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PTI Contours for Mortgage Affordability Risk

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Abstract. Mortgage affordability risk has increased as mortgage rates normalized while U.S. home prices remained elevated. This paper proposes a transparent, reproducible dashboard centered on payment-to-income (PTI), which appears as a contour map over the interest-rate and home-price space with decision thresholds at 25%, 30%, 35%, and 40%. Using official public data from FRED (30-year fixed mortgage rate, median house price) and a widely cited compilation of U.S. median household income consistent with Census reporting. This paper constructs a PTI surface, and quantify local sensitivities via a tornado chart, and compare a low-rate 2021 anchor with a representative 2024 anchor. With a 20% down payment and a 30-year fixed mortgage, the representative 2024 setting (price $419300; income $80610; rate 6.8%) implies a PTI of about 33%, i.e., above the commonly used 30% affordability threshold. Sensitivities show rate and price shocks dominate PTI changes at today's levels, while income shifts mitigate but more gradually. The approach is data-light and fully replicable, providing meaningful insights for integration into underwriting and macro-monitoring dashboards.

Keywords: mortgage affordability, pti, underwriting, sensitivity analysis, macro-prudential

1. Introduction

Housing affordability is central to credit risk management and supervisory monitoring. A simple, auditable indicator that translates macro conditions into micro, underwriting-relevant signals can help practitioners calibrate standards across cycles. A large empirical literature shows why an auditable, payment-based lens is useful for both lenders and supervisors. Campbell and Cocco develop a life-cycle framework in which income and interest-rate uncertainty feed directly into required mortgage payments, making payment pressure a central channel for household risk and product choice [1]. Mian and Sufi, using U.S. zip-code evidence around the housing bust, document that mortgage credit growth detached from local income trends is followed by materially higher default rates, indicating that borrower metrics anchored to income, such as PTI carry supervisory value [2]. Cross-country evidence from Akinci and Olmstead-Rumsey shows that borrower-based limits such as LTV and DTI caps that slow credit growth and cool house prices, effectively acting as affordability guardrails when markets run hot [3]. This motivates a transparent payment-to-income (PTI) "surface" that maps movements in rates, prices, and incomes into signals lenders can use.

This paper focuses on PTI and follows the Atlanta Fed HOAM's 30% affordability benchmark. PTI matters for two reasons: it makes the link from policy-rate changes to household budgets

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explicit via required mortgage payments [4], and it lines up with borrower-based macroprudential tools shown to rein in credit growth and house-price pressures [5]. We test whether a PTI contour map over the rate–price space—plus simple one-at-a-time sensitivities—can serve as a practical, data-light gauge of affordability risk. The contribution is a reproducible policy surface that turns market moves into clear decision thresholds and a prioritized set of levers, consistent with evidence that leverage amplifies downturns and that debt-service burdens shape spending and macro-outcomes [6,7].

2. Data and method

2.1. Indicator: PTI

PTI is decision-useful because it links macro conditions to a straightforward underwriting cap. HOAM operationalizes the HUD 30 percent standard: costs above 30 percent of median income imply unaffordability; an index value of 100 corresponds to the 30 percent line (affordable above 100, unaffordable below 100).

2.2. Data and assumptions

The paper uses official, internationally accessible sources: 30-Year Fixed Rate Mortgage Average (MORTGAGE30US), Freddie Mac PMMS mirrored on FRED (weekly), and a widely cited summary of U.S. median household income consistent with Census reporting [8,9]. It adopts 6.8% as a representative 2024 baseline within the observed 2024–2025 range. The paper then (i) plot PTI as a contour surface with thresholds at 25%, 30%, 35%, and 40%, (ii) rank one-at-a-time shocks with a tornado chart, and (iii) compare 2021 (low-rate) and 2024 (normalized-rate) anchors. External context from FHFA and the National Association of Realtors (NAR) situates results in current market conditions [10-12].

House price: Median Sales Price of Houses Sold (MSPUS). Anchors: Q4 2021 = $414000; Q4 2024 = $419300. Household income: median household income = $80610 (2023), taken from a widely cited historical compilation consistent with Census reporting; 2021 reference income $70784 for the 2021 scenario [8,9]. Assumptions: 20 percent down payment; 30-year fixed; P&I only (excludes taxes/insurance/HOA). Income is fixed at the 2023 national median for the heatmap to isolate rate/price effects; sensitivity analysis perturbs income by ±10 percent.

2.3. Contour-map construction

A PTI surface was constructed over a rectangular grid in mortgage rates and home prices. Mortgage rates span 3%–9% in 0.1-percentage-point increments (61 nodes), and prices span $300000–$600000 in $5000 increments (61 nodes). For each grid point (R,P), the loan principal uses a 20% down payment:

$$L = (1 - d)\, P, \quad d = 0.2 \tag{1}$$

The annual nominal mortgage rate R is converted to a monthly rate r for a 30-year fixed term with N=360 payments:

$$r = \frac{R}{12}, \quad N = 360 \tag{2}$$

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Monthly principal-and-interest (P&I) is computed by the standard annuity formula (and by straight-line division if r=0):

$$m = L\frac{r(1+r)^N}{(1+r)^N-1} \qquad \left(r > 0\right) \tag{3}$$

$$m = \frac{L}{N} \qquad \left(r = 0\right) \tag{3a}$$

Payment-to-income is then defined with annual median household income Y fixed at the 2023 national level to isolate the joint effect of rates and prices:

$$PTI\left(R,\ P\right) = 100\ \times\ \frac{m}{Y/12} \tag{4}$$

This yields a 61× 61 matrix of PTI values. Rendering iso-PTI contours at 25%, 30%, 35%, and 40% directly from the discrete surface; bilinear interpolation is used only to draw smooth contour lines, while all reported numbers come from the underlying grid. The 30% contour is treated as the operational affordability frontier: points below the line meet the conventional affordability benchmark, and points above it indicate elevated payment burden. The plots use interest rate (%) on the horizontal axis and home price in $1000 increments on the vertical. To make the results easy to replicate, the paper exports the complete grid as a CSV with the exact rate and price vectors. PTI is reported to one decimal place. All computations use double precision, apply an r=0 fallback in (3a), and enforce consistent units, which are the rates as decimals in code, percentages in the figures.

2.4. Tornado sensitivity

The paper assesses local, one-at-a-time shocks around the 2024 baseline (price $419300; income $80610; rate 6.8%; 20% down; 30-year fixed). Holding all other inputs constant, it re-computes PTI for a +1 and −1 percentage-point change in the mortgage rate, a +10% and −10% change in the home price, and a +10% and −10% change in household income.

For each lever, the effect reported in the chart is the change in PTI relative to baseline (in percentage points, one decimal), with the bar length based on the average absolute impact of the up and down shocks to mute small nonlinearities; signs are retained so upward bars indicate higher payment burden and downward bars indicate relief. Bars are ordered from largest to smallest effect to reveal which lever is most influential near current conditions. Step sizes reflect realistic pricing moves and plausible short-run variation in listing prices and borrower budgets. All calculations keep term and down-payment share fixed and use the same PTI definition as elsewhere in the paper. A companion CSV lists the baseline PTI, the up/down PTI changes, and the effect size used for ranking to ensure reproducibility.

2.5. Scenario comparison

Then the paper contrasts a 2021 anchor (price $414000; income $70784; rate 3%) with a 2024 anchor (price $419300; income $80610; rate 6.8%). This quantifies the payment shock due largely to rate normalization while prices at the anchors are similar.

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3. Results

Heatmap and contours (Figure 1). The 30% contour separates feasible and at-risk regions for a representative borrower. At a 6.8% mortgage rate, remaining below 30% PTI generally requires a price modestly below the national median or pricing relief (rate buydown). Contour spacing tightens at higher rates (7%–9%), evidencing non-linear convexity.

Tornado ranking (Figure 2). Baseline PTI is about 32.6%. A +1 percentage point rate shock raises PTI by roughly +3.4 percentage points; +10% in price is similar (about +3.3 percentage points). A +10% income shock reduces PTI by about −2.9 percentage points. Thus, rate and loan amount/LTV are dominant marginal levers at current conditions.

Scenario (Figure 3). PTI increases from about 23.7% (2021) to about 32.6% (2024). Because anchor prices are close, the rise is primarily rate-driven, consistent with FRED readings showing the 30-year rate moving from around 3% in 2021 to the high-6 percent range by 2024–2025. External indicators are consistent: FHFA indicates modest quarterly price gains into 2025 [10]; NAR's HAI indicates affordability remained strained in 2024–2025 [11,12].

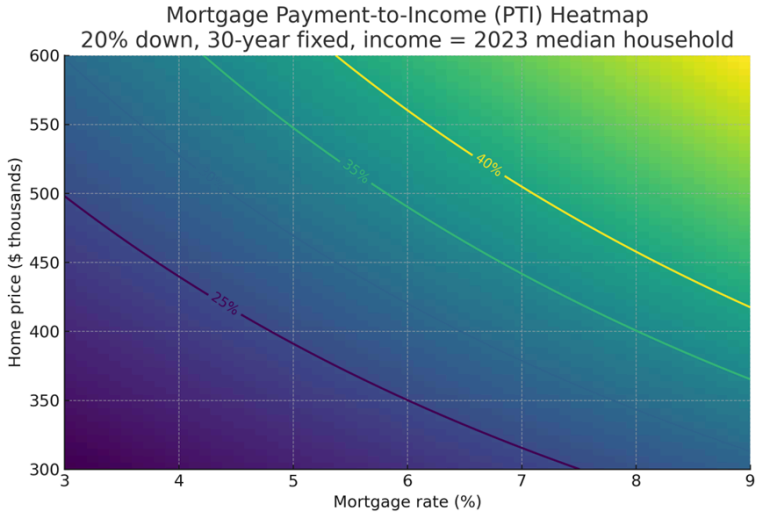

Figure 1. Mortgage payment-to-income (PTI) heatmap with 25%, 30%, 35%, and 40% contours. Assumptions: 20% down, 30-year fixed, income = 2023 median household

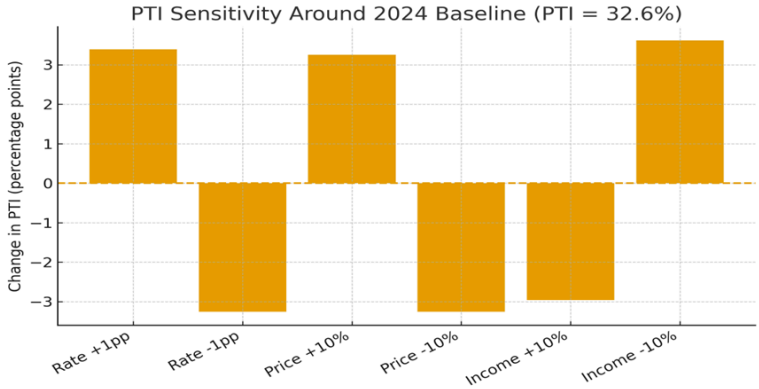

Figure 2. PTI sensitivity around the 2024 baseline (tornado)

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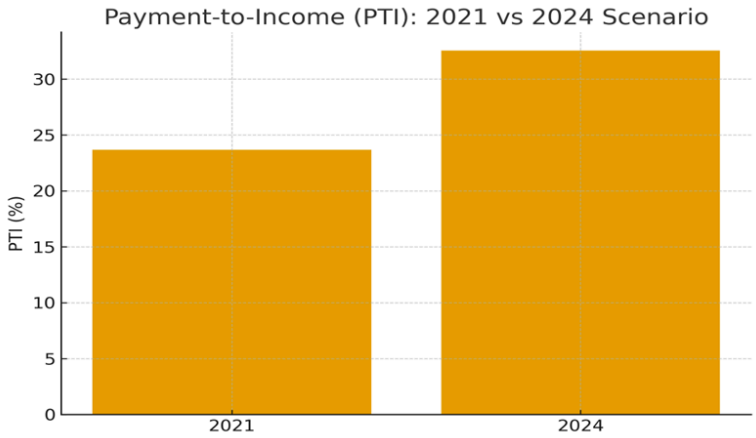

Figure 3. Payment-to-income (PTI): 2021 vs 2024 (20% down; 30-year fixed)

4. Discussion

The PTI surface provides a policy map that converts volatile macro inputs into actionable screening. The distance to the 30% contour gauges how much room remains before affordability caps are breached. Convexity on the heatmap implies stress designs should tighten as market rates rise, because equal rate moves yield larger PTI jumps at higher levels.

The tornado ranking clarifies the order of operations near today's conditions: target pricing/rate (e.g., points, buydowns) or adjust loan amount/LTV for borderline borrowers; income improvements help but usually on a slower timeline. Limitations include that national medians mask regional spread; P&I does not include taxes and insurance; median income is annual and lagged. These do not overturn the qualitative insights. Robustness is straightforward: replicate with regional series, add PITI factors, or explore lower down-payments.

5. Conclusion

Under a representative 2024 setting (price $419,300; income $80,610; rate 6.8%; 20% down), PTI is about 33%, above the 30% affordability boundary. The 30% contour cleanly partitions feasible from at-risk combinations, and the tightening of contour spacing at higher rates indicates non-linear rate sensitivity. Local sensitivities show that a +1 percentage-point rate or +10% price each increases PTI by roughly 3%–3.5% whereas a +10% income rise reduces PTI by about 3 percentage points.

From 2021 to 2024, PTI rises by roughly 9%, driven mainly by rate normalization with anchor prices little changed. For loans hovering near the 30% line, start with pricing/rate tools (points, temporary buydowns) or adjust the loan amount/LTV; add a +200 bp qualification stress when market conditions push typical borrowers toward 30%. Supervisors can add a national PTI surface and the PTI-at-origination distribution to dashboards and consider counter-cyclical guardrails when market PTI sits in the 30–35% range. The approach scales to regional panels and to PITI variants. By turning movements in rates and prices into borrower-level payment burdens with explicit thresholds, the PTI surface offers a practical early-warning tool for underwriting and surveillance, consistent with evidence that debt-service ratios are strong early indicators of systemic stress [13].

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