(z) = \mathbb{E}_{\varepsilon_i}[\max\{S_i(0) + z, M_i(\varepsilon_i)\}]. \tag{B5}$$

Since the shock has a continuous distribution, the household is indifferent between locations with probability zero. The envelope argument therefore gives $W_i'(z) = F_i(\mu_i + z)$. Integrating yields

$$\begin{aligned} W_i(\Delta V_i) - W_i(0) &= \int_0^{\Delta V_i} F_i(\mu_i + z)\,dz \\ &= \widetilde{s}_i \Delta V_i, \\ \widetilde{s}_i &= \frac{1}{\Delta V_i}\int_0^{\Delta V_i} F_i(\mu_i + z)\,dz. \end{aligned} \tag{B6}$$

Here $s_i(0) \le \widetilde{s}_i \le s_i(1)$. The average is needed because investment changes the moving decision itself. In particular,

$$\begin{aligned} \widetilde{s}_i \Delta V_i = s_i(0)\Delta V_i \\ + \int_{\mu_i}^{\mu_i + \Delta V_i} (\mu_i + \Delta V_i - e) f_i(e)\,de. \end{aligned} \tag{B7}$$

The last integral is the additional continuation gain from moving opportunities for which the household would move without the project but stay with it. Thus using only $s_i(0)$ would omit a nonnegative part of the project's expected benefit.

For feasible d_i, the period-zero objective is

$$J_i(d_i) = u_i(w_i - d_i K_i) + v_i(q_i + d_i \Delta q_i) + \beta \mathbb{E}[\max\{S_i(d_i), M_i(\varepsilon_i)\}]. \tag{B8}$$

Subtracting the payoff from not investing from the payoff from investing and using equation (B6) gives

$$\begin{aligned} N_i &\equiv J_i(1) - J_i(0) \\ &= \big[1 + \beta \widetilde{s}_i\big]\Delta V_i - \big[u_i(w_i) - u_i(w_i - K_i)\big]. \end{aligned} \tag{B9}$$

If $K_i > w_i - \underline{c}_i$, then $d_i = 0$ regardless of N_i. Otherwise the household invests exactly when $N_i \ge 0$, taking investment as the tie-breaking choice. This proves (2) and separates an affordability threshold from a profitability threshold.

Interest-rate comparative statics. First, raise r while holding the existing mortgage rate $\bar{r}_i$ fixed. Cash on hand w_i and project feasibility are unchanged, while c_i^M falls. Differentiating (B9) and using $\partial \mu_i / \partial r = B_i^M u_i'(c_i^M)$ gives

$$\left.\frac{\partial N_i}{\partial r}\right|_{\bar{r}_i} = \beta B_i^M u_i'(c_i^M)\big[s_i(1) - s_i(0)\big] \ge 0. \tag{B10}$$

Thus a higher market rate weakly increases the value of an otherwise feasible project through expected tenure. The effect is strictly positive when the project changes the staying probability and the other factors are positive. Because feasibility does not change, the investment decision is weakly increasing in r (with the stated tie-breaking convention). Adoption changes only for feasible owners whose net gain crosses zero.

Second, hold r fixed and increase the gap $g_i = r - \bar{r}_i$ by reducing $\bar{r}_i$. Then $\partial \mu_i / \partial g_i = B_i u_i'(c_i^S)$ and

$\partial w_i/\partial g_i = B_i$. The net-gain derivative is

$$\left.\frac{\partial N_i}{\partial g_i}\right|_r = \underbrace{\beta B_i u_i'(c_i^S)\big[s_i(1) - s_i(0)\big]}_{\text{expected-tenure channel}} + \underbrace{B_i\big[u_i'(w_i - K_i) - u_i'(w_i)\big]}_{\text{cash-flow channel}} \geq 0. \tag{B11}$$

The first term reflects the increased attractiveness of staying; the second reflects the smaller utility cost of a fixed outlay when the existing mortgage payment falls. Concavity of u_i makes the second term nonnegative. Moreover, w_i rises with g_i, so an initially infeasible project can become affordable but a feasible one cannot become infeasible. The optimal binary investment decision is therefore weakly increasing in g_i at fixed r as well. These results hold for either sign of g_i within the stated domain; the interpretation as stronger mortgage lock-in applies to $g_i > 0$. Changing r and changing $\bar{r}_i$ are different experiments, even though both can increase the gap.

Assets, income, and heterogeneous responses. For a feasible project, greater assets or period-zero income raise cash on hand without changing the moving cutoff. Their effects on net project value are

$$\frac{\partial N_i}{\partial a_i} = \frac{\partial N_i}{\partial y_{i0}} = u_i'(w_i - K_i) - u_i'(w_i) \geq 0. \tag{B12}$$

They can also relax the affordability restriction. In contrast, period-one income changes the relative consumption utilities of staying and moving:

$$\frac{\partial N_i}{\partial y_{i1}} = \beta\big[u_i'(c_i^S) - u_i'(c_i^M)\big]\big[s_i(1) - s_i(0)\big]. \tag{B13}$$

If moving entails a larger mortgage payment, $rB_i^M \geq \bar{r}_i B_i$, then $c_i^S \geq c_i^M$ and this derivative is nonpositive by concavity of u_i. Lower future income can therefore increase the project's tenure benefit, even while lower current resources make its outlay harder to finance. When a common income change affects both periods, the net sign is ambiguous. Positive lock-in $g_i > 0$ by itself does not imply the payment inequality unless the mortgage balances also satisfy an appropriate restriction (for example $B_i^M \geq B_i$ when $r > 0$).

The decision rule also distinguishes a *level* of investment from a *response* to lock-in. Owners below the financing threshold cannot respond to a rate change at fixed $\bar{r}_i$, whereas sufficiently liquid owners may already undertake the project before that change. Positive adoption responses are concentrated among owners whose projects are affordable and whose net gains cross zero. Accordingly, the size of a rate-induced investment response need not rise monotonically with resources. The model does not separately identify liquidity from current income because both enter w_i.

Housing quality and interpretation. Suppose v_i is increasing and concave over the interval $[q_i, q_i + \Delta q_i]$, with $q_i + \Delta q_i \leq q_i^*$, and hold project size and preferences fixed. Then

$$\frac{\partial \Delta V_i}{\partial q_i} = v_i'(q_i + \Delta q_i) - v_i'(q_i) \leq 0. \tag{B14}$$

Thus a lower initial quality, and hence a larger shortfall from fixed preferred quality q_i^*, raises the project's per-period utility gain. This does not by itself guarantee greater adoption: existing quality also affects the moving cutoff, and the project must remain financeable. Home age, project type, in-

come, and previous permitting may therefore proxy for different components of the project decision. The baseline abstracts from resale capitalization, refinancing, endogenous prices and loan balances, and market-rate borrowing for improvements. Allowing these features can introduce offsetting channels, particularly when a higher r raises project financing costs.