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PRICE IS THE MEDIUM THROUGH WHICH HOUSING FILTERS UP OR DOWN: A PROPOSAL FOR PRICE/INCOME AS AN INDICATOR OF HOUSING SUPPLY ELASTICITY

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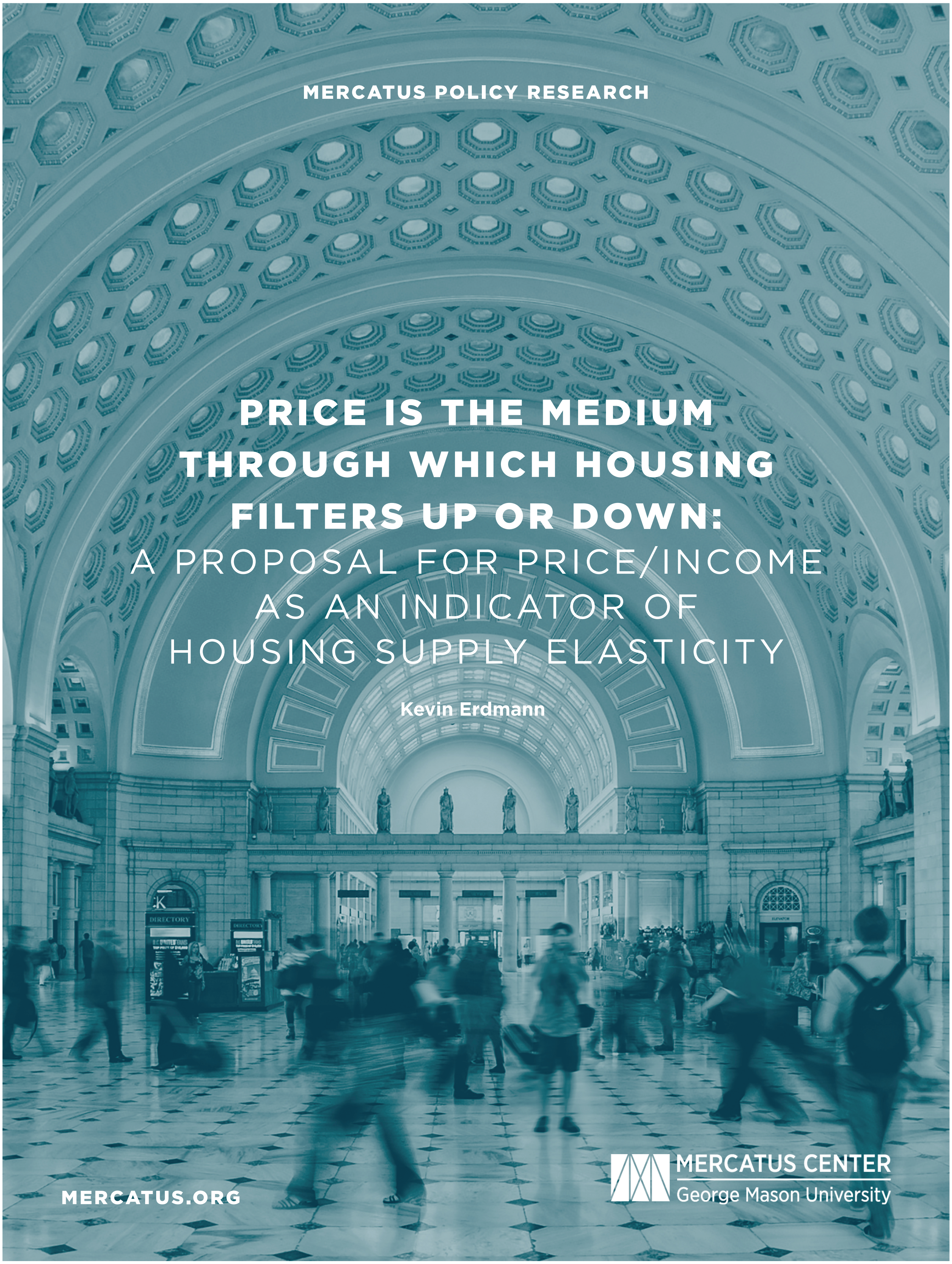

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ABSTRACT

A growing body of literature has shown that innumerable discretionary choices of home buyers and sellers spread the effects of housing supply conditions throughout a metropolitan area. New units draw residents with higher incomes from the existing stock of housing, which leaves existing homes available for residents with lower incomes. Where the production of new units is constrained, the existing stock of homes is instead claimed by residents with higher incomes, leaving residents with lower incomes to either accept higher rents on the housing that remains or move away to more affordable metropolitan areas. Inelastic housing supply causes price/income ratios to rise more in ZIP codes where incomes are low, and this pattern can be used as a real-time estimate of regional supply constraints.

Where the existing housing stock is filtering upward to residents with higher incomes, the mechanism through which homes filter is price. Home prices rise until the incomes and willingness to pay high housing costs of the households that have not migrated away from the metropolitan area become the dominant force mediating the distribution of the available stock of housing. Households are sometimes directly displaced, but frequently they self-select to move within or between metropolitan areas, depending on their willingness to accept higher housing costs.

JEL codes: R310, R380

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Price/income ratios[1] across a single metropolitan area are a surprisingly good indicator of housing supply elasticity. In metropolitan areas with inelastic housing supply, price/income levels are systematically higher in ZIP codes with lower incomes. In metropolitan areas where either demand for housing is low or housing supply is elastic, price/income ratios will be relatively flat across the region.

Where housing supply is elastic, as the housing stock across a metropolitan area ages, some of the older, depreciated housing normally becomes a source of affordable shelter for residents with lower incomes. This is referred to as filtering. The existing housing stock filters down to households with lower incomes. The systematic price/income patterns found across metropolitan areas shed light on this downward filtering process. The arrest or reversal of this process in cities with inelastic supply is evident in asymmetrical price/income patterns. Where the supply of new housing is lacking, residents with higher incomes claim more of the existing stock of homes, and that added demand prevents prices in aging neighborhoods from declining to more affordable levels. Existing homes filter up instead of down.

Rising prices lead to changing local demographics such that new residents in existing homes have higher incomes and many residents with lower incomes migrate out of the metropolitan area entirely. Affordability and financial constraints are important aspects of housing-motivated migration. Dislocations created by upward filtering of the housing stock are frequently the most noticeable in individual cases where a neighborhood undergoes swift change or some existing residents are displaced by a specific new housing development. But those individual cases are idiosyncratic outliers of the costs of inadequate hous-

1. The estimate I use for the price/income ratio in any given ZIP code is the median home value as reported by Zillow.com divided by the average adjusted gross income of each tax return as reported by the IRS. See appendix 5 for more details about data sources.

ing, which are conveyed throughout a metropolitan area via countless housing decisions.

Price/income differences across ZIP codes with different average income levels in a metropolitan statistical area (MSA) can be a useful and informative measure of MSA supply conditions. This measure has advantages over other supply elasticity estimates in that it can be easily calculated from publicly accessible and updated datasets; it reflects changing conditions in real time, both cross-sectionally and over time; and it appears to be correlated with several other important signals of housing supply, such as migration patterns, filtering rates of existing housing, permitting rates, and average home prices.

The paper will proceed with a background discussion, a review of recent price/income patterns in major metropolitan areas, and finally a discussion of the potential use of price/income patterns as a proxy for supply constraints in quantitative analysis. A set of appendices will address various caveats, adjustments, and extensions to the paper's concepts. Appendix 5 describes data sources.

BACKGROUND

Understanding about the distribution and use of the existing stock of homes within metropolitan areas over time has been growing. The price/income slope can quantify the scale of those processes and support further study.

Housing Substitutions and Filtering

Within metropolitan areas, there is ample substitution and overlap of buyers and sellers between neighborhoods in the long run. Substitutions across the housing market come in many forms, and most complaints at the planning department are basically complaints about substitutions—people and buildings encroaching on the existing landscape differently than they had previously, choosing new ways to consume and create shelter and community.

Brummet and Reed highlight the high baseline rate of interneighborhood migration.[2] In the aggregate, residents substitute between neighborhoods within metropolitan areas at a much faster rate than housing capital generally changes. This plethora of voluntary moves, both locally and interregionally, transmits the relative scarcity and value of housing in neighborhoods and metropolitan areas

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2. Quentin Brummet and Davin Reed, "The Effects of Gentrification on the Well-Being and Opportunity of Original Resident Adults and Children" (FRB of Philadelphia Working Paper No. 19-30, Federal Reserve Bank of Philadelphia, Philadelphia, PA, July 2019).

thoroughly throughout each city and region. New homes, the obstruction of new homes, the depreciation of declining neighborhoods, and the development of amenities in up-and-coming neighborhoods all trigger countless marginal economic housing decisions within the existing sets of constraints. When a home is built in Santa Monica, it imperceptibly affects the values of homes in suburban Tucson and in every neighborhood between.

Changes in home values are expressed through countless choices that households make about housing, many of which are experienced as voluntary choices based on the available set of options. When inelastic housing supply leads households to voluntarily migrate within or between metropolitan areas, it is a sort of displacement, but it is a displacement that is filtered through the narrowing of the choice set. When existing tenants are evicted from a home because of rising unaffordable rents or because of redevelopment, it registers categorically as "displacement," but the difference between evictions and the countless other decisions taken under a narrowed choice set is a difference in scale, not in kind. There would be many more explicit displacements if not for the countless semivoluntary housing decisions that moderate the quantity of housing demanded across a housing-constrained metropolitan area.[3] Direct displacement is the tip of the iceberg.

Research such as recent work by Evan Mast also points to the extensive substitutions and intra-MSA migrations that are moderated by new construction. The addition of new high-tier units leads to a chain of moves that soon free up units in less affluent parts of a city.[4] Analysis from Rosenthal[5] and from Liu, McManus, and Yannopoulos[6] suggests that where housing supply is ample for households with higher incomes in a given metropolitan area, the rental costs and prices of existing homes moderate so that households with lower incomes move into existing homes in that metropolitan area. In other words, the existing housing stock filters down to tenants with lower incomes over time.

Housing is a depreciating asset requiring some amount of maintenance and upkeep over time, with significant discretion. This creates ample space for the existing housing stock to decline or increase in value over time to meet the needs

3. Michael Munger describes that scale of voluntariness with the term "euvoluntary exchange." Michael C. Munger, "Euvoluntary or Not, Exchange Is Just," *Social Philosophy and Policy* 28, no. 2 (July 2011): 192–211.
4. Evan Mast, "JUE Insight: The Effect of New Market-Rate Housing Construction on the Low-Income Housing Market," *Journal of Urban Economics* (July 2021): 103383.
5. Stuart S. Rosenthal, "Are Private Markets and Filtering a Viable Source of Low-Income Housing? Estimates from a 'Repeat Income' Model," *American Economic Review* 104, no. 2 (May 2014): 687–706.
6. Liyi Liu, Douglas A. McManus, and Elias Yannopoulos, "Geographic and Temporal Variation in Housing Filtering Rates" (working paper, 2020).

of the broad spectrum of a city's residents. Since the United States has developed regional differences at the extremes of these processes of depreciation and maintenance, a range of outcomes is clearly visible among US cities.

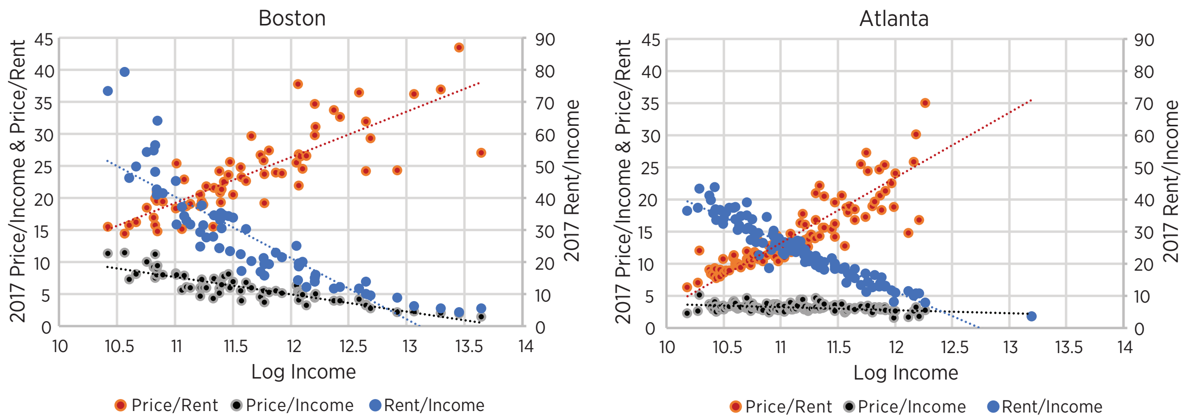
In cities that lack demand for housing because of declining population and limited economic prospects, housing frequently depreciates to the point of being uninhabitable, and sections of those cities, such as in Cleveland and Detroit, can become abandoned. At the other extreme, in cities where new building has been obstructed, gentrification is a common stressor. In those metropolitan areas, the lack of new housing leaves room only for potential residents with the means to bid rents higher, triggering income-sensitive migration out of the metropolitan area. Neighborhoods that would filter downward to residents with lower incomes if more new homes were approved are not only maintained but updated and improved to match the preferences of residents with higher incomes.[7] Most importantly, however, for a home with any given set of amenities where a lack of adequate new building increases the demand for an existing home, potential new residents with higher incomes are more able to pay higher rent for that home and are also able to tap credit markets in order to pay a higher price for that home than previous residents had.[8]

Building a Price/Income Ratio

Demand for shelter has historically been relatively inelastic, and it tends to be more inelastic where supply is inelastic.[9] This is because housing is a necessity good with a luxury component: basic shelter is a human need, but granite countertops, a fitness room, and a third bathroom are not. As rising prices lead to a reduction in the consumption of the luxury components of housing, leaving only the necessity components, demand becomes more inelastic. In the metropolitan

7. See Brummet and Reed, "Effects of Gentrification."
8. There is a growing literature on this subject of housing costs and regional sorting. In addition to other citations in this paper, a small sample of the literature includes Christopher R. Berry and Edward L. Glaeser, "The Divergence of Human Capital Levels across Cities," *Papers in Regional Science* 84, no. 3 (August 2005): 407–44; Enrico Moretti, *The New Geography of Jobs* (Boston: Houghton Mifflin Harcourt, 2012); Rebecca Diamond and Cecile Gaubert, "Spatial Sorting and Inequality" (working paper, 2021); Peter Ganong and Daniel Shoag, "Why Has Regional Income Convergence in the US Declined?" *Journal of Urban Economics* 102 (November 2017): 76–90; Elisa Giannone, "Skill-Biased Technical Change and Regional Convergence" (paper presented to the Annual Meeting of the Society for Economic Dynamics, Edinburgh, Scotland, June 2017); and Joseph Gyourko, Christopher Mayer, and Todd Sinai, "Superstar Cities," *American Economic Journal: Economic Policy* 5, no. 4 (November 2013): 167–99.
9. Eric A. Hanushek and John M. Quigley, "What Is the Price Elasticity of Housing Demand?" *Review of Economics and Statistics* 62, no. 3 (August 1980): 449–54.

FIGURE 1. MEASURES OF HOUSING AFFORDABILITY IN BOSTON AND ATLANTA



areas where inelastic supply has driven up rents, tenants become less willing and able to reduce their consumption of shelter—especially tenants with lower incomes, for whom most of the shelter is a necessity good.

The recent development of metropolitan areas with persistently inelastic housing supply has pushed housing costs outside their historical norms. The portion of a typical tenant's income that is claimed by rent is much higher in cities with inelastic supply than it is in cities with elastic supply. Figure 1 compares three housing cost measures in Boston and Atlanta. Atlanta is an example of a metropolitan area that has not developed binding political constraints in housing supply, and Boston is an example of one that has.[10] Each point in these scatterplots represents a ZIP code. The x-axis is the average adjusted gross income (AGI) for the ZIP code on a natural logarithmic scale (or log). For example, ln \$60,000 ≅ 11, ln \$100,000 ≅ 11.5, and ln \$160,000 ≅ 12.

The measures on the y-axis are the price/rent ratio, price/income ratio, and rent/income ratio. Rent/income ratios across the market in Atlanta reflect the typical relationship in areas without an unusual supply constraint. Rent

10. See E. L. Glaeser, J. Gyourko, and A. Saiz, "Housing Supply and Housing Bubbles," *Journal of Urban Economics* 64, no. 2 (September 2008): 198–217, for estimates of home prices relative to construction costs as a sign of relative elasticities. See Knut Are Aastveit, Bruno Albuquerque, and Andre Anundsen, "Changing Supply Elasticities and Regional Housing Booms" (Bank of England Working Paper No. 844, Bank of England, London, UK, January 2020), 18, for estimates of relative metropolitan area elasticities. Also, over the years from 1994 to 2020, Atlanta's maximum annual permits for new homes was 16.1 units per 1,000 residents, and Boston's was 3.7 (MSA permit estimates are from US Census Bureau, https://www.census.gov/construction/bps/historical_data/; see codes "BOST625BPPRIVSA" and "ATLA013BPPRIVSA" in https://fred.stlouisfed.org/).

(either paid or imputed) amounts to 30 to 40 percent of AGI in areas with lower incomes; as incomes rise, that rent/income ratio declines to 10 percent or less.[11]

In supply-constrained cities like Boston, rent in the richest ZIP codes also amounts to 10 percent or less of AGI; but in poorer areas, it can reach 50 percent or greater. This happens for a number of reasons: In Atlanta and cities like it, enough new supply is built to relieve pressure on rents, so that households that might be willing to spend more are not forced to. In Boston and cities like it, those same households are exposed to much more pressure to make compromises between comfort and spending.[12] As a result, cities like Boston have persistent and high rates of outmigration, especially among households with low incomes.

However, there are many sources of inertia in the decision to migrate. The housing-constrained cities typically have some rent control measures aimed at protecting tenants from high market rents. Additionally, there are frictions due to the high cost of moving, endowment effects, the value of local social and professional networks, and so forth, all of which tend to keep households in units where they would otherwise consider the rents to be too high. At the other end of the income spectrum, households with high incomes are also forced to make more compromises required by high costs, but they can more easily make those compromises by lowering their nominal expenditures on housing within a given metropolitan area.[13]

Price/rent ratios are also systematically related to incomes, but in the opposite direction. In figure 1, for both Atlanta and Boston, price/rent ratios are lower in ZIP codes with low incomes and higher in ZIP codes with high incomes. This is common across metropolitan areas. There are several potential reasons for this relationship: Income tax benefits to homeowners scale with price and income, up to a point. Within a metropolitan area, the rate of homeownership is lower in ZIP codes with lower incomes, so rents may reflect the added costs of third-party landlord services. And households with lower incomes have less access to credit, so the demand for ownership is less in those areas than the demand for tenancy.

11. See appendix 5 for data sources. The rent and price data are from Zillow and income estimates are from the IRS.
12. For an in-depth consideration of the income-sensitive rent burdens created by inelastic supply, see David Albouy, Gabriel Ehrlich, and Yingyi Liu, "Housing Demand, Cost-of-Living Inequality, and the Affordability Crisis" (NBER Working Paper No. 22816, National Bureau of Economic Research, Cambridge, MA, November 2016).
13. John Finlay and Trevor Williams, "Housing Demand, Inequality, and Spatial Sorting" (working paper, 2021).

However, there are mitigating factors in housing-constrained cities with high costs that push price/rent ratios higher in ZIP codes with lower incomes: low-priced areas may have potential as investments. Expected future rent inflation will push current prices up, and given the different elasticities of demand across the income spectrum, future rent inflation may be higher in low-priced areas than in high-priced areas. And where the rental value is due to economic rents and location value rather than to the cost of construction, depreciation will be lower relative to rents, justifying a higher price. Furthermore, some of the positive pressure on price/rent ratios can come from rising rents and prices themselves. The tax benefits of homeownership, and especially leveraged homeownership, can increase simply because rents and prices are higher. A more expensive home means a larger mortgage, which means a mortgage more likely to create a tax deduction, which, all else equal, justifies a higher price/rent ratio.

Thus, where costs are higher, price/rent ratios rise more at the low end; this effect is shown in figure 1. In 2017, each 1-point increase in log income in Atlanta was associated with a 10-point increase in the ZIP code price/rent ratio. In Boston, where costs are higher, it was associated with only a 7-point increase. This difference is especially noticeable in parts of the metropolitan areas where incomes are lower. Many ZIP codes in Atlanta in 2017 had homes with price/rent ratios below 10. In Boston, few had price/rent ratios below 15. The difference is even more acute than a simple regression would indicate. In the housing-constrained cities, the workers who are driven away tend to have lower incomes than the workers who move in. This creates a compositional change in the housing-constrained cities to households with higher incomes.[14]

So in addition to pulling up the low end of the price/rent scatterplot, housing-constrained metropolitan areas tend to have higher price/rent ratios overall because higher incomes are associated with higher price/rent ratios. The average log AGI of the ZIP codes shown in figure 1 in Boston in 2017 was 11.65 (about $115,000), compared to 11.16 (about $70,000) in Atlanta. Not only do ZIP codes with average AGI of less than $60,000 have lower price/rent ratios in Atlanta than they do in Boston, but there are also many more of them in Atlanta—in part because of the housing supply problem in Boston.

For all of these reasons, rising rents from a lack of supply can cause price/rent ratios in a city like Boston to rise in general, and they can also cause price/rent ratios in low-priced parts of the city to rise especially. During the 2000s

14. Cristobal Young, Charles Varner, and Douglas S. Massey, *Trends in New Jersey Migration: Housing, Employment, and Taxation* (Princeton, NJ: Policy Research Institute for the Region, Princeton University, September 2008), 4, 39.

housing boom, price/rent ratios of low-priced homes in some cities did rise more acutely than those of high-priced homes. Because of these mechanical, systematic relationships, much of the relative changes in price/rent ratios were actually due to rising rents.[15]

The last measure in figure 1 is price/income. Rent/income has a negative slope, and price/rent has a positive slope. Since price/income is the product of those two ratios, it tends to be relatively flat across ZIP codes in most cities. In Atlanta, using the measure in figure 1, price/income tends to be between 2.5 and 3.5 across the city. In Boston, however, while ZIP codes with high incomes also tend to have price/income levels in that range, those with lower incomes can have price/income ratios as high as 10.

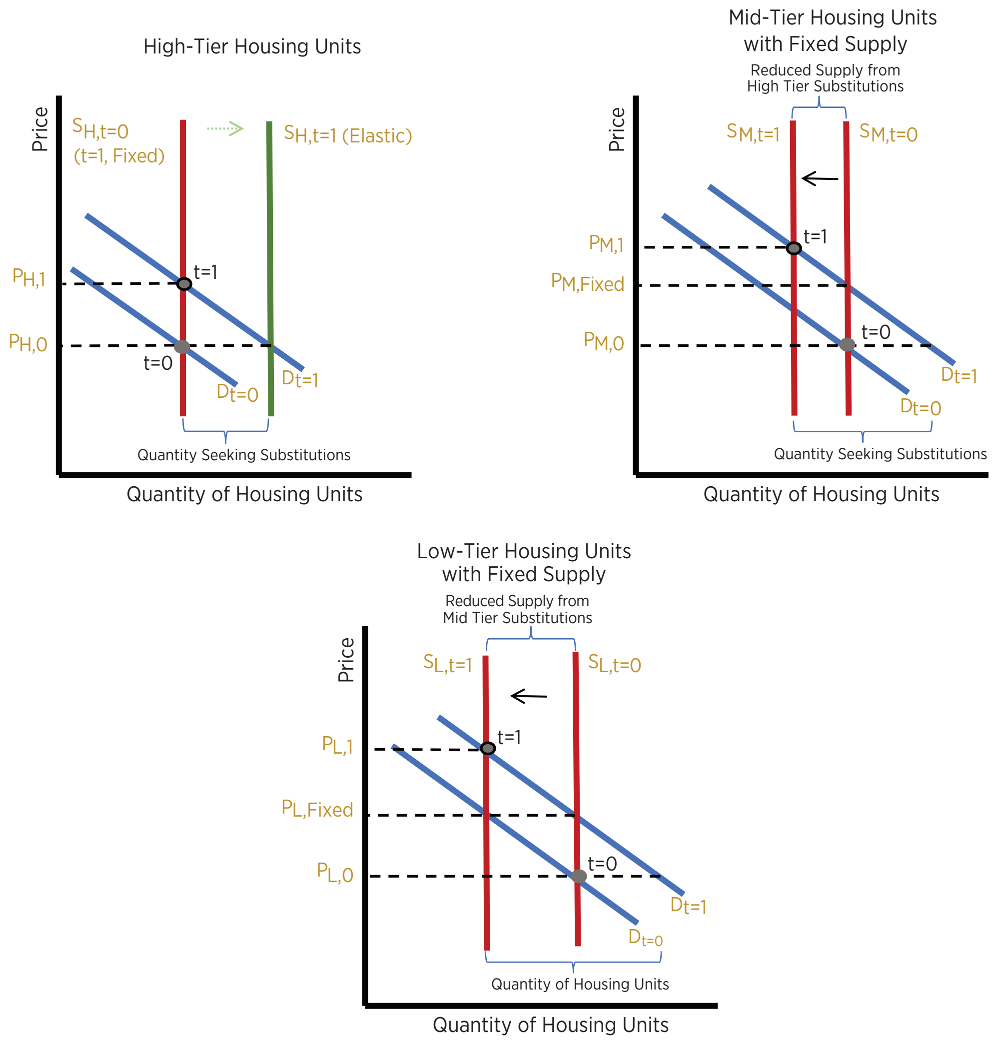
The Systematic Relationship between Price and Income with Inelastic Supply

Glaeser and Gyourko show that where home prices are elevated, the elevation is not generally driven by the basic cost of construction.[16] Where homes are filtering upward and potential new residents have high incomes, it is mostly the value of the lot that increases rather than the cost of the improvements. As location becomes a more important factor in the price of homes and the value and cost of the physical amenities becomes less important, the incomes of other potential tenants and owners become increasingly dominant factors mediating home prices. In other words, in a housing-constrained city like Boston, the incomes of other households who may rent or buy a unit in your neighborhood is a more important factor than the cost of windows or framing is; where the value of the lot is derived from a limited urban location, that value will be determined by the purchasing power of the marginal potential tenant more than by the cost of construction.

The price/income slope is the slope of the regression line in figure 1 for price/income in each metropolitan area. Figure 2 shows the dynamics that lead to a steeply negative price/income slope. Consider an idealized housing market with three tiers—high, mid, and low—each with some small natural increase in population over time. The high tier is shown in the upper-left panel. In a

15. Scott Sumner and Kevin Erdmann, "Housing Policy, Monetary Policy, and the Great Recession" (Mercatus Applied Research, Mercatus Center at George Mason University, Arlington, VA, August 2020), 24–26.
16. Edward Glaeser and Joseph Gyourko, "The Impact of Building Restrictions on Housing Affordability," *FRBNY Economic Policy Review* (June 2003): 21–39.

FIGURE 2. SUPPLY AND DEMAND FOR HIGH-, MID-, AND LOW-TIER HOUSING MARKETS UNDER INELASTIC SUPPLY CONDITIONS



market with sufficiently elastic supply ($S_{H,t=1\ (Elastic)}$), as demand increased, supply would increase until home prices settled near the original price ($P_{H,0}$). With elastic supply, the mid and low tiers might exhibit similar market behavior, and all three panels would appear the same. Some of the new supply in the low tiers would be from depreciating homes that had originally been built for higher tiers.

In a market with fixed supply, price in the high tier would rise (to $P_{H,1}$). Growth in demand would require a number of moderating market reactions, motivated by rising prices, by households in the high-tier submarket. These would include the following:

1. Increasing household size to reduce the number of units demanded.
2. Substitution into mid-tier neighborhoods formerly populated by households with lower incomes.
3. Migration out of the metropolitan area completely.

With fixed supply, population in the high-tier local housing market would still be able to rise due to natural increases from births minus deaths or inmigration to preferred metropolitan areas. Without new supply, the new high-tier households would have to claim adjacent supply that was formerly mid-tier supply.

In the mid-tier part of the market (the upper-right panel of figure 2), fixed supply would lead to a similar upward pressure on prices, with similar moderating changes in housing demand (to $P_{M,Fixed}$). However, substitution from the high-tier submarket into mid-tier neighborhoods would be one of the moderating reactions to inelastic supply from the high-tier submarket. This is part of the process of upward filtering, discussed earlier. The substitution of high-tier households into the mid-tier submarket effectively reduces the supply of homes available to the existing mid-tier households. So while the high-tier submarket had fixed supply, buyers in the mid-tier submarket would experience a reduction of supply (from $S_{M,t=0}$ to $S_{M,t=1}$). The resulting price would be $P_{M,1}$. In a market where the housing stock is fixed, this would mean that prices in the mid-tier submarket would rise even more than in the high-tier submarket. There would be more pressure in the mid-tier submarket to increase household size, substitute into the low-tier submarket, or migrate away from the metropolitan area.

The additional increase in price would, in turn, lead to an even greater decline in supply for the low-tier submarket (the lower panel in figure 2) than it did for the mid-tier submarket. So the low-tier submarket would have even more of a price increase than the mid-tier submarket (to $P_{L,1}$), and thus more pressure to increase household size or migrate out of the metropolitan area. Low-tier residents would not have a lower tier of housing to substitute into, so only two of the three options available to high-tier and mid-tier households would be available to them.[17]

One way to think of the downward substitutions of residents into lower tiers of the housing market is that in each lower tier, the households that remain

17. Increasingly, homelessness is the third alternative for low-tier residents in housing constrained cities.

are the households that reside at the left end of the demand curve, as it were. They are those who are somehow shielded from rising housing costs, who are more willing to spend a larger portion of their incomes for housing, who lack viable options, or who had the most consumer surplus at the previous rent levels. As downward substitutions create compositional changes in local populations, the shrinking pool of residents with low incomes is increasingly biased toward residents willing to accept higher housing costs.

These price pressures that cumulatively press onto lower tiers of a metropolitan area's housing market will be in proportion to supply elasticity. We could imagine the metropolitan area being divided into more than three tiers, with these one-way substitutions pressing increasingly on each lower tier. As supply becomes more and more constrained, the cost of housing in the respectively lower tiers exceeds the norms of metropolitan areas with more elastic supply. As the distance from those norms increases, both the portion of a household's income that they are willing to spend on housing and the incomes of other potential residents become increasingly important among the factors that determine who continues to live in the metropolitan area.

In a metropolitan area with increasing pressures from residents substituting downward, the price/income level will increase at each lower tier. And as these substitutions become the dominant factor determining local prices, those price pressures will naturally tend toward a systematic, linear function of incomes. Demand from the mid and high tiers will relentlessly lead to changes and substitutions within the metropolitan area that will eventually push prices throughout the low tier higher. Complaints of gentrification result from housing filtering upward—but more fundamentally, households are substituting downward. Local attempts to stop gentrification or to starve neighborhoods of new amenities and capital infusions may temporarily slow the process very locally, but the source of demand is systematic, from the lack of supply of high-tier housing broadly within the metropolitan area. So the demand, substituting downward, will be expressed systematically across the metropolitan area, and idiosyncratic differences among neighborhoods that speed or slow that process are orthogonal to the systematic force of a steepening price/income relationship across the region.

In other words, in a city with moderate housing costs, a family may weigh various factors—the local idiosyncratic mix of amenities, the social idiosyncrasies of the existing neighbors, aesthetics, proximity to work, and so forth. As housing costs become more binding, the decision of how far down-market to substitute to moderate costs naturally becomes a dominant factor. So as downward substitutions increase (as a metropolitan area's housing stock filters upward to tenants with higher incomes), both income and the price/income ratio the remaining residents are willing to accept will naturally become more important factors in determining the distribution of housing among a metropolitan area's residents.

It is increasingly common to see local residents oppose improvements in local public amenities, fearing that they will "gentrify" the neighborhood and displace existing residents.[18] That opposition is the result of a steep price/income slope that has made the income of potential tenants a primary driver of housing costs. To residents of cities where housing is ample, it can seem nonsensical for locals in high-cost cities to oppose improvements in their neighborhoods, but where the price/income slope is steep, poor local public amenities can reduce the demand from potential outside tenants. Neighborhood improvements are valuable to residents only if they are captured as consumer surplus. In a supply-constrained context, consumer surplus is bid away by outsiders.

Residents experience these downward substitutions, quite explicitly, as a decline in supply. For example, San Francisco supervisor David Campos writes in a 2015 op-ed, "When people are evicted from their rent controlled homes we diminish supply. When apartment owners convert units to condos we diminish supply."[19] He isn't describing a loss of supply in a literal, broad sense; those units weren't going away. He means that low-tier or mid-tier supply was being diminished, and what he is describing is the reduction in that supply as it was claimed by high-tier tenants. In that op-ed, he opposes increasing the supply of high-tier housing, calling it "trickle-down economics." That, ironically, invokes the real and necessary process of downward filtering that low-tier residents in San Francisco sorely need for housing to become more affordable. Existing low-tier units are being transitioned to high-tier supply because there are *not enough* new high-tier units in San Francisco. The irony of that condition has led to a vicious cycle of antisupply housing politics from officials such as Campos, which has prevented San Francisco and any large American metropolitan areas from reversing the process and reattaining affordability.

Recent Literature on Geography, Housing Costs, and Incomes

As inelastic housing supply increasingly influences the American economy, a literature about its effects is growing. The implications of that literature are

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18. Emily Chong, "Examining the Negative Impacts of Gentrification," *Georgetown Journal on Poverty Law & Policy*, September 17, 2017.
19. David Campos, "It's Still Called Trickle-Down Economics, Even in San Francisco," *San Francisco Examiner*, February 25, 2015.

becoming increasingly clear, and a primary intention of this paper is to propose a relatively easily collected measure (the metropolitan area price/income slope) that can be used as quantitative tool to test hypotheses about housing supply constraints and to measure or control for the effects of housing supply in economic analysis.

According to Diamond and Moretti:

> We find that for college graduates, there is essentially no relationship between consumption and cost of living, suggesting that college graduates living in cities with high costs of living—including the most expensive coastal cities—enjoy a standard of living on average similar to college graduates with the same observable characteristics living in cities with low cost of living—including the least expensive Rust Belt cities. By contrast, we find a significant negative relationship between consumption and cost of living for high school graduates and high school drop-outs, indicating that expensive cities offer a lower standard of living than more affordable cities.[20]

This comports with the description I have laid out earlier. In an economy with universally elastic housing supply, cities with more potential for productive work grow in both skilled and unskilled workers. Where there is not universally elastic housing supply, productivity growth in metropolitan areas with elastic supply can still lead to population growth. However, productivity growth in metropolitan areas with inelastic supply leads to population growth within those metropolitan areas of highly skilled, more educated workers with high incomes. Their arrival pushes up home prices, raising the cost of living for workers with less remunerative skills, less education, and lower incomes, until some number of them move away.

This creates a peculiar pattern wherein the difference between metropolitan area incomes is largely driven by housing supply elasticity. This is a perverse reversal of what should be a natural symbiosis. Households with lower incomes should benefit when their cities become more productive and attractive to newcomers.

Hoxie, Shoag, and Veuger find that these cost pressures are clear in migration trends:

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20. Rebecca Diamond and Enrico Moretti, "Where Is Standard of Living the Highest? Local Prices and the Geography of Consumption" (NBER Working Paper No. 29533, National Bureau of Economic Research, Cambridge, MA, December 2021).

> We find that that non-college workers now effectively face a housing-inclusive urban wage penalty, while workers with college education continue to face a significant urban wage premium. We relate these findings to the share of native-born cross-state migrants across different parts of the country, and find that native-born cross-state migrants, especially non-college workers, have become less likely to live in the highest-productivity areas.[21]

Also, comparing wages after housing costs of migrants versus existing residents, Hoxie, Shoag, and Veuger find that, since 1970, it is existing residents with less education who have experienced the greatest decline in relative wages after housing costs. And within that category, there are a noticeable handful of metropolitan areas that are outliers, with much lower wages after housing costs;[22] those are the cities with very inelastic housing supply where the workers who remain are those who self-selected due to inertia, endowment effects, and so forth to accept lower local standards of living rather than moving away.

Card, Rothstein, and Yi find that the sorting triggered by relative housing costs could account for most of the difference in incomes across metropolitan areas. They conclude that "the main explanation for high wage places is the presence of high wage people."[23] They also find "that larger and higher-earnings CZs [commuting zones] have much higher housing costs than smaller or lower-earnings CZs, enough so to more than completely offset their [higher] nominal earnings. Thus, movements to larger or to higher earnings locations mean reductions in real income."[24]

In an economy with free movement of labor and capital, incomes and housing costs should converge while population shifts toward regions with favorable productivity. That process is hobbled in American metropolitan areas with inelastic housing supply. Since population cannot grow if housing capacity doesn't grow, metropolitan areas with inelastic housing supply must meet the population inflows that are driven by productivity with equal outflows. Where housing supply is inelastic, the population of residents with high skills, incomes, education, and so forth continues to grow, much as it normally would. As this

21. Philip Hoxie, Daniel Shoag, and Stan Veuger, "Moving to Density: Half a Century of Housing Costs and Wage Premia from Queens to King Salmon" (AEI Economics Working Papers, American Enterprise Institute, Washington, DC, April 2022).
22. Hoxie, Shoag, and Veuger, "Moving to Density," 16, 29.
23. D. Card, J. Rothstein, and M. Yi, "Location, Location, Location" (CES Working Paper 21-32, Center for Economic Studies, US Census Bureau, Washington, DC), 41.
24. See Card, Rothstein, and Yi, "Location, Location, Location," 4.

population grows, the population of residents with less than the highest skills, incomes, and education must decline. Real estate owners inevitably raise costs to claim the value of local productivity until the higher costs lead to a new equilibrium where residents self-select to migrate away to maintain the limited population level.

As technology increases the potential for capital and labor flows, incomes continue to converge geographically, as they have for at least a century. But as a result of inelastic housing supply, it is incomes after housing costs rather than gross incomes that are now converging. The exception is where frictions and inertia push incomes after housing costs lower for residents who do not respond immediately to the forces of housing displacement. High-income households that move aspirationally do not, on average, move to places that will lower their incomes after housing costs. But households with lower incomes that move due to privation from rising housing costs naturally resist moving until the costs are more substantial.

Price/income ratios above 10 in the metropolitan areas with the worst supply constraints, where supply cannot be adequately created through new production, seem to support the idea of recurring housing "bubbles." Such home prices are surely unsustainably high for the local residents. However, where supply cannot be adequately created through new production, high prices are the mechanism through which those residents will be forced to relent, to finally move away in order to salvage a reasonable living standard, freeing local housing supply for other households. Home prices in supply-constrained metros must become unsustainable to force the migration that allows the existing homes to filter upward. Although this looks like a market repeatedly prone to "bubbles," it is actually quite the opposite. In a city deprived of adequate residential construction, existing home prices *must* be unsustainable by some families' standards.

In an American economic landscape where an important subset of metropolitan areas has binding housing supply, economic expansions are increasingly associated with housing "bubbles." Policy reactions such as tighter monetary or lending policies have been the primary policy tools applied to pop those putative bubbles. But unless urban housing supply becomes more elastic, the only long-term remedy for unsustainably high home values will be migration. Housing "bubbles" are a form of disequilibrium, but it is not a disequilibrium created by speculative activity moving markets too fast. It is a disequilibrium created by the inertia that slows the migratory response away from cities with inelastic urban housing supply. The significant personal costs of inter-MSA migration are the source of unsustainably high housing prices in supply-constrained MSAs.

A Conceptual Bound for Home Prices with Inelastic Housing Supply: A Model of Flows, Not Statics

Where housing supply is elastic and demand is stable or increasing, home prices are theoretically bounded: the price floor for new homes is the cost of constructing new homes. The market price is the present value of future net rents; it is conceptually derivative of a market expectation of future rents and a market discount rate. Price can be measured, while those fundamental determinants cannot. Where the market price is lower than the cost of construction, new construction will be low until the lack of supply pushes rents high enough for the market price to rise above the cost of construction, inducing new building. Where the market price is above the cost of construction, new construction will be active until the additional new supply brings down rents or pushes up the cost of inputs, or until rising discount rates lower the value of future rents and market values decline to the cost of construction.

These bounds don't apply where supply is very inelastic because rising market values cannot induce enough new building to bring rents down in that case. Home prices remain above the cost of construction, and either the gains are claimed by existing land and real estate owners or the difference between cost and value is eaten up by queuing and delaying of projects as they struggle through extended municipal review processes and other obstructions. Nevertheless, in cities with inelastic supply, a different model bounding the market value of homes might be derived from the ratios shown in figure 1.

Price/rent ratios of homes with lower values are lower than price/rent ratios of homes with higher values. In every metropolitan area, the regression of price/rent ratios against ZIP code incomes is positive, as shown for Boston and Atlanta in figure 1. During the housing boom that peaked in 2005, prices of low-priced homes increased much more than prices of high-priced homes in some MSAs with very high home prices. One reason temporary price appreciation could be so much higher for low-priced homes is that they normally have lower price/rent ratios. This temporary *divergence* of *price appreciation*, in some MSAs, between high-priced and low-priced homes was brought about primarily by the *convergence* of *price/rent ratios*. In some MSAs, by the peak of the market in 2005, low-priced homes were selling at price/rent ratios similar to those of high-priced homes.[25]

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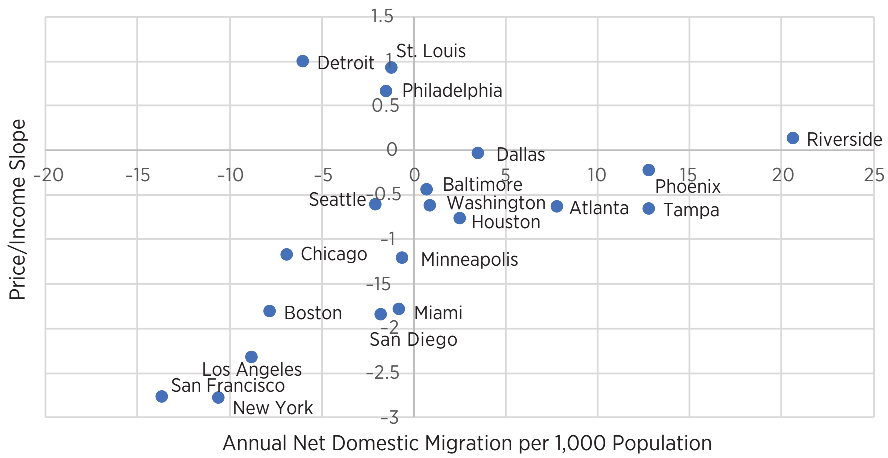
25. See Kevin Erdmann, *Shut Out: How a Housing Shortage Caused the Great Recession and Crippled Our Economy* (Lanham, MD: Rowman and Littlefield, 2018), chap. 4.

The price/rent ratios of high-priced homes serve as a natural bound on price appreciation of low-priced homes. If homes with lower rental values begin to sell at price/rent ratios higher than homes with higher rental values, buyers will substitute to homes with higher rental values. A price/rent ratio that is similar in low- and high-priced homes in an MSA could thus be considered a bound on relative price changes. All else equal, low-tier home prices are unlikely to rise past the point where they have the same price/rent levels as higher-priced homes in the same metropolitan area.

The slope of another ratio from figure 1, rent/income, also steepens under conditions of inelastic supply, as shown in the figure. In ZIP codes with lower incomes, rent takes a larger portion of tenant incomes in housing-constrained Boston than it does in Atlanta. The binding constraint here is the ability of existing residents to pay rising rents. And so the upper bound on rents is relieved by migration of residents with lower incomes away from housing-constrained MSAs. The numerator in the rent/income ratio reaches a maximum because rents become unaffordable for residents with lower incomes.

Price/income is a product of price/rent times rent/income. So, as an MSA's price/income slope steepens, further rising rents and prices require inter-MSA migration. Prices can continue rising only if the denominator in the price/income ratio increases through the compositional effects of income-sensitive migration into and out of the MSA. Thus, there is a correlation between a steeply negatively sloped price/income line and net domestic outmigration. Figure 3 shows a scatterplot of MSAs using these measures (net domestic migration on the x-axis and price/income slope on the y-axis) based on migration estimates from the Census

FIGURE 3. PRICE/INCOME SLOPE AND NET DOMESTIC MIGRATION IN 2000–2003



Bureau for 2000 to 2003.[26] Three types of MSAs stand out. MSAs that are growing and are willing to permit enough new homes to meet demand tend to have positive net domestic migration and price/income ratios that are similar across the MSA (i.e., the slope of the price/income line is near zero or is slightly negative); Riverside, Phoenix, and Atlanta were examples of these cities before the Great Recession. MSAs with struggling local economies tend to have negative or low net domestic migration and relatively flat or positively sloped price/income lines (with some nonlinearity); Detroit and St. Louis are examples.[27] MSAs that have high demand but inelastic housing supply have very negative rates of domestic migration and also very negative price/income slopes; San Francisco, Los Angeles, Boston, and New York City are examples.

Cities with strong economies attract international immigrants, so international migration may be a useful proxy for demand for shelter in a given MSA. In a regression of the price/income slope against both net domestic and net international migration into the 20 largest MSAs, net international immigration equal to 1 percent of an MSA's population was associated with a negative price/income slope of 2.1 points per each 1-point rise in log ZIP code income. A rate of net domestic migration into an MSA of 1 percent was associated with a positive slope of 0.5 points per each 1-point rise in log ZIP code income. An MSA with zero net domestic and international migration was associated with a slightly positive price/income slope.[28] These relationships are compatible with the hypothesis that housing demand (associated here with more international immigration) creates a negatively sloped price/income line unless it is mitigated by adequate supply, which allows domestic migration to remain positive.

Residents of expensive cities frequently complain about foreign home buyers. This reaction is understandable, because economically dynamic cities

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26. Paul J. Mackun, "Population Change in Metropolitan and Micropolitan Statistical Areas: 1990–2003" (Current Population Report P25-1134, US Census Bureau, Washington, DC, September 2005). Since the Census Bureau study, I am referencing here estimates both domestic and international migration rates for the years 2000 to 2003, I have used the average price/income slopes from the data on home prices and incomes that I have from the years 2001 and 2002 for this analysis. In all analysis here, the price/income level of each ZIP code in each year is estimated with the median home price from Zillow (ZHVI) and the average AGI of income tax filers as reported by the IRS. See appendix 5 for details on data sources. This analysis is limited to 20 metropolitan areas because the Census Bureau migration estimates are limited to 20 metropolitan areas.
27. See appendix 1 for some comments on nonlinearity.
28. Regression of price/income slopes calculated using the average of the 2001 and 2002 price/income lines for each MSA and using 2000–2003 annual migration estimates from Mackun, "Population Change." Adjusted standard errors are 0.59 points for international migration and 0.21 points for domestic migration. See appendix 2 for a scatterplot of predicted price/income slopes based on both international and domestic migration (figure 14).

attract foreign residents and investors, so metropolitan areas with the economic potential for high housing costs tend to have high levels of foreign activity in the housing market. However, the variable that primarily differentiates the cities with steeply negative price/income slopes from growing cities with more affordable housing is the rate of domestic migration. For instance, from 2000 to 2003, Phoenix averaged 0.8 percent annual net international immigration and 1.3 percent annual net domestic migration. San Francisco averaged 1.0 percent annual net international immigration and 1.4 percent annual negative net domestic migration. Both Phoenix and San Francisco were attractive enough destinations to attract substantial international migration. Phoenix accommodated that migration with new homes, so its price/income slope remained relatively flat (it remained affordable for households with lower incomes) and domestic households could comfortably move there. San Francisco did not accommodate migration with new homes, so the additional international immigrants steepened the price/income slope and domestic households moved to other cities to lower costs. St. Louis, Philadelphia, and Detroit, in contrast, had lower international migration paired with somewhat negative domestic migration. They have flat price/income slopes because there isn't high demand from either international or domestic households, and so local housing supply isn't as strained.

For cities like San Francisco, the value of homes isn't determined by the cost of construction. It is determined by the personal cost of displacement. To put it another way, saying that high costs are causing households to move away may be putting the causality backwards. From 2000 to 2003, a 1.4 percent annual negative net rate of domestic migration from San Francisco was more or less fixed, because the number of homes was relatively fixed. The slope of the price/income line had to steepen until life in San Francisco was unsustainable for 1.4 percent its domestic households. That slope has little to do with measurable things like the cost of lumber. It has to do with ethereal costs like the value of community.

This is not an equilibrium; this is a disequilibrium, and the scale of the disequilibrium is driven by economic conditions that affect migration flows. Again, this is why the housing market appears to perpetually be in some "bubble" state. Housing "bubbles" aren't driving economic growth. Economic growth increases the pressures of housing disequilibrium, which leads to the appearance of "bubble" conditions. Putative housing bubbles are a reflection of the personal costs that inelastic housing supply imposes on its residents.

THE PRICE/INCOME SLOPE IN RECENT HOUSING MARKETS

The price/income slope is different in each metropolitan area, depending on local supply constraints and the cyclical state of the economy. Changes in the slopes over time and cross-sectionally across metropolitan areas can convey information about migration patterns, the effect of localized supply constraints, and the condition of cyclical ebbs and flows in housing market activity.

Applying the Flow Framework to the 2002–2006 Housing Boom

In "Build More Houses," I describe a relationship between MSAs during the 2002–2006 boom.[29] A general, moderate increase in housing demand led to a migration event out of MSAs with inelastic supply. One way to describe a housing boom is that the number of homes demanded per capita rises. In MSAs where supply of units is relatively fixed, that rise in demand must lead to a decline in population. It also leads to an acceleration within those MSAs of the downward substitutions that steepen the price/income slope. So when there was a moderate, general increase in demand for housing during the 2000s, housing costs especially rose in low-income ZIP codes within MSAs having the highest average incomes, in part because of inelastic housing supply. Hundreds of thousands of households flooded out of the MSAs with inelastic supply and into other MSAs.

Increased construction activity during the boom was largely limited to the MSAs with inelastic supply and the MSAs that experienced a population surge from the migrant households that moved away from those metros. However, rates of building in the metropolitan areas with very high costs were so low that a large relative increase in building was not sufficient to match the increase in demand.[30] For example, annual permits for new homes in the Los Angeles metropolitan area grew by more than 40% from the late 1990s to 2004 and 2005, but on a per capita basis, it still approved fewer new homes in 2004 and 2005 than every major metropolitan area except Pittsburgh.[31]

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29. Kevin Erdmann, "Build More Houses: How an Incorrect Perception of Housing Supply Fueled the Great Recession and Slowed Recovery" (Mercatus Applied Research, Mercatus Center at George Mason University, Arlington, VA, May 2021).
30. For an extensive analysis of migration and the cyclical relationships between housing markets in different metropolitan areas, see Gregor Schubert, "House Price Contagion and US City Migration Networks" (Meyer Fellowship Paper, Joint Center for Housing Studies, Harvard University, Cambridge, MA, March 2021).
31. MSA permit estimates are from US Census Bureau, https://www.census.gov/construction/bps/historical.

FIGURE 4. POPULATION GROWTH VS. PRICE/INCOME IN 30 MSAS

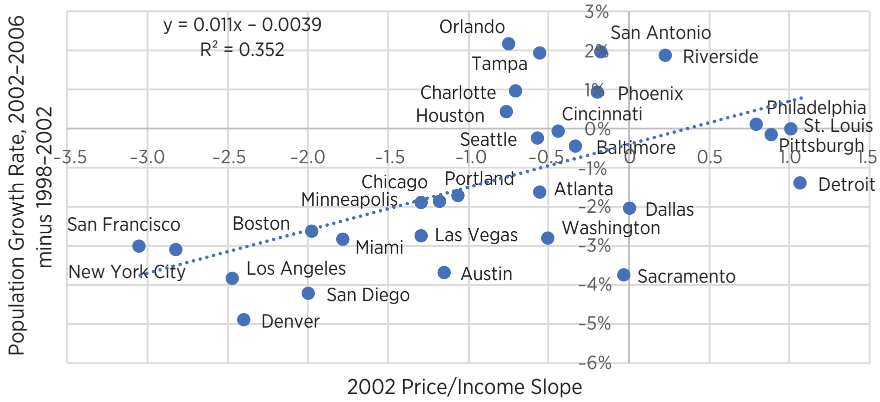


Figure 4 highlights the relationship between price/income slopes and population trends in 30 MSAs during the boom. In figure 4, the x-axis is the price/income slope in 2002. The y-axis measures the change in the population growth rate between 2002–2006 and 1998–2002.[32]

The MSAs at the right end of the scatterplot in figure 4 that had positive price/income slopes because they lacked strong demand saw little change in population growth. Two types of cities experienced volatile population trends—those that lost substantial population and those that gained. At the left end of figure 4, the MSAs with very steeply negative price/income slopes had sharply negative shifts in population growth that were correlated with the steepness of the price/income slope. These supply-inelastic cities created outmigration when demand for housing increased, and their populations trended downward. The more negative the price/income slope, the farther away those metropolitan areas were from the equilibrium cost of living, and the more pressure there was on the flow of outmigration.

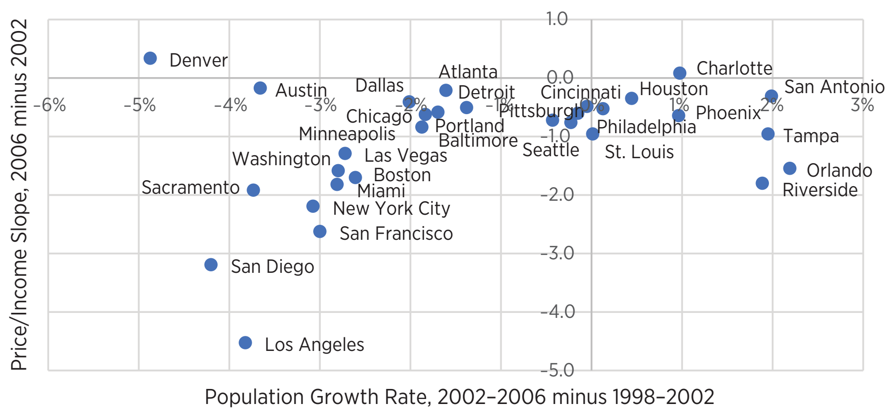
The MSAs that appear well above the regression line in figure 4 generally were the main recipients of those housing migrants. They had a doubly positive demand shock in housing: their populations trended upward because their housing supply is generally elastic, so they were able to build for growth, and that growth was accelerated by the migration out of the cities with inelastic supply. Because the change in population growth rate in recipient metropolitan areas was a result of their exposure to the migration outflows from the expensive metros, their change in population growth was orthogonal to their beginning price/

32. Population estimates from the US Bureau of Economic Analysis. See appendix 5.

income slope rather than correlated with it. For instance, Dallas, Austin, and Atlanta were exposed to less migration from California and the Northeast, and so they had lower growth rates, which were unrelated to their local housing constraints, and they appear below the regression line. Orlando, Riverside, Tampa, and Phoenix were exposed to more migration, and so they experienced higher growth rates, which were unrelated to their local housing constraints, and they appear above the regression line.[33]

During the same period, there was also a relationship between the change in population growth rate and the *change* in the price/income slope. In the MSAs that began the period with inelastic supply and steep price/income slopes, the boom in housing demand steepened their price/income slopes and increased the rate of outmigration. The price/income slope also steepened in some of the MSAs which experienced an uptick in population from that migration, though not nearly as much. The relative change in population growth rates and price/income slopes of the 30 largest MSAs from 2002 to 2006 is shown in figure 5. One could say that the slight steepening of the negative price/income slope in metropolitan areas in Florida, Arizona, and inland California was caused by increased inflows while the steepening in the supply-constrained cities like Los Angeles was associated with accelerated outflows. Eventually, when housing costs did rise in Florida, Arizona, and inland California, people responded as they do in

FIGURE 5. POPULATION GROWTH AND HOUSING AFFORDABILITY IN 30 MSAS



33. There are exceptions reflecting variables omitted in this simple analysis, such as Sacramento and Las Vegas, which had declining population growth in spite of being important cities in the housing "bubble," and San Antonio, which had an increase in population growth while maintaining relatively moderate home prices.

the metropolitan areas with long-term inelastic supply: households also started to move away from those metropolitan areas.[34]

Price/Income Patterns in 30 MSAs, 2001–2019

To establish the estimates for the price patterns in the 30 MSAs in this dataset, I ran simple linear regressions for each MSA in each year, with ZIP code average log income as the independent variable and the ZIP code price/income ratio as the dependent variable. (This is the regression of the black dots in the scatterplots in figure 1.) The zero bound creates some nonlinearity at high incomes in some markets, so I limited the estimate of the slopes to ZIP codes with log incomes less than 12 in 2018.[35] Using those two variables, equation 1 estimates the correlation between ZIP code average income and average price/income ratio, separately for each year and each metropolitan area.[36]

Equation 1: $$(\text{ZIP code Price/Income})_{\text{Year}} = \alpha(1)_{Year,MSA} + \alpha(2)_{Year,MSA} \times (\text{Log ZIP code Income})_{\text{Year}} + \varepsilon$$

The coefficient α(1) may be useful for some purposes, and it is discussed further in appendix 3. The coefficient α(2), or the price/income slope, is the relative change in the price/income ratio across ZIP codes within an MSA associated with an increase in log income of 1. The price/income slope is the key measure that may have informational value regarding housing supply conditions within each MSA. It can be calculated for any MSA at any point in time with an estimate

34. Author's calculations from IRS county-to-county migration data. See appendix 5. Also see Kevin Erdmann, "Housing Was Undersupplied during the Great Housing Bubble" (Mercatus Policy Brief, Mercatus Center at George Mason University, Arlington, VA April 2018), fig. 8.
35. In other words, in MSAs with steep price/income slopes and some ZIP codes with exceptionally high incomes, a linear regression would attribute negative expected price/income ratios for those ZIP codes. This could be rectified by, for instance, transforming the price/income ratios to a log scale, but I think the relative price/income ratios on a normal scale convey the most useful information driving American migration and consumption patterns, so I have truncated the few ZIP codes with very high incomes to estimate the linear relationship of price/income across most MSAs. See appendix 2.
36. In equation 1, and in the output reported in table 1, I have limited the analysis to reported median home prices, without the complications of various control variables. One control that does appear to improve linearity and homoscedasticity within some metropolitan areas is property tax rates. In appendix 4, I attempt to control for different property tax rates. There is an alternative table of results from equation 1, with estimated price/income slopes if all ZIP codes shared the same property tax rate.

TABLE 1. SLOPE OF PRICE/INCOME REGRESSION LINE ANNUALLY IN 30 MSAS

	2001	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Atlanta	−0.72	−0.55	−0.72	−0.78	−0.76	−0.84	−0.25	0.21	0.30	0.53	0.47	0.44	0.22	0.07	0.02	−0.25	−0.50	−0.80
Austin	−1.17	−1.15	−1.28	−1.28	−1.32	−1.39	−1.26	−1.16	−1.12	−0.98	−0.99	−0.91	−1.03	−1.13	−1.27	−1.48	−1.61	−1.60
Baltimore	−0.56	−0.33	−0.33	−0.46	−1.06	−1.67	−1.14	−0.91	−0.80	−0.49	−0.43	−0.24	−0.28	−0.25	−0.39	−0.45	−0.57	−0.76
Boston	−1.64	−1.97	−3.23	−3.59	−3.68	−3.88	−2.64	−1.98	−2.09	−1.95	−1.98	−2.18	−2.36	−2.53	−2.86	−3.12	−3.26	−3.36
Charlotte	−0.73	−0.70	−0.84	−0.73	−0.62	−0.69	−0.37	−0.33	−0.48	−0.30	−0.30	−0.14	−0.13	−0.22	−0.30	−0.42	−0.64	−0.81
Chicago	−1.17	−1.18	−1.50	−1.68	−1.81	−2.20	−1.59	−0.97	−0.75	−0.49	−0.37	−0.14	−0.19	−0.34	−0.44	−0.60	−0.96	−1.10
Cincinnati	−0.60	−0.44	−0.80	−0.78	−0.94	−1.38	−0.64	−0.18	−0.33	−0.24	−0.34	−0.15	−0.17	−0.14	−0.18	−0.23	−0.36	−0.46
Dallas	−0.09	0.01	−0.22	−0.36	−0.40	−0.55	−0.12	0.01	−0.04	0.15	0.05	0.15	0.01	0.03	−0.13	−0.46	−0.77	−1.05
Denver	−2.33	−2.40	−2.41	−2.17	−2.06	−2.04	−1.20	−1.06	−1.30	−1.10	−1.12	−1.25	−1.46	−1.83	−2.18	−2.49	−2.66	−2.77
Detroit	0.92	1.07	0.83	0.67	0.55	0.12	0.39	0.61	0.75	0.85	0.83	1.02	0.81	0.70	0.52	0.33	0.16	0.08
Houston	−0.77	−0.76	−0.95	−1.09	−1.11	−1.27	−0.97	−0.79	−0.76	−0.65	−0.64	−0.58	−0.63	−0.70	−0.73	−0.96	−1.08	−1.30
Las Vegas	−1.35	−1.30	−1.73	−2.24	−2.60	−2.72	−1.87	−1.05	−0.88	−0.54	−0.66	−0.99	−1.28	−1.45	−1.64	−1.83	−2.25	−2.47
Los Angeles	−2.19	−2.47	−4.16	−5.69	−7.01	−7.77	−5.51	−3.49	−2.99	−2.87	−2.94	−3.52	−3.98	−4.08	−4.31	−4.66	−4.57	−4.59
Miami	−1.78	−1.78	−2.34	−2.92	−3.60	−4.93	−3.49	−2.11	−1.40	−1.01	−1.15	−1.20	−1.44	−1.64	−1.99	−2.49	−2.96	−3.20
Minneapolis	−1.13	−1.29	−1.77	−1.95	−2.15	−2.25	−1.66	−1.23	−1.23	−0.96	−0.94	−0.95	−1.09	−1.18	−1.29	−1.42	−1.51	−1.66
New York City	−2.73	−2.82	−3.49	−4.17	−5.02	−5.67	−5.03	−4.15	−3.57	−3.31	−3.24	−3.25	−3.31	−3.48	−3.75	−3.93	−4.20	−4.41
Orlando	−0.80	−0.75	−1.18	−1.70	−2.29	−2.52	−1.69	−0.84	−0.54	−0.41	−0.56	−0.77	−1.04	−1.14	−1.32	−1.71	−2.04	−2.26
Philadelphia	0.51	0.80	0.74	0.45	0.26	−0.34	0.24	0.39	0.24	0.29	0.20	0.41	0.35	0.24	0.27	0.11	−0.03	−0.22
Phoenix	−0.27	−0.19	−0.43	−0.63	−0.84	−1.07	−0.32	0.22	0.34	0.35	0.15	0.02	−0.29	−0.49	−0.73	−0.99	−1.07	−1.20
Pittsburgh	0.56	0.89	0.57	0.39	0.29	0.09	0.53	0.77	0.52	0.73	0.51	0.73	0.72	0.64	0.72	0.56	0.56	0.50
Portland	−1.08	−1.06	−1.33	−1.42	−1.65	−2.08	−1.58	−1.45	−1.43	−1.08	−1.15	−1.01	−1.23	−1.45	−1.74	−2.03	−2.33	−2.38
Riverside	0.03	0.23	−0.07	−0.81	−1.59	−1.63	−0.48	0.08	0.28	0.31	0.08	0.08	−0.23	−0.50	−0.85	−0.98	−1.22	−1.42
Sacramento	0.30	−0.03	−0.84	−1.75	−1.96	−1.57	−0.37	0.00	−0.12	0.06	−0.12	−0.25	−0.82	−1.07	−1.41	−1.70	−1.70	−1.71
San Antonio	−0.31	−0.17	−0.38	−0.47	−0.49	−0.71	−0.37	−0.11	−0.15	−0.13	−0.09	0.01	−0.05	−0.08	−0.15	−0.36	−0.60	−0.80
San Diego	−1.69	−1.99	−4.20	−5.11	−5.19	−5.15	−2.86	−1.33	−1.53	−1.71	−1.91	−2.42	−2.94	−3.08	−3.31	−3.56	−3.31	−3.36
San Francisco	−2.49	−3.05	−4.25	−5.09	−5.68	−5.57	−3.66	−2.56	−2.50	−1.98	−1.88	−2.14	−2.73	−2.92	−2.96	−3.49	−3.77	−3.42
Seattle	−0.66	−0.57	−0.85	−1.10	−1.34	−1.79	−0.92	−0.63	−0.55	−0.24	−0.13	0.12	−0.13	−0.30	−0.32	−0.46	−0.56	−0.95
St. Louis	0.82	1.02	0.57	0.27	0.05	−0.13	0.14	0.46	0.36	0.44	0.34	0.55	0.28	0.54	0.64	0.53	0.42	0.35
Tampa	−0.78	−0.55	−0.89	−1.15	−1.51	−1.75	−1.08	−0.59	−0.43	0.04	−0.05	0.01	−0.13	−0.31	−0.41	−0.78	−0.96	−1.13
Washington	−0.74	−0.50	−0.68	−1.12	−2.09	−2.65	−2.04	−1.14	−0.50	−0.13	−0.26	−0.56	−0.87	−1.10	−1.36	−1.53	−1.75	−1.78

of home prices and incomes at the ZIP code level. Table 1 lists the price/income slopes for each year from 2001 to 2019 for 30 MSAs.[37]

Table 1 is limited to years with published income data from the IRS—through 2019. Price/income slopes flattened during and after the 2008 financial crisis, but then resumed steepening. In a forthcoming paper in which I extend ZIP code income trends to 2021 and use more recent home price estimates from Zillow, I find that price/income slopes have continued to steepen.[38] Much of the rise in recent home prices has been attributed to increased demand for housing associated with the Covid pandemic, but rising prices associated with steepening price/income slopes have largely been a continuation or acceleration of pre-Covid trends.

Discerning Cyclical from Secular

Figure 6 highlights the price/income slopes of selected MSAs from 2001 to 2019. The patterns described earlier can be seen here. New York City and Los Angeles began with steeper slopes, those slopes became proportionately steeper during the 2002–2007 period, and they remain steeper today. In some other MSAs, the price/income slope steepened somewhat during the 2002–2007 boom, though clearly much less so than in New York City and Los Angeles.

The effect of both persistent and cyclical effects on the price/income slope can be inferred from a supply and demand graph. Figure 7 is an idealized supply and demand graph with notations for various metropolitan areas during the 2000s housing boom.

Figure 7 includes a short-term supply curve for cities with inelastic housing supply and one for elastic cities with elastic supply. Supply is inelastic at low levels of demand in all cities because the supply of the existing stock of homes is relatively sticky. MSAs differ according to how many units the local bureaucracy is willing to approve over a given period of time. So, each metropolitan area has a relatively stationary supply curve that is vertical (inelastic) when demand is very low or very high, and relatively flat (elastic) when demand is moderate. As demand shifts cyclically, it affects each metropolitan area differently, depending on the pace of construction where the supply curve becomes vertical in each metropolitan area.

37. The price/income slopes listed correspond to the coefficients $\alpha(2)_{Year,MSA}$ from equation 1. Zillow, the source for the estimate of home prices, updates prices monthly. Incomes used for these estimates are from the IRS, and they are updated annually with some lag. At the time these estimates were compiled, the IRS data were published through 2019. Gap in 2003 is due to missing IRS data. See appendix 5 for details.

38. Kevin Erdmann, "Home Price Trends in 2021 Point to a Worsening Lack of Supply" (Mercatus Policy Research, Mercatus Center at George Mason University, Arlington, VA, forthcoming).

FIGURE 6. PRICE/INCOME SLOPE IN SELECTED MSAS

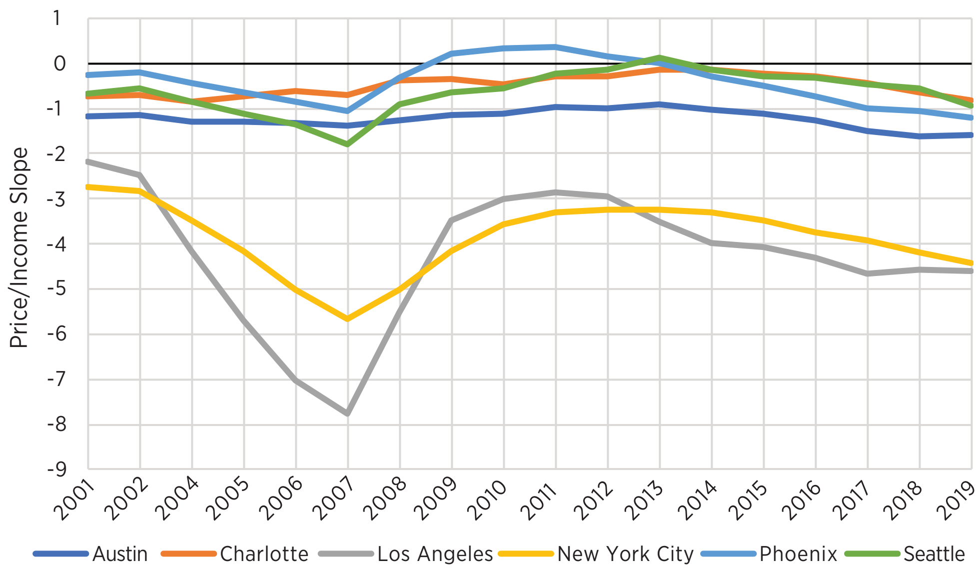
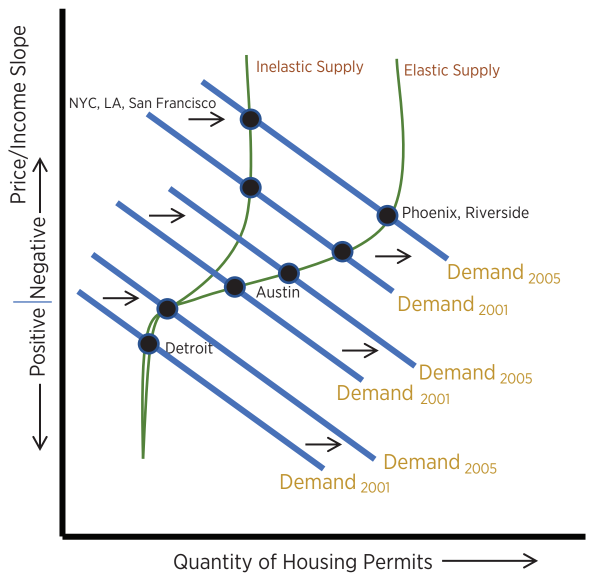


FIGURE 7. IDEALIZED SUPPLY AND DEMAND CURVES FOR METROPOLITAN AREAS



In MSAs where demand is within the bureaucratic limit, such as 2005 Austin as shown in the figure 7, new units can be built in adequate quantities and prices remain moderate. Where demand exceeds an MSA's growth limit, supply becomes inelastic; price/income slopes steepen more in those MSAs. That happens in New York City, Los Angeles, and San Francisco at very low quantities of new permits. Riverside and Phoenix are generally capable of issuing more permits for new homes, but by 2005 demand had risen so much that even they reached the inelastic part of the supply curve where construction activity reached a limit and prices started to rise. Where low demand moves the market equilibrium to the lower part of the supply curve, the price/income slope can actually become positive, because for households with inelastic housing demand, the existing stock of housing provides extra supply. Homes can sell for less than the cost of replacement. Parts of the Detroit market has been in that condition.

Austin is an MSA with more elastic local supply conditions that did not experience exceptional population growth during the housing boom, so it remained in the sweet spot for housing supply, and the price/income slope didn't steepen appreciably during the housing boom. Phoenix and Riverside also have relatively elastic local supply conditions, in that they have been able to allow above-average rates of population growth and housing construction. But during the 2000s housing boom, they experienced a migration boost of households moving out of the inelastic MSAs that challenged their local supply capabilities, and they temporarily moved to the inelastic (vertical) part of the supply curve, albeit with rates of home building higher than the average city. New York City, Los Angeles, and San Francisco have inelastic local housing supply, and they face high demand for housing, so they are permanently pegged near a bureaucratic local maximum for housing production.

Because prices are determined by both supply and demand, supply constraints cannot be perceived from housing permit data alone. Only cities with elastic housing supply conditions can have high rates of new home construction, but cities can have low rates of construction because of low demand or because of inelastic supply conditions. The price/income slope can be helpful in this regard. Cities with low demand (Detroit in figure 7) have flat price/income slopes, while cities that have ventured into a context of inelastic supply because demand is higher than the local willingness to permit homes (Los Angeles in figure 7) have steeply negative price/income slopes. If demand outstrips local supply capabilities, or local political shifts create more inelastic supply conditions, a steepening negative price/income slope can be a timely signal.

THE PRICE/INCOME PATTERN AS A QUANTITATIVE PROXY FOR SUPPLY CONSTRAINTS

The price/income slope provides timely and novel information about the scale of supply constraints in a metropolitan area's economy. The price/income measure can aid analysis of variables, such as changing home prices or incomes, by serving as a quantitative proxy for housing supply constraints.

Cantilevered Housing Markets, Regional Controls, and Fixed Effects

An equal cyclical increase in demand in both Austin and Los Angeles will produce a much steeper change in the price/income slope in Los Angeles because of the differences in supply elasticity, as shown in figure 7. Even if an increase in demand is not related to income-sensitive factors such as credit access, prices will tend to appreciate the most in ZIP codes with low incomes in Los Angeles. In a recent research paper, I note that the aggregate national price/rent ratio in the United States has increased over the last few decades, but not uniformly across the country.[39] Ironically, high rents drive price/rent ratios higher. Cities with low rents tend to have stable price/rent ratios, and cities with high rents have elevated price/rent ratios. The phenomenon with regard to price/income ratios is similar.

As seen in figure 8, metro area median price/income ratios are higher where median incomes are higher. As discussed earlier, constrained housing supply may frequently be responsible for both higher local incomes and higher home prices. Just as price/income levels have not risen uniformly across the United States, price/income levels also have not risen uniformly within metropolitan areas. In fact, the high median price/income levels in *high*-income *metropolitan areas*, shown in figure 8, are systematically the result of high price/income levels in *low*-income *ZIP codes* within these metropolitan areas.

In other words, the upward sloping correlation shown in figure 8 reflects the fact that middle-and lower-income consumers pay considerably higher prices for housing in the high-income metropolitan areas than they do in the others. The primary reason that the regression trend line in figure 8 is *positively* sloped is that the price/income lines *within* the cities in the upper right of figure 8 are more *negatively* sloped, as shown in figure 9. In figure 9, the upward sloping correlation of 50 metropolitan area price/income median in 2016 is shown

39. Kevin Erdmann, "Rising Home Prices Are Mostly from Rising Rents" (Mercatus Research, Mercatus Center at George Mason University, Arlington, VA, August 2022).

FIGURE 8. MEDIAN PRICE/INCOME IN 50 METROPOLITAN AREAS

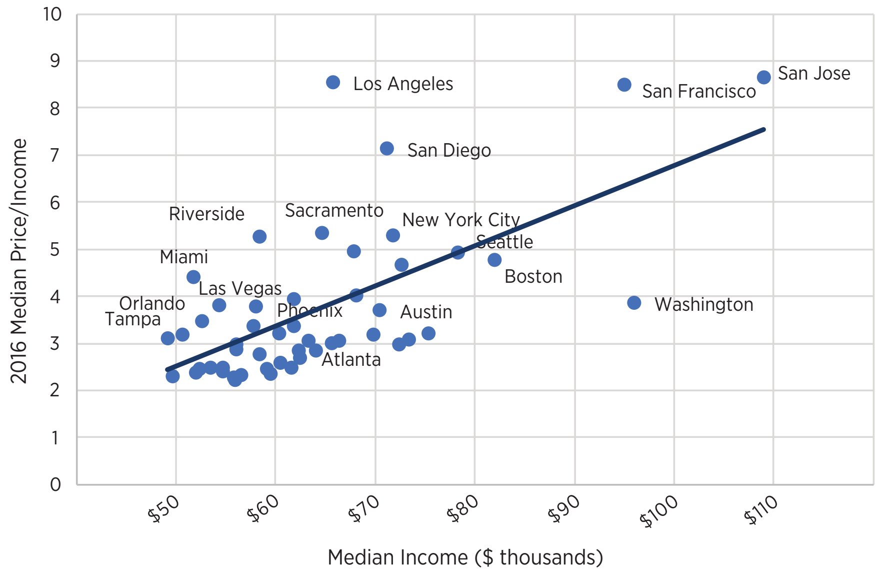
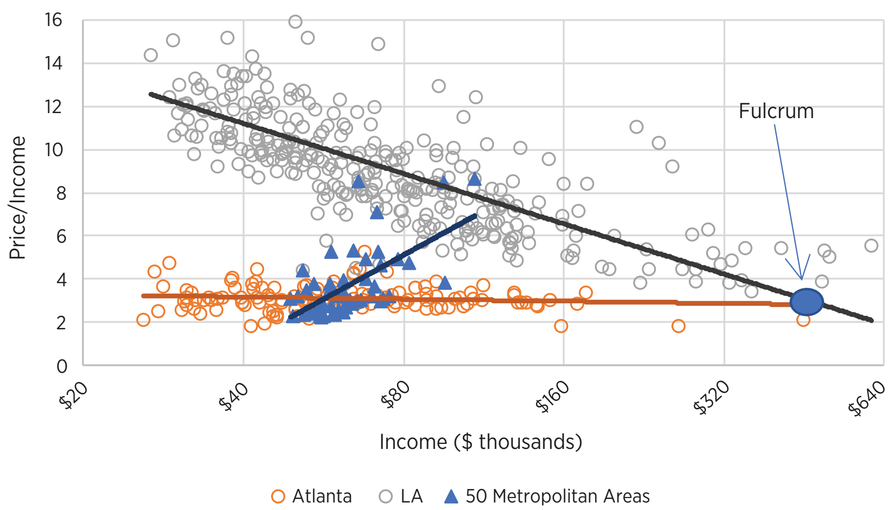


FIGURE 9. MEDIAN PRICE/INCOME IN 50 METROPOLITAN AREAS AND IN LOS ANGELES AND ATLANTA ZIP CODES



by the blue triangles and their associated regression line. But the difference in median price/income levels between, say, Atlanta and Los Angeles (ZIP code price/income ratios for those metropolitan areas are also shown in figure 9) is entirely the result of their different price/income slopes. In other words, the reason the median price/income ratio in Los Angeles is triple the median price/income ratio in Atlanta, as shown in Figure 8, is because the poorest ZIP codes in Los Angeles have price/income ratios that are quadruple the price/income ratios of the poorest ZIP codes in Atlanta, while the richest ZIP codes in Los Angeles have price/income ratios double the richest ZIP codes in Atlanta, and the median ZIP codes just happen to be halfway between those extremes. In fact, at some hypothetical high-income level, most metropolitan areas eventually will converge at a similar price/income ratio. Comparing price/income ratios across two metropolitan areas, such as Los Angeles and Atlanta, is like comparing two rays projecting from a common point, or cantilevers with a shared fulcrum at some high-income level, as shown in figure 9 at very high annual incomes of nearly half a million dollars. The same is also generally true when comparing valuations at two different times within each metropolitan area.[40]

The median price/income ratio in 2016 was 2.6 in Atlanta and 8.7 in Los Angeles.[41] Controlling for differences between Atlanta and Los Angeles by applying a uniform multiple across each metropolitan area would create a biased dataset that would make housing in all ZIP codes below the median income in Los Angeles appear to be highly overvalued. Since price/income levels over time within each metropolitan area also tend to swivel from a fulcrum point, similar issues would arise in time series analysis.

Much of the important and persistent change in valuations within metropolitan areas is the result of this cantilevered type of pattern. In analysis of changing prices, where controlling for regional differences is required, it may frequently be prudent to apply both a uniform control (position A to position B in figure 10) and a price/income slope control (position B to position C in figure 10). See appendix 3 for more discussion of relative price changes and the use of regional fixed effects to control for price appreciation related to local conditions.

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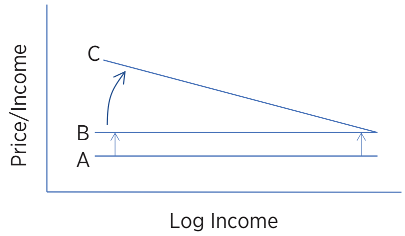
40. See figures 21 and 22 in appendix 3 for examples of San Diego and Atlanta at several points in time, which display the same cantilevered pattern.
41. These estimates and the metropolitan area estimates used in figure 8 are from a slightly different data set than the ZIP code level data. Here, I have used Zillow ZHVI estimates for metropolitan areas and median household income estimates for each metropolitan area, which is available in archived versions of the Zillow data website, under “More Metrics” at https://web.archive.org/web/20190118150152/https://www.zillow.com/research/data/.

FIGURE 10. TWO TYPES OF SYSTEMATIC PRICE APPRECIATION IN METROPOLITAN AREAS



More on Migration, Filtering, and Home Prices

Income growth, filtering rate (the relative change in the income of new owners of the average home compared to the income of the previous owners over time in each metropolitan area), and the price/income slope all have correlations with migration trends. Here, I use data from the American Community Survey from 30 MSAs for the period 2005 to 2014. I have four measures: (1) the average income of outmigrants compared to that of all MSA residents, (2) the rate of outmigration, (3) the average income of inmigrants compared to that of all MSA residents, and (4) the rate of inmigration.[42] Table 2 shows the correlations between filtering rate, income growth, and the price/income slope and those four variables. Filtering rates and income growth are from the Liu, McManus, and Yannopoulos paper mentioned earlier that estimated the rate of filtering among different metropolitan areas.[43]

42. Here, migrant incomes are based on the income at the destination. That could lead to bias that makes the number lower for metropolitan areas with above-average incomes. On the other hand, if these differences in metropolitan area income are largely a product of housing supply and costs, then lower outmigrant incomes would still be a signal of housing constraints, even if the bias is created by the income differential of the move itself. In either case, this limited analysis is intended to be an exploratory introduction rather than a definitive quantification of the correlations, so I have included these results.

43. The filtering data cover the period 1993 to 2018, as reported by Liu, McManus, and Yannopoulos, "Geographic and Temporal Variation," table A1. Liu, McManus, and Yannopoulos also report filtering rates relative to MSA income growth (table A5). I have inferred MSA income growth from the reported filtering rates. If Liu, McManus, and Yannopoulos report that the average house filtered to owners with 1.5 percent higher incomes annually and that the average house filtered to owners with 0.5 percent higher incomes annually relative to MSA incomes, then I inferred that the relative increase in MSA income had averaged 1.0 percent annually. Migration data are based on the American Community Survey, years 2005 to 2014, because ACS data are generally limited to 2005 and after. I have an existing dataset covering those years. Price/income slope data are the average from 1998 to 2017 in order to match as fully as possible the period of time covered by the Liu, McManus, and Yannopoulos filtering estimates.

TABLE 2. REGRESSION COEFFICIENTS OF FILTERING, INCOME, AND PRICE/INCOME SLOPE WITH VARIOUS MIGRATION VARIABLES

	Dependent Variable			
	Outmigration Rate	Outmigrant Income	Inmigration Rate	Inmigrant Income
Filtering Rate	**0.59**	**–5.70**	0.22	–0.34
	0.018	*0.0002*	*0.54*	*0.80*
Income Growth	0.45	**–5.40**	0.27	–1.14
	0.057	*0.008*	*0.52*	*0.55*
Price/Income Slope	**–0.0038**	**0.023**	–0.0015	–0.0035
	0.000001	*0.0008*	*0.24*	*0.59*
Observations	30	30	30	30

Notes: p-values in italics. Migration rates are adjusted for MSA size. Migrant income is relative to the MSA average. Statistically significant (p<0.05) coefficients in bold. Results are for 12 individual bivariate regressions.

The results shown in table 2 are not for multivariate regressions; they are for twelve separate regressions, each with a single independent variable. Interestingly, none of the independent variables has a statistically significant correlation with either inmigrant income or the rate of inmigration. However, they all have strong correlations with both outmigrant incomes and outmigration rates.

The correlations between filtering and outmigration rates are the easiest to consider. Table 2 shows that where the filtering rate is 1 percent higher (new residents in a typical home have a higher income over time), an additional 0.6 percent of the population migrates away. Here, we can see the direct result of the fact that a city that builds fewer homes has room for fewer people. When homes aren't built, residents must move away, and the residents who remain tend to have higher incomes. This is also suggested by the correlation between filtering rates and the income of outmigrants: where the filtering rate is 1 percent higher, the income of the average outmigrant is 6 percent lower. An MSA with 1 percent higher income growth is associated with a 0.5 percent higher rate of outmigration and 5 percent lower incomes among those outmigrants. An MSA with a 1 point steeper negative price/income slope is associated with a 0.433percent increase in outmigration and a 2.3 percent lower income among the outmigrants.

These results align well with the earlier discussions. Inelastic housing supply leads to upward filtering of the existing stock of homes as households with higher incomes substitute downward into lower-tier neighborhoods. This process plays out systematically through a steepening negative price/income slope, leading to outmigration of residents with lower incomes and leaving the metropolitan area with a higher average income among the remaining households.

Figure 11 shows the correlations that the outmigration rate has with filtering rate, income growth, and price/income slope. Upward filtering of homes is associated with outmigration both when it is associated with rising MSA incomes (e.g., the average home filtered up to an owner with 0.5 percent higher income each year, while the average resident in the metropolitan area had an annual increase in income of 0.5 percent; shown in top panel) and when it is orthogonal to rising MSA incomes (e.g., the average home filtered up to an owner with 0.5 percent higher income each year, while the average resident of the metropolitan area had stable income; shown in second panel).[44] The correlation between the rate of outmigration and the slope of the price/income line (shown in bottom panel) is stronger than the correlations between outmigration and both filtering and income growth. This suggests that filtering is thoroughly mediated through the price mechanism so that the price/income slope appears to be a reliable indicator of the process.

Table 3 highlights additional analysis. Here, I ran multivariate regressions for the same four migration variables using the price/income slope and housing permits per capita from 2005 to 2014.[45] The rate of permits is highly correlated with inmigration but not with outmigration. Also, when permits are included as a variable, the price/income slope has a significant correlation with inmigration rates (though still no correlation with inmigrant incomes). This makes sense. In order to grow, a city must build homes. And the way cities grow faster is generally by accepting more inmigrants. After accounting for that strong correlation, the effect of a negatively sloped price/income line becomes clear: the price/income slope conveys information about the dual relationship between supply and demand. Where demand is higher, at a given supply of new homes, the

44. Inertia about moving is central to these patterns. In the full experience of a city, these interactions are complex and messy, but it might be clarifying to consider idealized scenarios under a regime of inelastic housing supply. In the first two scenarios, filtering would be proportional to average income growth. In the third scenario, most of the filtering would be orthogonal to average income growth. Scenario 1 (no migration): rising local economic fortunes mean that the same families have 10 percent higher incomes and 10 percent higher rents. Scenario 2 (frictionless migration): new families who have 10 percent higher incomes and pay 10 percent higher rents than the original residents move into the city. Scenario 3 (high migration friction): new families have 10 percent higher incomes than the original families, and all families pay 10 percent higher rents; only 1 percent of original families migrate, while 99 percent choose to remain in spite of higher rents.
45. This period was chosen to match the period covered by the data of the dependent migration variables from the American Community Survey. See appendix 5 for list of data sources.

FIGURE 11. CORRELATION OF THE RATE OF OUTMIGRATION WITH MEASURES OF FILTERING, INCOME GROWTH, AND THE PRICE/INCOME SLOPE

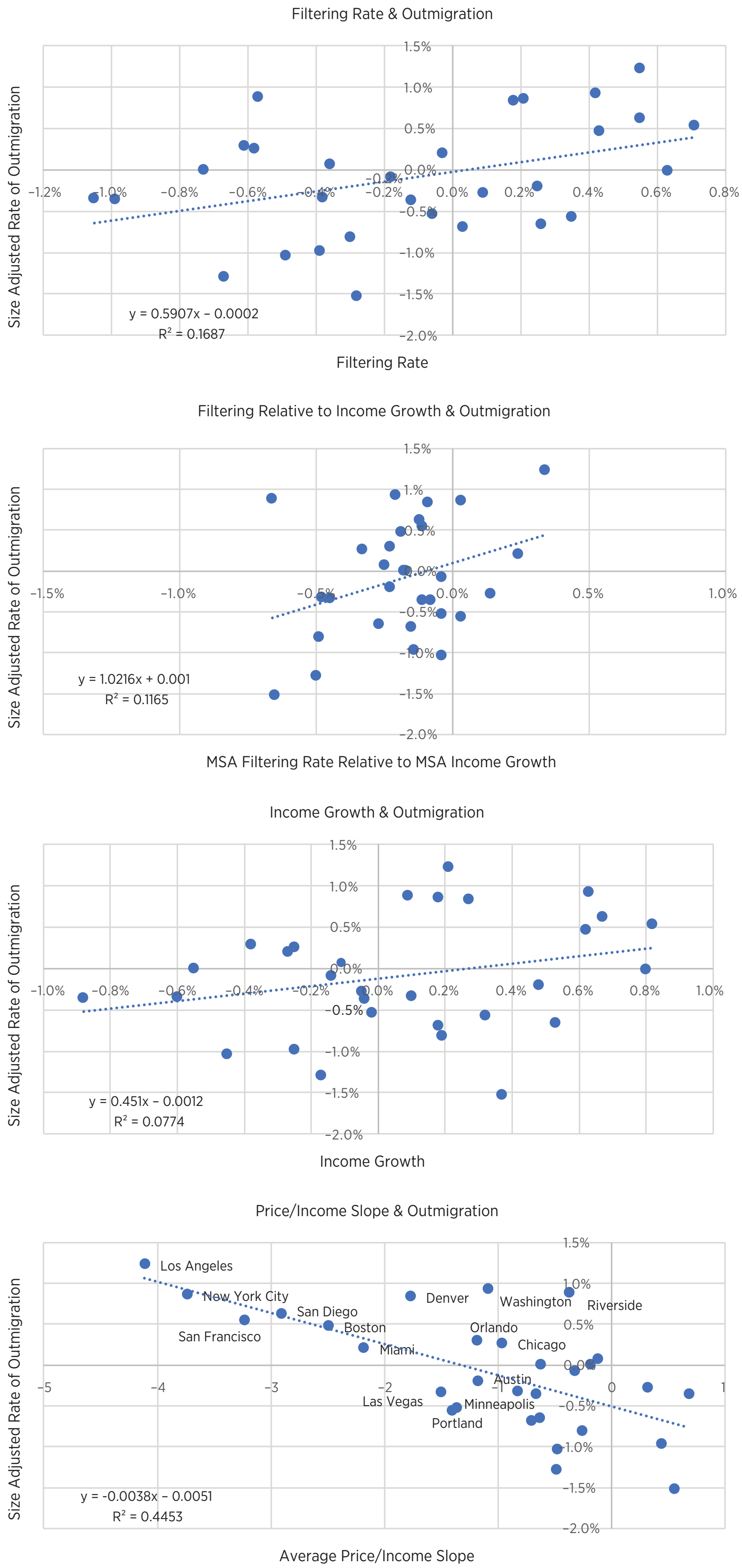


TABLE 3. MULTIVARIATE REGRESSION COEFFICIENTS OF PRICE/INCOME SLOPE AND HOUSING PERMITS WITH VARIOUS MIGRATION VARIABLES

	Dependent Variable			
	Outmigration Rate	Outmigrant Income	Inmigration Rate	Inmigrant Income
Price/Income Slope	**–0.0038**	**0.024**	**–0.0025**	*–0.0024*
	0.00001	*0.001*	*0.0015*	*0.70*
Permits per Capita	0.006	–0.25	**0.29**	–0.32
	0.88	*0.65*	*0.0000003*	*0.41*
Observations	30	30	30	30
Adjusted R^2	0.40	0.27	0.57	–0.05

Notes: p-values in italics. Migration rates are adjusted for MSA size. Migrant income is relative to the MSA average. Statistically significant (p<0.05) coefficients in bold. Results are for multivariate regressions.

slope will be steeper. In Atlanta that leads to more permits and a stable price/income slope while in Los Angeles it leads to a steeper price/income slope but few permits.

Permit rates aren't correlated with outmigration; however, this shouldn't be interpreted to mean that more supply will not help alleviate displacement. In a city with ample supply, migration is voluntary and aspirational. Atlanta permits a lot of housing, which allows a lot of residents to move to Atlanta and creates an increase in migration into Atlanta. But there is no reason to expect those new units to cause migration out of Atlanta to change. The reasons people may move away from Atlanta are the same regardless of who is moving into Atlanta, and are not particularly driven by housing costs.

So metropolitan areas are effectively in one of two regimes, as shown in figure 7: either on the elastic part of the supply curve, in which case the price/income slope is relatively flat and inmigration is aspirational; or on the inelastic part of the supply curve where the price/income slope is steeply negative. In the second case, inmigration is not adequately accommodated with new housing supply; outmigration is required to create available housing units in lieu of new homes, and it is generated through the economic stress of rising housing costs, especially on residents with lower incomes.

Some locals in metropolitan areas with steeply negative price/income lines notice the process of displacement created by the areas' lack of adequate housing, and they oppose new units on the grounds that the new units will simply attract more of the rich newcomers who are driving away poor locals. But the correlations shown in table 3 suggest that inmigration pressure exists independently of the rate of home building. One way to interpret the correlations with migration rates in table 3 is that most of the inmigrants are coming whether new homes are permitted or not. If new homes are not permitted, then the price/income slope will steepen. The outmigrant rate only increases when the price/income slope steepens (i.e., when new homes are not permitted for the inmigrants). The inmigration leads to either more housing permits or a steeper price/income slope. Where it leads to a steeper price/income slope rather than more homes, it also leads to more outmigration.

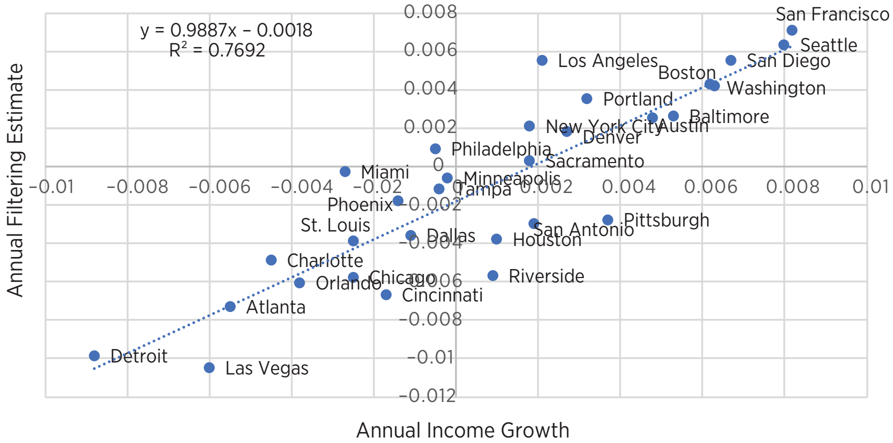
This combination of evidence suggests an addendum to the "superstar city" explanation of rising home prices.[46] The high demand for residency in expensive cities like New York City or Los Angeles is often highlighted. Certainly, some level of demand is necessary to push cities to the inelastic part of the supply curve. However, the creation of "superstar cities" may be more a product of constrained housing supply than of demand for residency. It is hard to know how much the populations of Los Angeles or New York City would rise if local housing regulations accommodated growth. But it is objectively the case that the metropolitan areas with highly negative price/income slopes and very negative net domestic migration rates have, without exception, the lowest permitting rates among the major metropolitan areas.[47] Is Los Angeles more expensive than Kansas City because there is more demand for living in Los Angeles? Los Angeles would need to double its rate of home building in order to test that hypothesis.

More on Filtering and Income Growth

Liu, McManus, and Yannopoulos note that much of the correlation between filtering rates of existing housing and average home price appreciation across MSAs is associated with rising incomes. Figure 12 highlights how strongly the filtering rate of existing homes is correlated with MSA income growth.[48] It is

46. Joseph Gyourko, Christopher Mayer, and Todd Sinai, "Superstar Cities," *American Economic Journal: Economic Policy* 5, no. 4 (November 2013): 167–99.
47. Kevin Erdmann, "Build More Houses: How an Incorrect Perception of Housing Supply Fueled the Great Recession and Slowed Recovery" (Mercatus Applied Research, Mercatus Center at George Mason University, Arlington, VA, May 2021); and Erdmann, *Shut Out*, figure 1-4.
48. See note 43. Liu, McManus, and Yannopoulos, "Geographic and Temporal Variation," 14–15, show that their measure of filtering is correlated with both the housing elasticity estimates from A. Saiz, "The Geographic Determinants of Housing Supply," *Quarterly Journal of Economics* 125, no. 3 (August 2010): 1253–96; and the Wharton Residential Land Use Regulatory Index from J. Gyourko, A. Saiz, and A. A. Summers, "A New Measure of the Local Regulatory Environment for Housing Markets: The Wharton Residential Land Use Regulatory Index," *Urban Studies* 45, no. 3 (March 2008): 693–729. The price/income slope appears to have a relationship to filtering similar to that of those two indexes; it also offers the benefit of being easily estimated both over time and cross-sectionally, so that it captures the dynamics of changing conditions in real time.

FIGURE 12. FILTERING RATE AND MSA INCOME GROWTH



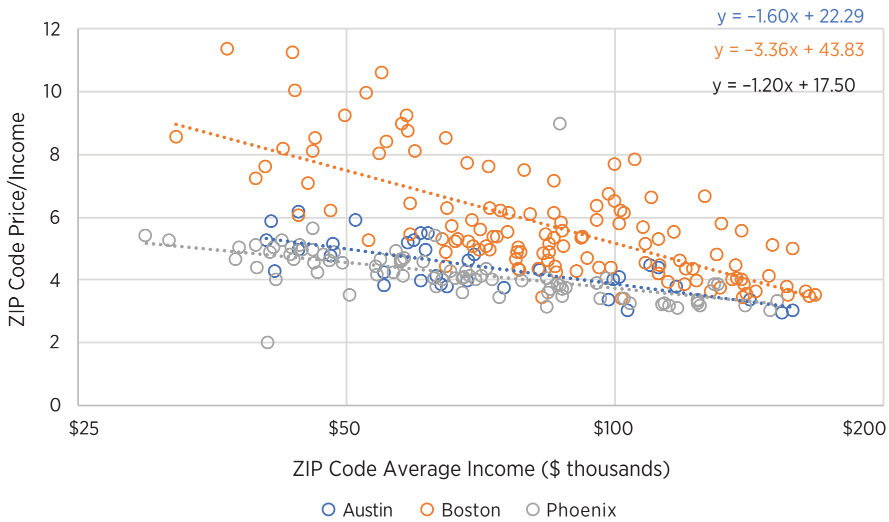
difficult to come to a firm conclusion about this correlation because there are many moving parts regarding both the spatial sorting of households within an MSA over time and the change in the housing stock in terms of new units and upgrades of existing units. In addition, home values should naturally correlate with incomes somewhat in any context. Do rising local incomes of existing residents lead to changing consumption decisions throughout the MSA on new and upgraded homes? Does inelastic housing supply lead to a bidding war for the existing stock of homes in cities where incomes are rising? Does an inelastic housing supply lead to inter-MSA sorting so that the poorest residents move away from cities that lack adequate housing growth? Does the lack of housing increase average local incomes simply by forcing the poor residents out?

The other recent research cited earlier (in section "Recent Literature on Geography, Housing Costs, and Incomes") regarding incomes and housing costs suggests that the high correlation between filtering rates and metropolitan area incomes is due increasingly to economic segregation—residents with high incomes moving into cities with limited housing and poorer residents moving away.

Perhaps the pattern of price/income ratios across each MSA can shed further light on the interactions between housing supply, home prices, incomes, and migration. Housing demand is homothetic—spending increases as incomes increase, but at less than a 1:1 ratio—so home prices should increase with incomes, but price/income ratios should decline.

Figure 13 highlights the average price/income ratios of ZIP codes in Phoenix, Austin, and Boston. Average income and income growth have both been

FIGURE 13. 2019 PRICE/INCOME BY ZIP CODE IN AUSTIN, BOSTON, AND PHOENIX



higher in Austin and Boston than in Phoenix.[49] In a city with elastic housing supply and an advantageous local economy, rising incomes might lead to an increase in housing consumption, and this should lead to a shift similar to the difference between Phoenix and Austin seen in figure 13. At any given income level, the price/income ratio in the two MSAs is similar, but the average household in Austin has a higher income than the average household in Phoenix. Thus, the average home price in Austin is higher than the average home price in Phoenix, but the average price/income is similar.

As shown in figure 12, filtering of homes, on average, in these three MSAs is correlated with changing incomes. But looking at the price/income slopes within these three MSAs, shown in figure 13, Boston is a clear outlier. Higher housing costs are much higher in Boston for households with lower incomes. Of course, Boston also has approved many fewer homes, and so has had more negative domestic migration and lower population growth than Phoenix and Austin over the past few decades.[50] Broadly speaking, the relative difference between Boston and Austin is that households with higher incomes move into new homes in Austin and households with lower incomes move out of existing homes in Boston.

49. In MSAs with steep price/income slopes, the zero lower bound creates nonlinearity at high incomes, so the regression line has been truncated in Boston at log income of 12. See appendix 2.
50. Permit data are from US Census Bureau, https://www.census.gov/construction/bps/historical_data/. See appendix 5 for data sources.

Filtering and income data cannot easily clarify that difference, because in both cases, the activity may be associated with positive filtering and rising incomes. Perhaps the price/income slope can help to clarify where rising incomes from economic progress lead to rising home prices, and where rising home prices from obstructed supply lead to rising local incomes.

This is a complicated causal web to untangle, and I do not intend to fully untangle it here. It is plausible that families in Austin chose to spend more on housing than families in Phoenix because the incomes of families in Austin increased. That is not a plausible story for the pattern of home prices in Boston. The price/income slope and migration rates in Boston suggest that housing costs in Boston have been driven up by inelastic supply and, further, that the average income in Boston has been driven higher by the compositional effects put in motion by inelastic housing supply.[51] The slope of price/income ratios across an MSA may be helpful for determining the effect of housing supply on cost of living, incomes, and migration.

The average slope of the price/income line in an MSA is negatively correlated with MSA income on three dimensions: (1) average MSA income (p-value: 0.003), (2) standard deviation of incomes across an MSA's ZIP codes (p-value: 0.029), and (3) change in average MSA income from 2001 to 2017 (p-value: 0.007).[52] These three strong correlations between the price/income slope and MSA income statistics are likely related to the migration process described earlier. Some of the effects of inelastic housing supply lead to rising variance in gross incomes.[53] So MSAs with a steep price/income slope are associated with high and rising average incomes and variance in those incomes.

Table 4 highlights some of the correlations between income growth, filtering rates, and the price/income slope in the 30 largest MSAs. The "Price/Income Slope" panel shows how much steepening of the price/income slope is associated with filtering relative to MSA income growth (if homes filtered up by 0.5 percent and average incomes increased by 0.3 percent, then the relative filtering was 0.2 percent). The figures mean that 1 percent annual filtering is

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51. According to BEA data (see appendix 5), from 2014 to 2019, Boston grew by an average of about 0.5 percent annually, while Phoenix grew by nearly 2 percent and Austin grew by nearly 3 percent.
52. These correlations use the price/income slopes from table 1, and average income, income growth, and income standard deviation are based on the average reported incomes of the ZIP codes used in equation 1 to estimate the price/income slopes. All variables are based on average or change in values from 2001 to 2017.
53. Enrico Moretti, "Real Wage Inequality," *American Economic Journal: Applied Economics* 5, no. 1 (January 2013): 65–103.

TABLE 4. MULTIVARIATE REGRESSIONS BETWEEN FILTERING, PRICE/INCOME SLOPE, AND INCOME GROWTH

	Dependent Variables		
Independent Variables	Price/Income Slope	Filtering Rate	
Filtering Rate	−2.422		
	0.789		
Avg Price/Income Slope		−0.233	−0.107
		0.061	*0.035*
Annual Income Growth	−1.194		0.864
	0.427		*0.098*
Observations	30 MSAs	30 MSAs	30 MSAs
Adjusted R^2	0.34	0.32	0.82

Notes: Standard errors below coefficients.

associated with a price/income slope steepening of 1.2 points if it is associated with higher incomes and 2.4 points if it is orthogonal to higher incomes.

In the "Filtering Rate" panel of table 4, a 1-point steepening of the price/income slope is associated with additional upward filtering of the housing stock of about 0.23 percent annually. That relationship weakens in a regression that includes income growth (shown in the rightmost column), again suggesting that much of the correlation between filtering and a steepening negative price/income slope is associated with the compositional increase of average incomes in supply-constrained MSAs.

CONCLUSIONS

Each metropolitan area has a unique housing price/income behavior, which is sensitive to local housing supply elasticity. Where housing supply is inelastic, the price/income ratio in ZIP codes with lower incomes tends to rise much higher than the price/income ratio in ZIP codes with higher incomes. The scale of that difference (the price/income slope) in each MSA is an informative measure that can clarify analysis of housing markets. The price/income slope provides a dynamic measure of housing supply constraints that changes with conditions and can be measured both cross-sectionally and over time. The differential effect of supply elasticity on home prices across different incomes may be a useful variable in analysis of changing home prices.

Recent research on incomes, migration, home prices, and filtering rates—a measure of how the incomes of new residents in existing homes change over time—suggests that where home supply is inelastic, aging homes do not become available as more affordable units over time. The price/income slope illuminates the processes that are put in motion by strangled housing supply. Inelastic supply leads to rising housing costs among the poorest residents of the metropolitan area, forcing poorer residents to migrate away to other metropolitan areas for economic reasons. Previous research has shown that positive filtering is correlated with higher average home prices in an MSA. That higher average is the result of higher prices, especially in the homes of residents with lower incomes. Homes filtering upward rather than downward has been associated with mass displacement of poorer residents. The key to reducing that displacement is greater housing supply. To a great extent, the high and rising average incomes in cities like New York City and Los Angeles are a product of the outmigration of their poorest citizens as a result of the costs imposed on them from inadequate supply of housing.

This has important cultural and political ramifications. Inadequate urban housing supply means that when a city offers new opportunities for some residents, those opportunities create hardships for others, especially the households that are already at an economic disadvantage. Capitalist systems with free movement of labor and capital can provide broad-based, shared benefits. Shared prosperity is key to maintaining support and trust in economic growth and progress. Cities that have obstructed adequate housing have derailed the potential for shared progress. If this context continues, communal support for progress and growth will wane.

A return to ample urban home building is an important element in securing a future of shared growth for all Americans. The price/income slope can be a useful framing mechanism for understanding and highlighting this important issue.

APPENDIX 1: NONLINEARITIES IN THE PRICE/INCOME DATA—TWO FORMS

The first form of nonlinearity in price/income data appears in metropolitan areas with some ZIP codes that have very high incomes and a steeply negative price/income slope so that at high incomes there is a lower bound on price/income ratios. In these cases, I have based the price/income slope estimate on ZIP codes that had log incomes below 12 in 2018. Figure 14 shows Los Angeles ZIP codes in 2019 and the regression line for the ZIP codes with log incomes below 12 in 2018.

FIGURE 14. 2019 PRICE/INCOME BY ZIP CODE

The second form of nonlinearity appears in MSAs that exhibit concavity in ZIP codes with lower incomes. This may be due to localized depopulation that leads to some neighborhoods that accumulate deferred maintenance, vacant lots, and negative neighborhood externalities such as crime. In those areas, the negative amenities drive home prices below the cost of replacement. Among the 30 largest MSAs, Detroit, Philadelphia, Pittsburgh, and St. Louis exhibit this sort of nonlinearity. Price/income levels in ZIP codes in those four metropolitan areas in 2019 are shown in figure 15.

The nonlinearity makes the price/income slope estimate at a point in time unreliable as a linear estimate of local housing supply constraints compared to other metropolitan areas. However, even in these metropolitan areas, where price/income levels change over time, the sensitivity of first differences in prices to ZIP code income appears to be more linear. In other words, the price/income slope in St. Louis in, say, 2004, is not comparable to the price/income slope in Austin or Atlanta as a measure of relative supply elasticity, because the price/income levels in St. Louis do not have a reliably linear relationship with ZIP code incomes. But rising demand for housing that isn't adequately met with supply will push prices proportionately higher in parts of St. Louis where incomes are lower than it will in parts of St. Louis where incomes are higher, just as it does in other cities.

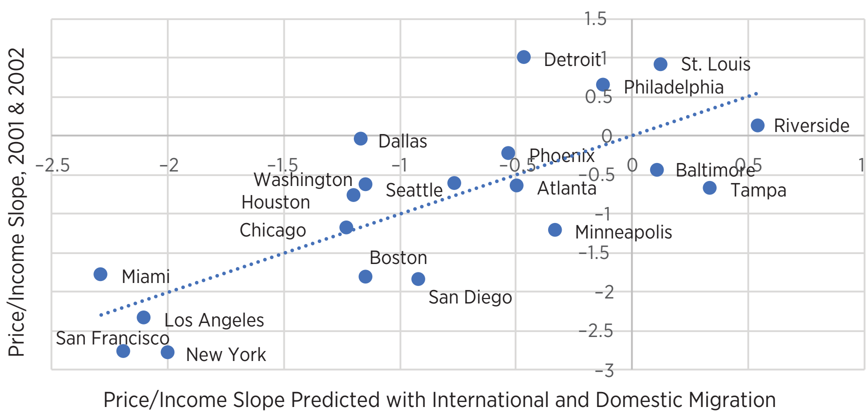
FIGURE 15. METROPOLITAN AREAS WITH NONLINEARITIES IN PRICE/INCOME SLOPES

APPENDIX 2: PRICE/INCOME SLOPE AND MIGRATION RATES

This table reports the coefficients and p-values of both international migration rates and net domestic migration rates for the 20 largest metropolitan areas in a multivariate regression with price/income slopes as the dependent variable. Figure 16 compares the price/income slope of each metropolitan area estimated from annual migration rates with the actual average price/income slopes.

	Coefficient	p-value
International Migration	−0.211	0.002
Net Domestic Migration	0.048	0.038

FIGURE 16. PRICE/INCOME SLOPE VS. MIGRATION IN 20 MSAS



APPENDIX 3: CREATING A PRICE/INCOME SLOPE AND A METROPOLITAN AREA FIXED EFFECTS VARIABLE

Since supply conditions create price sensitivities across individual metropolitan areas that aren't uniform, it may be difficult to create unbiased variables to control for regional differences in price changes. Before attributing additional price appreciation in low-income parts of an MSA like Los Angeles to factors such as subprime lending, one must estimate the expected income-sensitive price appreciation that would happen in Los Angeles from any source of demand. In analysis of relative price appreciation, regional fixed effects applied uniformly across each MSA introduce an income-sensitive bias into analysis, because where supply is constrained, prices do not appreciate uniformly across an MSA. Market factors that influence household demand for housing uniformly across an MSA will lead to more price appreciation in ZIP codes with lower incomes than in ZIP codes with higher incomes. Any factor that is correlated with income may be falsely identified as a factor pushing up home prices in supply-constrained metropolitan areas. As table 1 and figure 6 make clear, much of the relative difference in price appreciation at the ZIP code level, especially in the 2002–2009 period, is dominated by income-sensitive changes in a few metropolitan areas with inelastic supply that would not be captured by fixed effects controls applied uniformly across the metropolitan area.

Price/Income Slope and Fully Correcting for Incomes

If the effect of inelastic housing supply is asymmetrical across a metropolitan area, it may be useful to supplement metropolitan area fixed effects with an additional variable that is interacted with income. It may also be possible to specify these variables so that the uniform metropolitan area fixed effect and the income-interacted fixed effect both convey information about housing supply and demand in each region.

Equation 2 is an example of a typical analysis of factors that might influence home prices, ΔP. Here, various independent variables, $D(i)$, would be estimated, along with control variables, $C(j)$, and a metropolitan area fixed effect, Dummy_{MSA}, applied uniformly to each MSA. A regression analysis will produce the coefficients (or betas) for each demand variable, control variable, and metropolitan area dummy that estimate the price appreciation associated with each of those factors:

$$\textit{Equation 2: } \Delta P = \beta(1) + \beta(i) \times D(i) + \beta(j) \times \mathrm{C}(j) + [\Sigma\beta(3)_{MSA} \times \text{Dummy}_{MSA}] + \varepsilon$$

Figure 17 shows residuals from equation 2, using ZIP code income, density, and $t-1$ price trends[54] as independent variables, with and without fixed effects dummies for each metropolitan area. In both cases, the dependent variable is the log price change over a four-year period. In all cases, residuals are not correlated with income. Visually, one can see that fixed effects were much more important for reducing residuals in 2002–2006 than in 2017–2021.

54. This is the rate of price appreciation in each ZIP code during the period before the period of analysis to account for existing local trends in prices.

FIGURE 17. RESIDUALS USING A UNIFORM INCOME CONTROL VARIABLE

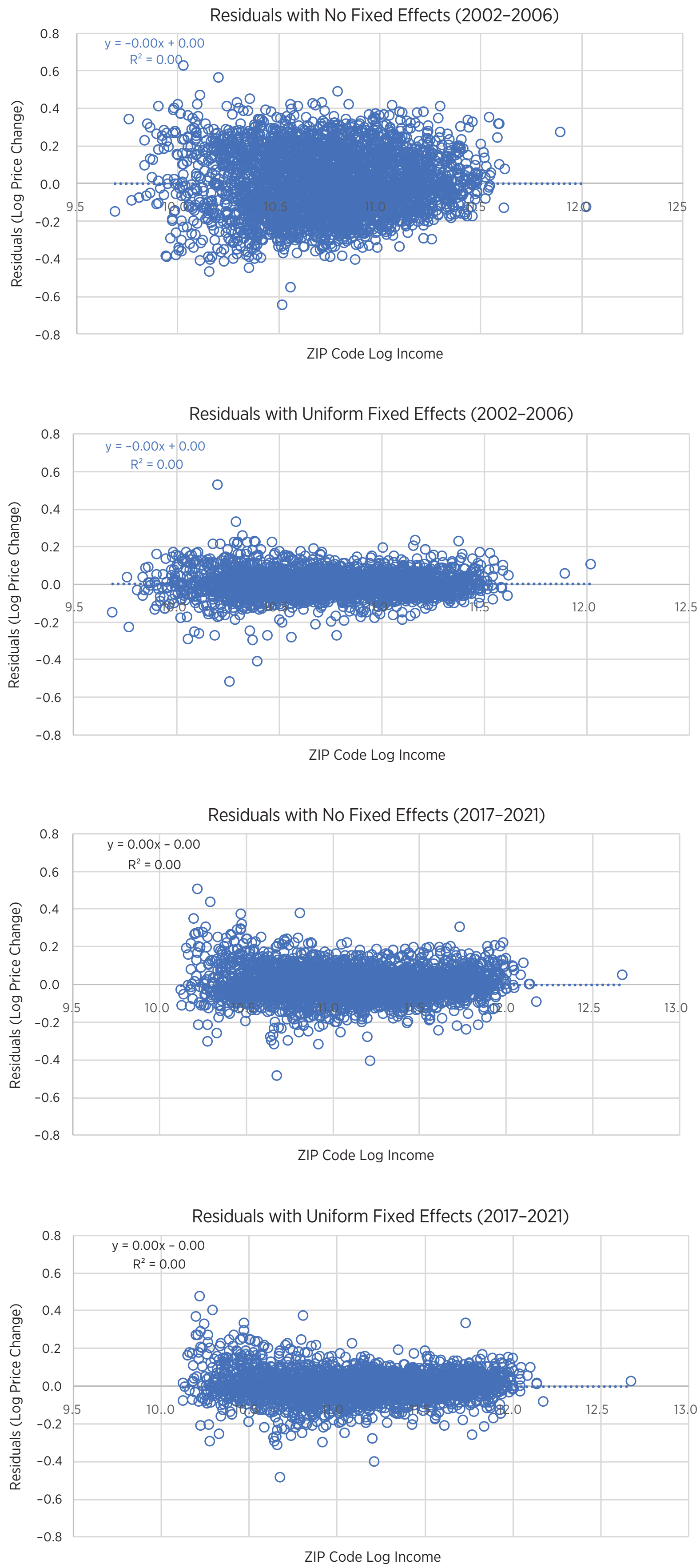
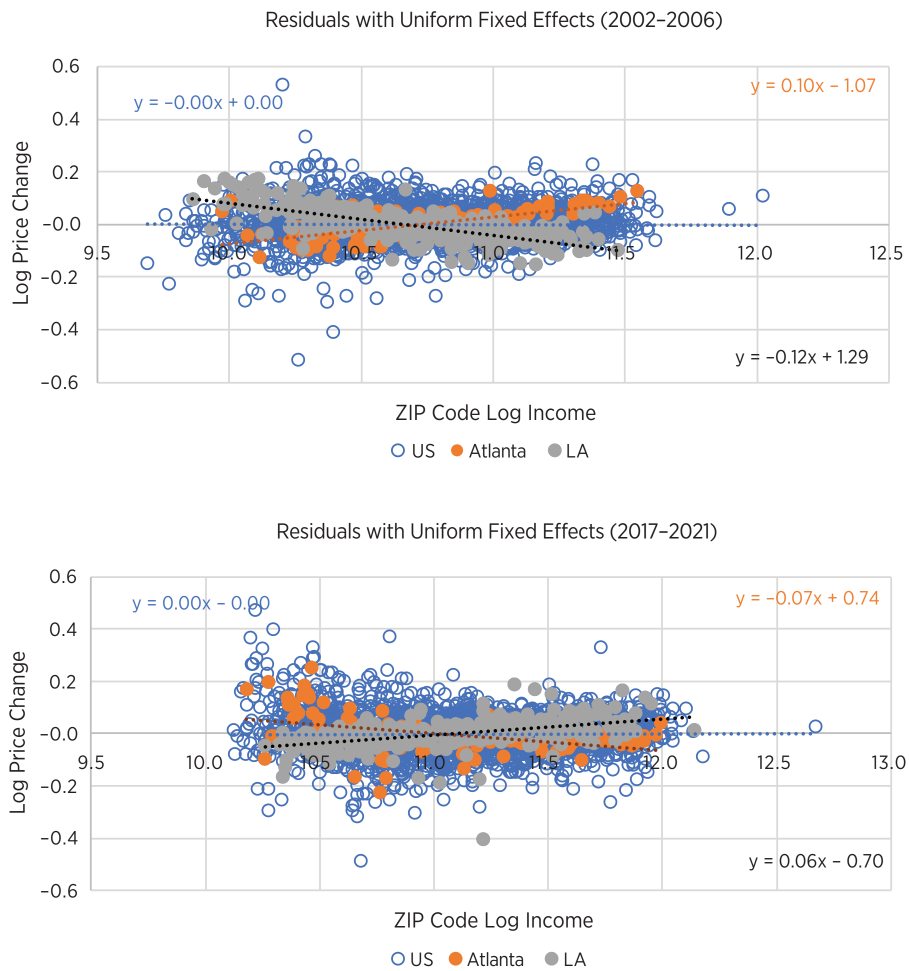


Figure 18 copies the residuals for the regressions that include uniform metropolitan area fixed effects from the second and fourth panels of figure 17. In figure 18, I have highlighted the residuals for ZIP codes in Los Angeles and Atlanta. In both periods, residuals for the entire dataset are unbiased, but within most MSAs, residuals are systematically sensitive to ZIP code income.

As I have argued above, home prices in each metropolitan area have a different sensitivity to incomes depending on local supply conditions. Controlling for income with a single national coefficient simply estimates an average correlation between incomes and price appreciation. But Los Angeles has a much steeper price/income slope than Atlanta. The existing state of housing supply and changes in housing supply elasticity will systematically effect home prices

FIGURE 18. RESIDUALS USING A UNIFORM INCOME CONTROL VARIABLE, WITH LOS ANGELES AND ATLANTA HIGHLIGHTED



differently in each metropolitan area. When ZIP code incomes are not correlated with model residuals in the full national data set, they will routinely be systematically correlated with incomes within many metropolitan areas as a result of pre-existing or changing local supply conditions.

Especially where fixed effects have a large influence on the model output, uniform metropolitan area fixed effects can add tremendous bias to that output. In this case, the national data appear to have unbiased residuals, so it appears that income has been controlled for. But if the same data had been limited to Los Angeles or Atlanta, or most other MSAs, the coefficient for the income control would have been significantly different. Applying the same coefficient for the income variable to all ZIP codes actually introduces income-sensitive bias within each MSA.

One way to account for the asymmetrical effect of supply elasticity on home prices would be to include an additional fixed effect coefficient for each MSA, $\beta(4)_{MSA}$, that is proportional to ZIP code income, I, as shown in equation 3:

$$\textit{Equation 3:}\ \Delta P = \beta(1) + \beta(2) \times D(i) + \beta(j) \times C(j) + [\Sigma\beta(3)_{MSA} \times \text{Dummy}_{MSA}] + [\Sigma\beta(4)_{MSA} \times \text{Dummy}_{MSA} \times \text{I}] + \varepsilon$$

Adding the income-interacted MSA variables removes the income-sensitive bias of the metropolitan area fixed effects in equation 2.

The Existing Literature on the Negative Correlation of Price Appreciation with Incomes

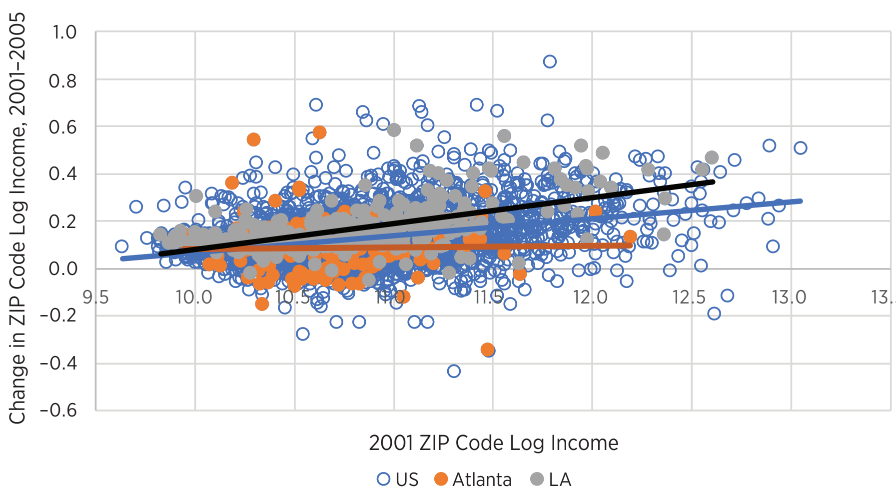
Income-sensitive price changes have been an important factor in the debate about the causes of rising home prices. In a widely cited 2008 paper, Atif Mian and Amir Sufi found that home prices from 2001 to 2005 increased the most in "high latent demand" ZIP codes, which are ZIP codes that usually have high credit constraints. "High latent demand" ZIP codes are strongly correlated with low ZIP code incomes. They report, "We show that an expansion in the supply of mortgage credit to high latent demand zip codes led to a rapid increase in house prices from 2001 to 2005 . . . despite the fact that these zip codes experienced negative relative income and employment growth."[55]

55. A. Mian and A. Sufi, "The Consequences of Mortgage Credit Expansion: Evidence from the 2007 Mortgage Default Crisis" (Initiative on Global Markets Working Paper No. 15, University of Chicago Graduate School of Business, Chicago, IL, May 2008), abstract.

On that last point, Mian and Sufi report that "any changes in income that are common across zip codes in the same county are nonparametrically removed."[56] As noted earlier, recent work from Card, Rothstein, and Yi and Hoxie, Shoag, and Veuger[57] has shown that housing supply elasticity is a primary driver of different metropolitan area income trends. So figure 18 shows that home prices rose relatively more in portions of Los Angeles with lower incomes than they did in Atlanta from 2002 to 2006. That difference was systematically related to inelastic housing supply. And inelastic housing supply may be responsible for some of the rising incomes in Los Angeles, in general. Figure 19 compares income growth across Atlanta and Los Angeles from 2001 to 2005, when Mian and Sufi applied their analysis. The fundamental driver of all of these trends—rising incomes in Los Angeles, rising home prices in Los Angeles, and the negative correlation between price appreciation and income in Los Angeles—was localized inelastic housing supply in Los Angeles. Home prices rise the most in the portions of housing-constrained metropolitan areas where incomes are lowest, and incomes in those metropolitan areas rise more than incomes in other metropolitan areas as a result of the migration and economic pressures that inelastic supply sets in motion.

Before regional differences are removed, the low-tier ZIP codes in Los Angeles that experienced such high price appreciation had relatively normal income growth. But when compared to other ZIP codes in their counties, as they

FIGURE 19. INCOME CHANGE IN 2001–2005



56. Mian and Sufi, "Consequences," 9.
57. See Card, Rothstein, and Yi, "Location, Location, Location"; and Hoxie, Shoag, and Veuger, "Moving to Density."

were in Mian and Sufi's analysis, they appear to have the lowest income growth in the country. That outcome is likely the result of geographical controls and adjustments in Mian and Sufi's data; by attempting to control for regional variations, they may have introduced biases from regional variations.

This actually increased their confidence in their conclusions: "(T)he fraction of subprime customers at the beginning of our sample is negatively correlated with observable measures of future income shocks. This negative correlation strengthens our identifying assumption that future income shocks are not positively correlated with the initial fraction of subprime customers, and further suggests that our estimates may understate the effect of credit expansion on outcomes."[58] It is possible that metropolitan areas with inelastic housing supply create more variance in ZIP code income and more credit stress in ZIP codes with low incomes, so that the variables Mian and Sufi used were not independent. The correlations between ZIP codes with low incomes within their counties, negative relative income growth within their counties, high credit stress, and high price appreciation could all be caused by inelastic housing supply.

The Price/Income Slope and Encroaching Demand vs. Homegrown Demand

Most analysis, such as Mian and Sufi's referenced above, implicitly or explicitly, attributes rising prices in each ZIP code to the character of the residents in that ZIP code. Are they credit-constrained? Are their economic prospects improving? And so on. This seems reasonable. But home prices in the parts of Los Angeles where incomes are lower are *not* being driven higher because of the rising incomes of their residents. They are being driven higher by the encroachment of demand associated with rising incomes in the other parts of Los Angeles. In Los Angeles's supply-constrained environment, housing markets are increasingly being driven by substitutions across neighborhoods and across metropolitan areas. The controls applied by Mian and Sufi assume that those substitutions aren't important and that each ZIP code's housing market is driven by its own residents.

Mian and Sufi note:

> The primary counter-argument to our supply interpretation is that high latent demand zip codes experience relative mortgage origination and house price growth from 2001 to 2005 because of relative improvements in demand conditions such as credit quality

58. See Mian and Sufi, "Consequences," 10.

> or productivity. However, a number of facts dispute this concern. First, high latent demand zip codes experience negative relative income, wage, employment, and establishment growth from 2001 to 2005. Second relative growth in non-home debt (auto loans and credit cards) is negative for high latent demand zip codes, a fact that is inconsistent with the hypothesis that relative permanent income increases in these areas over this time period.[59]

The framework I described earlier introduces a new counterargument, different from the one that Mian and Sufi considered: Local residents with low incomes weren't driving home prices in their neighborhoods higher. On net, they were being forced to move to other, less expensive metropolitan areas. The higher prices rose, the more locals with low incomes moved away.

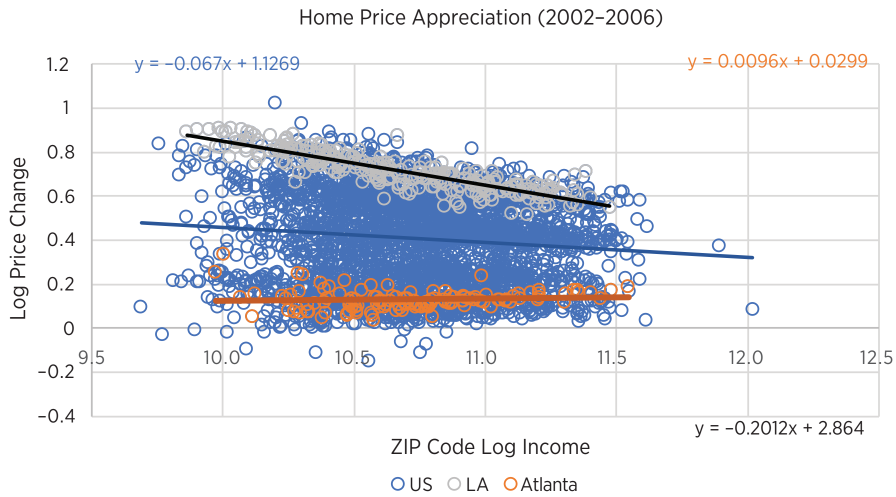
A comparison of home price appreciation in the 2002–2006 period with that in the 2017–2021 period may be illuminating. The variation between metropolitan areas in the 2002–2006 period is clear in the top panel of figure 20—in terms of both uniform price changes across each metropolitan area (every ZIP code in Los Angeles versus every ZIP code in Atlanta) and income-sensitive changes (the steeper slope in Los Angeles versus Atlanta). The similar chart for 2017–2021 in the bottom panel of figure 20 shows much less variation between metropolitan areas, though differences in the slopes remain substantial. It appears that controlling for regional differences is much more important for the 2002–2006 period than for the 2017–2021 period.

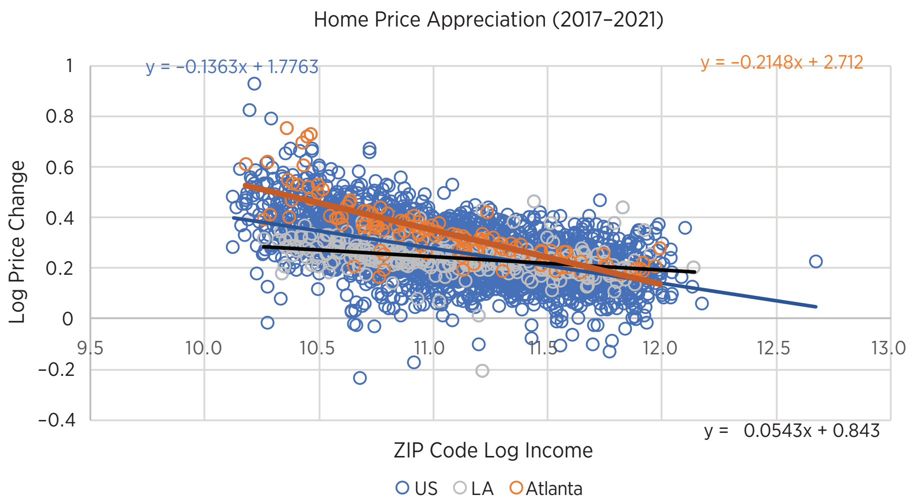
As I have outlined in the body of this paper, the income-sensitive differences between metropolitan areas are plausibly due to preexisting supply conditions. Furthermore, this should cause some doubt about the importance of loose credit in creating a negative correlation between income and price appreciation. The earlier period was famously associated with active lending markets, and the latter period is associated with much lower rates of home building in most metropolitan areas and with relatively tight lending standards. However, the latter period is the period with steeper price appreciation in ZIP codes with low incomes in many metropolitan areas.[60]

Obviously, much more work needs to be done to clarify these issues, but certainly the influence of supply constraints should be addressed as an additional counterargument to Mian and Sufi's credit supply thesis. And reassess-

59. See Mian and Sufi, "Consequences," 2.
60. See table 1. Recent years have been associated with steepening price/income slopes in many metropolitan areas at least as sharp as in the pre-2008 period.

FIGURE 20. HOME PRICE CHANGES BY ZIP CODE INCOME IN THE UNITED STATES, LOS ANGELES, AND ATLANTA





ments of the existing literature might do well to include some attempt at carefully controlling for the income-sensitive effects of inelastic supply. Additionally, it may be possible to specify the dummy metropolitan area fixed effects ($Dummy_{MSA}$) in equation 3 so that the coefficients for both the regional dummy fixed effect and the income-interacted fixed effect convey independent and informative output.

Applying Price/Income Slopes toward a More Comprehensive Analysis of Home Price Appreciation

Since price/income is systematically more volatile within each MSA in the areas with lower incomes, the price/income slope tends to swivel over time on a fulcrum at a point with a high-income level and a positive, relatively stable price/income ratio. If that fulcrum point can be estimated reliably, then changing home prices in each metropolitan area can be described in three dimensions:

1. The change in the slope of the price/income line.
2. The uniform change in home prices across the MSA.
3. Idiosyncratic changes in individual ZIP codes, either correlated with other variables or as residuals to a given model.

Figure 21 shows the relationship between price/income ratio and income in San Diego in three different years. Figure 22 shows a similar graph for three different years in Atlanta. The price/income slope in Atlanta is much flatter than in San Diego (note the different scales on the y-axis)—in fact, it has been positive in some recent years—yet both metropolitan areas have a fulcrum point where price/income has been relatively stable.

The coefficients from equation 1 from several points in time can be used to infer the estimated location and price/income level of the fulcrum in each MSA. Please note, however, that the slope of the price/income line and the change in that slope are not dependent on the identification of a fulcrum point. The price/income slope measure would exist and would potentially be informative even if there were no stochastically stable fulcrum point. The fulcrum point may be useful for creating a uniform MSA fixed effect variable that might be informative independent of the price/income slope measure. But in either case, the price/income slope appears to be a useful and informative variable associated with metropolitan area housing supply.[61]

To estimate the income level and price/income level of the fulcrum, we need to use equation 4 to measure the relationship between α(1) and α(2) from equation 1:

$$\textit{Equation 4: } \alpha(1)_{Year,MSA} = \beta(1)_{MSA} + \beta(2)_{MSA} \times \alpha(2)_{Year,MSA} + \varepsilon$$

61. For some analysis, a single national fulcrum point might be sufficient for differentiating price changes associated with dummy regional differences from price changes associated with changing MSA price/income slopes.

FIGURE 21. SAN DIEGO PRICE/INCOME RATIOS IN SELECTED YEARS

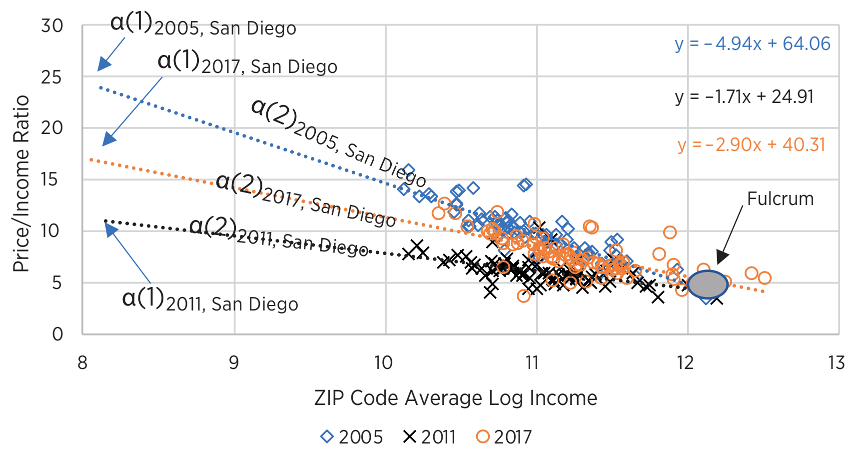
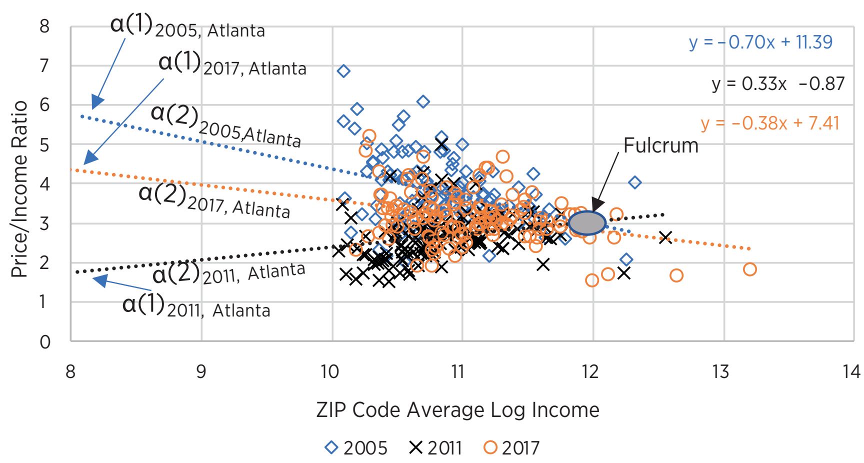


FIGURE 22. ATLANTA PRICE/INCOME RATIOS IN SELECTED YEARS



Looking at figures 21 and 22, we see that α(2), price/income slope, changes from year to year. Between 2011 and 2017, in San Diego, it ranged from −5.19 to −1.33; in Atlanta, it ranged from −0.84 to 0.53.[62] By using equation 4, we can estimate what the y-intercept, α(1), would have been if α(2) had been either 0 or −1 in any given year. As shown in figure 23, the stable price/income ratio in the hypothetical fulcrum ZIP code is given by $\beta(1)_{MSA}$ in equation 4, and the log income of the hypothetical fulcrum ZIP code is given by $-\beta(2)_{MSA}$. When α(2) = −1, the y-axis,

62. Ranges reflect all years shown in table 1.

the regression line, and a line with slope 0 from the y-axis to the regression line at y= $\beta(1)_{MSA}$ would form an isosceles right triangle. The distance, $\beta(2)_{MSA}$, on the y-axis would equal the distance from the y-axis to the log income of a ZIP code with an expected stable price/income ratio of $\beta(1)_{MSA}$, which provides an estimate for the average log income at the fulcrum.

Figure 24 compares the correlations between α(1) and α(2) for Atlanta and San Diego. In San Diego, the estimated log income of the fulcrum ZIP code, −β(2), is 12.02, and the expected price/income ratio in that ZIP code, β(1), is 4.61. In Atlanta, the fulcrum ZIP code has a log income of 11.98 and a price/income ratio of 3.02.

FIGURE 23. ESTIMATING THE FULCRUM ZIP CODE INCOME AND PRICE/INCOME LEVEL

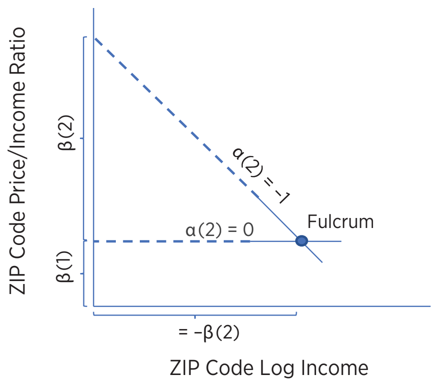
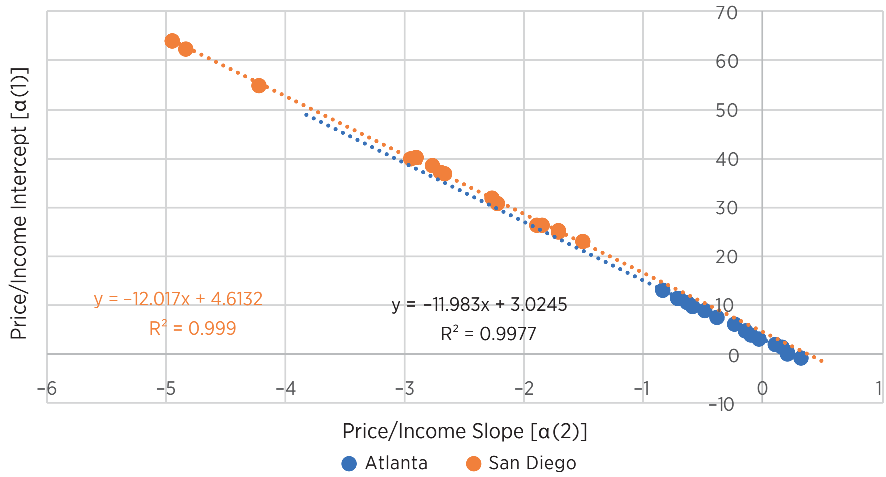


FIGURE 24. PRICE/INCOME COEFFICIENTS AND INTERCEPTS IN 2001–2017



β(1) is universally a positive number with high confidence in all MSAs, and α(1) and α(2) are strongly correlated over time within each MSA. In all 30 MSAs, the p-values for both β(1) and β(2) are near zero. Every MSA has a hypothetical fulcrum ZIP code with a positive income and a price/income level that is a stochastic constant. Across MSAs, there is not a significant correlation between the price/income level of an MSA's fulcrum ZIP code and either the MSA price/income slope, the income of the fulcrum ZIP code, or the average income of the MSA. On average, the fulcrum ZIP code has an income about 2.7 standard deviations greater than the average ZIP code income of the MSA. There is quite a bit of variance among MSAs in fulcrum income and price/income levels. That variance is not correlated with the price/income slope. In other words, the price/income slope [α(2)] and the fulcrum [described with β(1), and β(2)] for each MSA are independent of one another.

Thus, in analysis of home prices, the price/income ratio at the fulcrum may be a proxy for the shared price levels or trends of homes across an MSA. Differences in the fulcrum price/income level can be influenced by a number of factors related to supply and demand, including local construction costs and property tax rates. The price/income slope is a proxy for income-sensitive price differences across an MSA, which, I have argued earlier, are driven to a large extent by supply constraints.

Analysis using the dummy metropolitan area fixed effect variables depends on accurately estimating the fulcrum income. If the fulcrum income estimate is too low, for instance, the dummy fixed effect will simply be catching some of the change in the slope of the price/income line. In figure 20, analysis that only uses a dummy fixed effect variable in Los Angeles would reflect the price appreciation of the ZIP code with average income. That is what creates the asymmetrical residuals in figure 18. The income level associated with the hypothetical fulcrum ZIP code can be reliably estimated to produce two independent regional fixed effect variables, with little or no correlation between the dummy fixed effect and the income-sensitive fixed effect.

The price appreciation associated with the fulcrum ZIP codes (located at a log income of approximately 12 in both Atlanta and Los Angeles) would be the dummy price appreciation associated with those metropolitan areas.[63] Additionally, as shown in figure 20, from 2002 to 2006 in Atlanta, 1 log point

63. Using the regression line equations from figure 20, the log change in the fulcrum ZIP code price/income ratio is:

Los Angeles: 0.46 = -0.2012 x 11.94 + 2.864
Atlanta: 0.14 = 0.0096 x 11.71 + 0.0299

lower ZIP code income was associated with 0.01 points less price appreciation, and in Los Angeles it was associated with 0.20 points more price appreciation. To fully control for the differences between metropolitan areas without adding bias to the data, both sets of coefficients need to be determined for every MSA (the coefficient that applies to the fulcrum ZIP code, which is estimated with the MSA dummy variable; and the coefficient that applies to the product of the price/income slope and the ZIP code income relative to the fulcrum income).

APPENDIX 4: ADDING A PROPERTY TAX CONTROL

Property taxes can vary greatly, and so it could be the case that different property tax rates in different metropolitan areas or within metropolitan areas might bias the price/income slope in some cases.

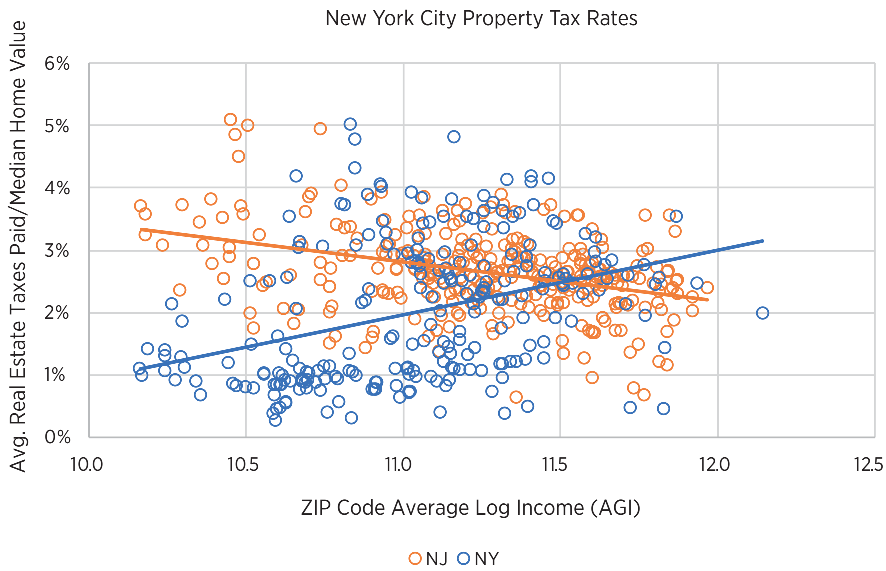
Evidence of the Effect of Different Property Tax Rates on Price/Income Ratios

The metropolitan area where different property tax rates seem to create the most noticeable distortion is New York City. Property taxes are generally higher in New Jersey than they are in New York State, and by the measure I use, they appear to be relatively more progressive in New York. The New York City metropolitan area has substantial territory in both states. Figure 25 is the scatterplot of estimated property tax rates and price/income ratios (both plotted against ZIP code log income on the x-axis) in New York City metropolitan area ZIP codes in 2016, by state. There is clearly a difference between New Jersey and New York ZIP codes by both measures.

A comparison of rents is one way to infer the source of the difference in prices. Higher property taxes should lower prices relative to rents.[64] Using Zillow data on median rents in some New York City ZIP codes, it does appear that income/rent levels are more uniform throughout New York City (figure 26) than price/income ratios. Much of the difference in the slope of the price/income line between New Jersey and New York ZIP codes (shown in the bottom panel of figure 25), appears to come from differences in price/rent ratios (shown in the bottom panel of figure 26). Thus, valuation differences between New Jersey and New York may be due at least partially to property tax differences.

64. Byron Lutz, "Quasi-Experimental Evidence on the Connection between Property Taxes and Residential Capital Investment," *American Economic Journal: Economic Policy* 7, no. 1 (February 2015): 300–330.

FIGURE 25. NEW YORK CITY PROPERTY TAX RATES AND PRICE/INCOME RATIOS BY ZIP CODE INCOME



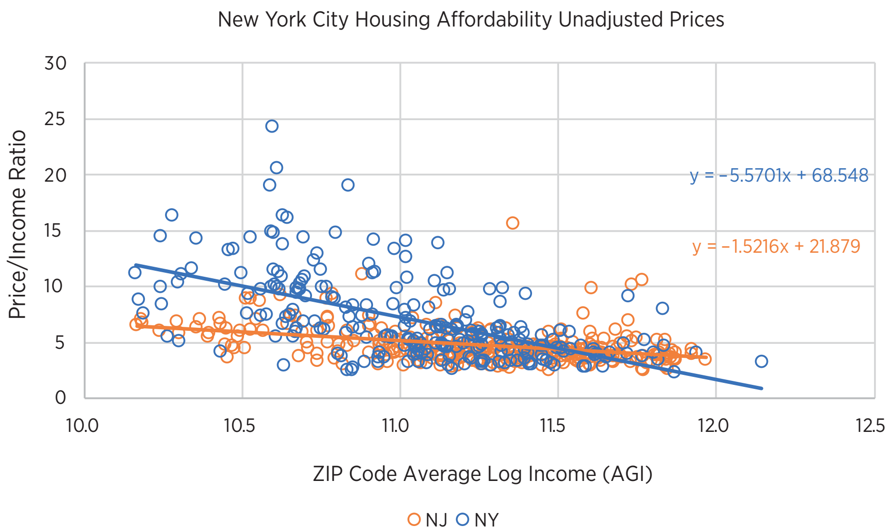
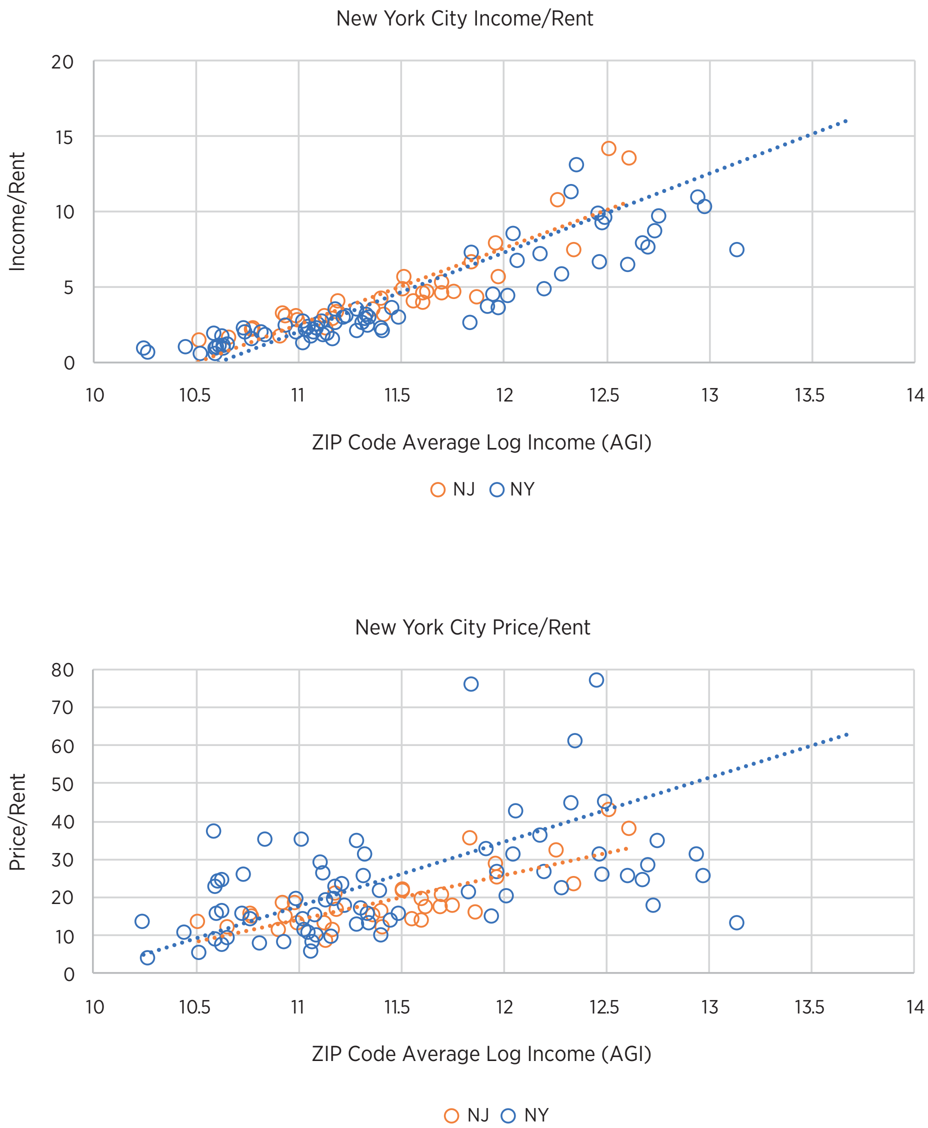


FIGURE 26. NEW YORK CITY INCOME/RENT AND PRICE/RENT BY ZIP CODE INCOME



Controlling for Property Tax Differences

To estimate the effect of property tax rates on home values, I used ZIP code level income tax data from the IRS—the average amount of real estate taxes claimed by filers who paid real estate taxes. The property tax rate attributed to each ZIP code is that average real estate tax divided by the median home price estimated by Zillow. I used data from 2016 for the estimate.[65] For all ZIP codes, I estimated coefficients of equation 5 by solving for least squares of residuals:[66]

$$\textit{Equation 5: } \text{Log Price} = \beta(1) + \beta(2) \times \text{Density} + \beta(3) \times \text{Log Income} \\ - \text{Log}\,[\beta(4) \times \text{Property Tax Rate} + \beta(5)] + \varepsilon$$

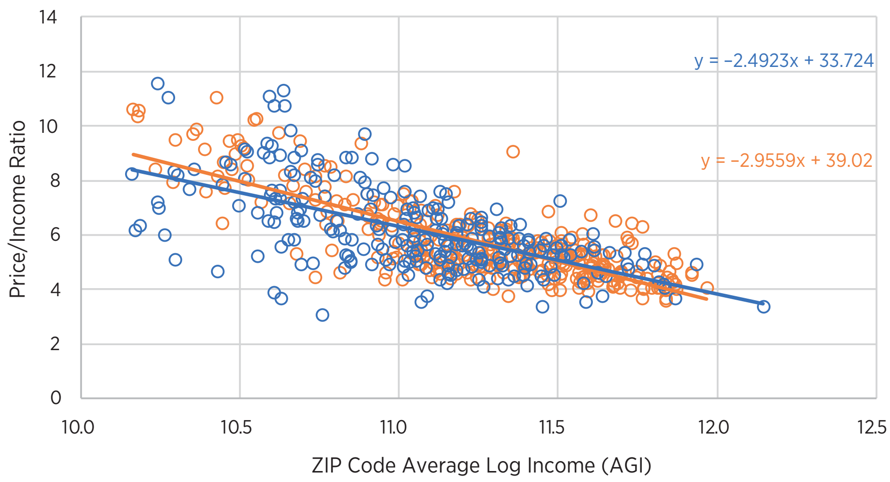
Here, the combination of coefficients $\beta(4)$ and $\beta(5)$ provides an estimate of the relative sensitivity of home prices to different property tax rates. For 2016, with the 3,575 metropolitan ZIP codes used here, $\beta(4) = 0.67$ and $\beta(5) = 0.007$.

I created a tax-adjusted home price by using these coefficients to estimate the median home price in each ZIP code if each ZIP code had the average property tax rate (1.9 percent) from this dataset. Using these tax-adjusted home prices, there is little difference between the New Jersey and New York price/income slopes within the New York City metropolitan area (figure 27).

New York City is a singular example of a metropolitan area with a noticeable discontinuity in property tax rates, but the adjustment also appears to create a more uniform price/income relationship in other metropolitan areas that have property tax discontinuities. Figure 28 compares price/income patterns within Chicago and Washington, DC, before and after adjusting for property taxes. ZIP codes in Cook County and in the District of Columbia tend to have lower property tax rates than the surrounding areas, so without the adjustment, the price/income ratios tend to be higher in those areas. After the adjustment, the price/income ratios tend to be more similar throughout the metropolitan areas. Also, in Chicago, property taxes tend to be above average, while in the Washington, DC, metropolitan area they tend to be low. So the adjustment generally raises the price of

65. There may be some compositional biases in using these measures to construct a property tax estimate. Possibly more accurate estimates could be obtained by using the median property tax reported by Zillow. Also, I have used the estimates from 2016 in the analysis below. It is possible that measuring property tax rates and re-estimating sensitivity annually would produce more accurate analysis; however, property taxes do not tend to change abruptly, so the effects on relative price estimates from year to year should not be substantial. See appendix 5 for references to data sources.
66. Density in equation 5 is on a scale from 0 to 1; data from Salim Furth, "Housing Supply in the 2010s" (Mercatus Applied Research, Mercatus Center at George Mason University, Arlington, VA, February 2019).

FIGURE 27. NEW YORK CITY HOUSING AFFORDABILITY (PRICES ADJUSTED FOR PROPERTY TAXES)



homes (that is, the price that homes would fetch if property taxes were the same average rate in every ZIP code) in Chicago and lowers them in Washington, DC.

Los Angeles is an example of a metropolitan area where effective average ZIP code property taxes are relatively similar across the metropolitan area, so the price-sensitive price/income pattern is quite regular without the adjustment. However, property taxes are low throughout Los Angeles, so tax-adjusted prices are lower throughout the metropolitan area (figure 29) than unadjusted prices. This lowers the price/income slope simply because with higher property taxes, prices throughout the metropolitan area would be proportionately lower, which lowers the scale of all differences.

As noted in appendix 1, some metropolitan areas—particularly Detroit, Philadelphia, Pittsburgh, and St. Louis—exhibit nonlinearity in their price/income patterns. Specifically, they exhibit a concavity (see figure 16) in which price/income ratios in the ZIP codes with the lowest incomes are much lower than they would be in the typical linear pattern. Christopher Berry at the University of Chicago has shown that property taxes are frequently applied regressively.[67] This has especially been the case in some rust belt cities where the market values of some properties have become very low. It appears that the nonlinearity in those metropolitan areas is related to regressive property taxes. When the property tax

67. Christopher R. Berry, "Reassessing the Property Tax" (University of Chicago—Harris School of Public Policy working paper, March 2021).

FIGURE 28. PRICE/INCOME PATTERNS IN CHICAGO AND WASHINGTON, DC (BEFORE AND AFTER ADJUSTING FOR PROPERTY TAX RATES)

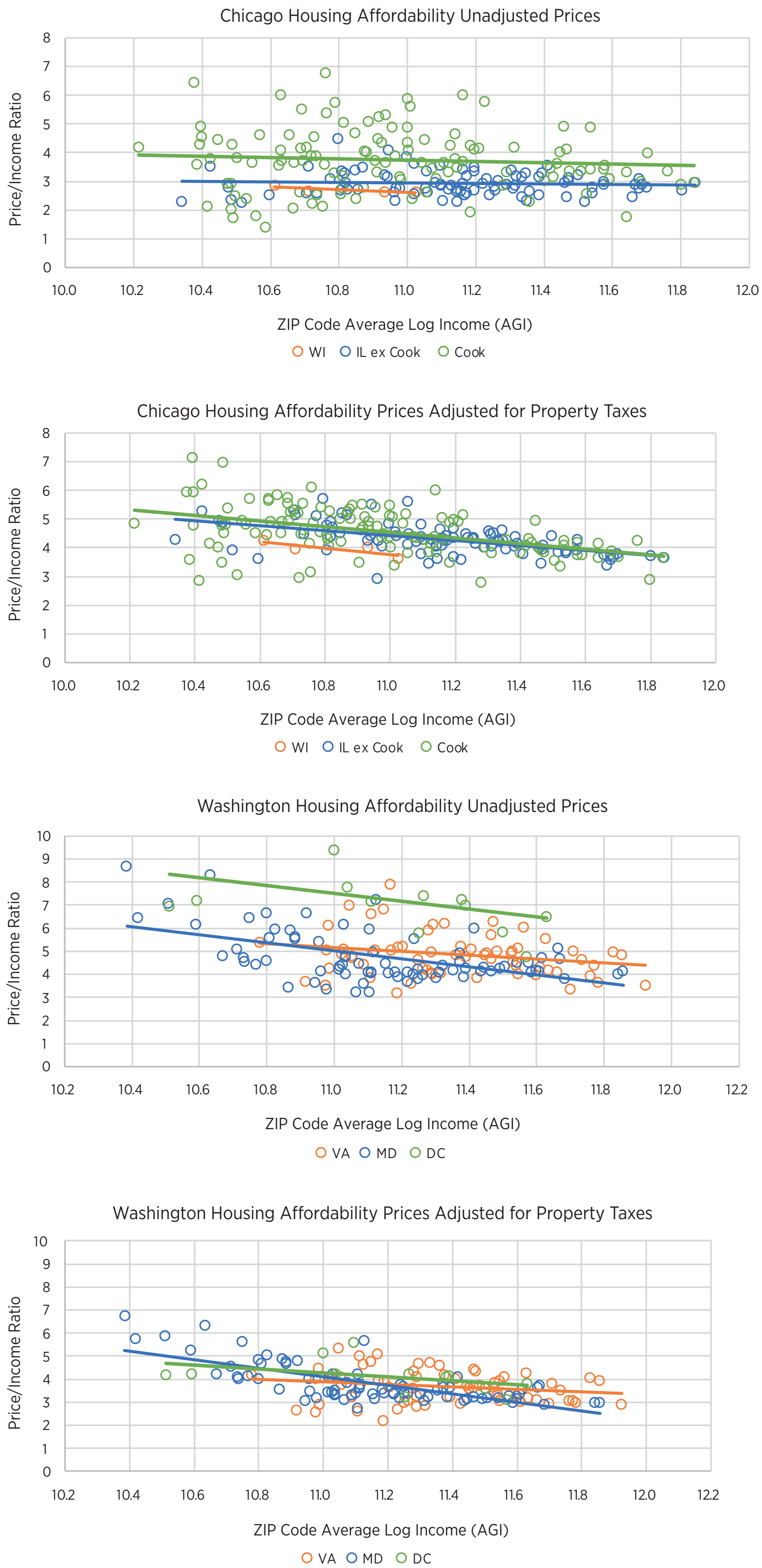
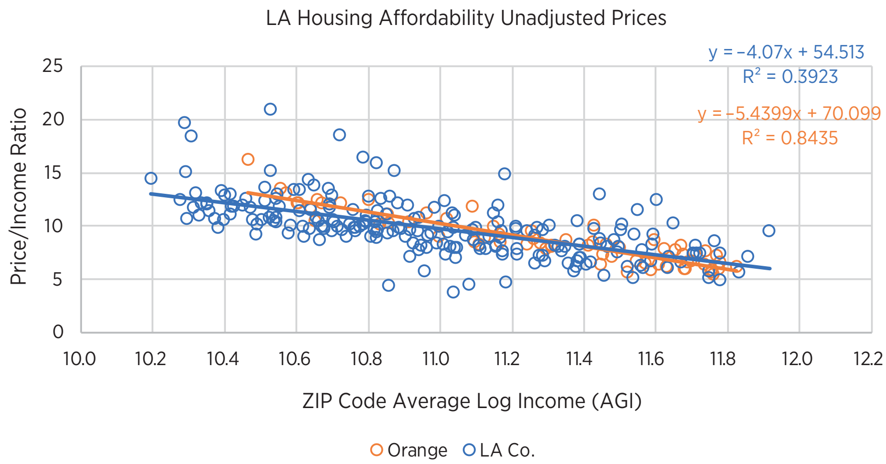


FIGURE 29. PRICE/INCOME PATTERNS IN LOS ANGELES (BEFORE AND AFTER ADJUSTING FOR PROPERTY TAX RATES)



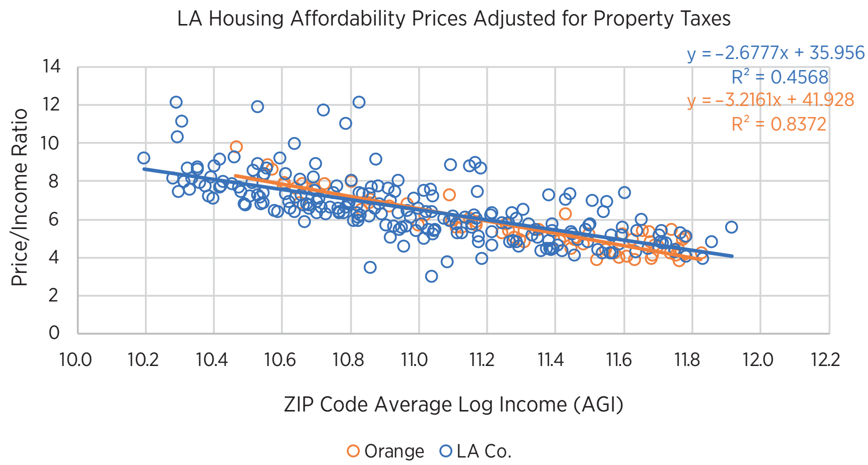


FIGURE 30. METROPOLITAN AREAS WITH NONLINEARITIES IN PRICE/INCOME SLOPES (AFTER ADJUSTING FOR PROPERTY TAXES)

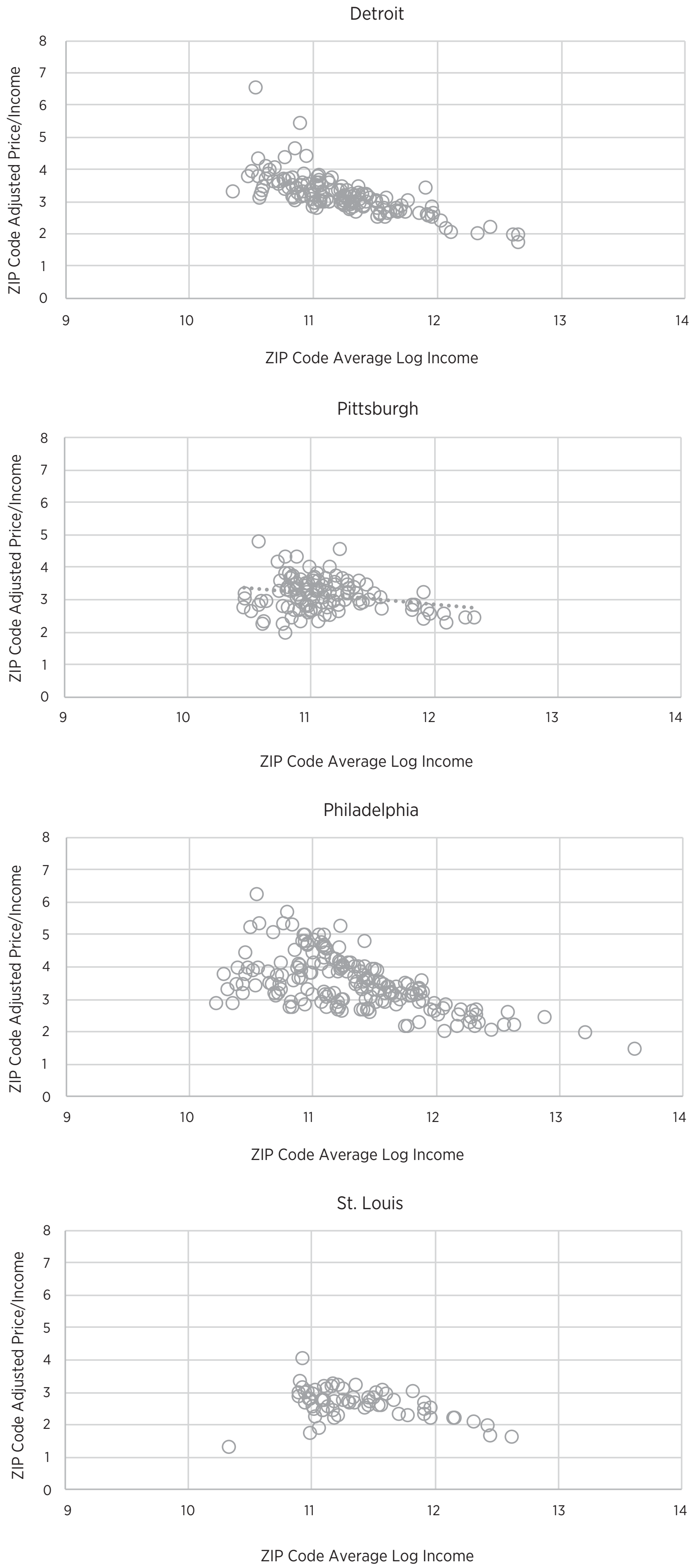
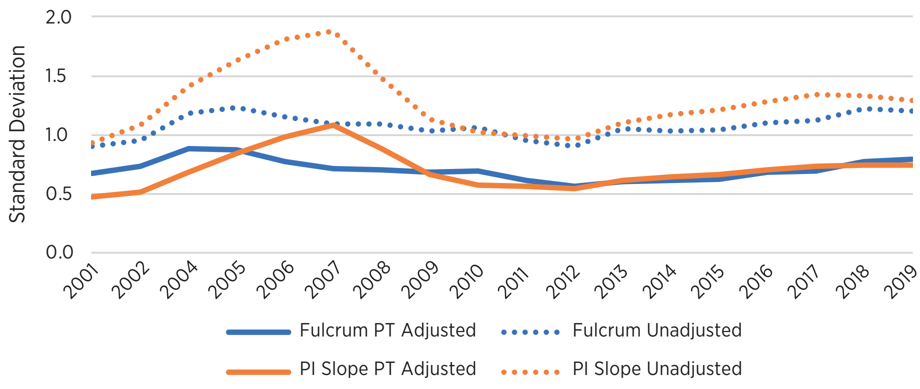


FIGURE 31. FULCRUMS AND PRICE/INCOME SLOPES, ANNUAL STANDARD DEVIATION AMONG 30 MSAS



adjustment is applied, the price/income slope in all four highlighted metropolitan areas becomes more linear, as shown in figure 30 for 2019. In Detroit and Pittsburgh, there is still noticeable heteroscedasticity, but it is now more in the form of irregularities than in the form of a shared, common concavity.

These results suggest that price/income slopes may be a more reliable indicator of relative supply constraints when they are adjusted for property taxes. Figure 31 compares the standard deviations of the estimated price/income ratio at the fulcrum ZIP code (see appendix 3 for a discussion about fulcrum ZIP codes) and the slope of the price/income line among 30 metropolitan areas from 2001 to 2019. The variance of both measures is much lower after adjusting for property tax rates. Differing property taxes are responsible for some of the variance in the price/income slopes and levels among different metropolitan areas.

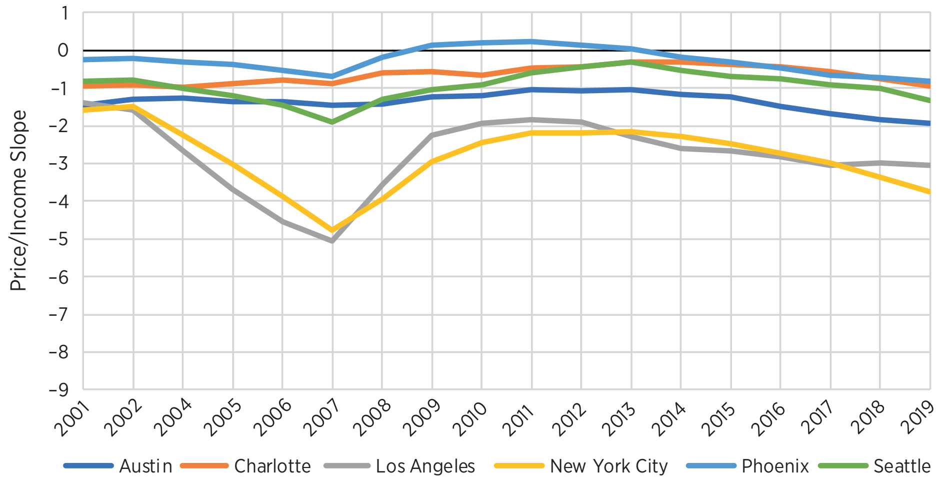
A Review of Price/Income Slopes After Controlling for Property Tax Differences

Table 5 is a reproduction of table 1 after adjusting prices for property taxes. Figure 32 compares the price/income slopes of selected metropolitan areas after adjusting prices for property taxes. Figure 32 differs from figure 6, but the differences are relatively minor in the broad question of supply constraints of various metropolitan areas. The price/income slopes for both New York and Los Angeles are slightly less negative after adjusting for property tax differences, but they are both still more negative than the other metropolitan areas' slopes.

TABLE 5. SLOPE OF PRICE/INCOME REGRESSION LINE ANNUALLY IN 30 MSAS (ADJUSTED FOR PROPERTY TAX RATES)

	2001	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Atlanta	-1.00	-0.93	-1.08	-1.10	-1.09	-1.15	-0.64	-0.20	-0.06	0.16	0.16	0.11	-0.09	-0.21	-0.25	-0.47	-0.70	-0.98
Austin	-1.47	-1.30	-1.27	-1.36	-1.35	-1.46	-1.42	-1.24	-1.19	-1.03	-1.09	-1.05	-1.15	-1.23	-1.48	-1.68	-1.85	-1.92
Baltimore	-0.91	-0.74	-0.72	-0.90	-1.44	-1.97	-1.56	-1.33	-1.16	-0.84	-0.76	-0.64	-0.65	-0.61	-0.72	-0.77	-0.87	-1.01
Boston	-0.28	-0.25	-1.05	-1.37	-1.63	-1.95	-0.98	-0.53	-0.70	-0.67	-0.78	-0.91	-1.10	-1.21	-1.46	-1.71	-1.87	-1.98
Charlotte	-0.95	-0.93	-0.99	-0.90	-0.79	-0.89	-0.60	-0.56	-0.65	-0.45	-0.43	-0.30	-0.30	-0.36	-0.43	-0.56	-0.77	-0.94
Chicago	-1.32	-1.34	-1.87	-2.19	-2.49	-3.02	-2.36	-1.54	-1.25	-0.90	-0.72	-0.45	-0.55	-0.78	-0.98	-1.27	-1.82	-2.07
Cincinnati	-1.03	-0.90	-1.14	-1.12	-1.18	-1.57	-0.96	-0.53	-0.67	-0.43	-0.45	-0.30	-0.33	-0.28	-0.35	-0.45	-0.59	-0.78
Dallas	-0.89	-0.76	-0.95	-1.02	-0.99	-1.20	-0.55	-0.48	-0.48	-0.21	-0.24	-0.14	-0.28	-0.29	-0.53	-0.89	-1.29	-1.67
Denver	-1.18	-1.19	-1.16	-1.01	-0.97	-0.95	-0.44	-0.38	-0.53	-0.44	-0.46	-0.51	-0.63	-0.84	-1.00	-1.17	-1.26	-1.33
Detroit	-0.34	-0.41	-0.58	-0.78	-0.90	-1.16	-0.79	-0.40	-0.06	0.15	0.21	0.28	0.00	-0.16	-0.36	-0.60	-0.85	-1.01
Houston	-0.98	-0.95	-1.18	-1.35	-1.39	-1.62	-1.20	-0.96	-0.92	-0.77	-0.77	-0.69	-0.71	-0.79	-0.82	-1.13	-1.31	-1.61
Las Vegas	-0.67	-0.69	-0.98	-1.18	-1.39	-1.57	-1.10	-0.60	-0.53	-0.23	-0.28	-0.50	-0.71	-0.82	-0.95	-1.02	-1.33	-1.44
Los Angeles	-1.40	-1.58	-2.67	-3.68	-4.54	-5.06	-3.57	-2.26	-1.93	-1.85	-1.90	-2.28	-2.59	-2.66	-2.81	-3.05	-3.00	-3.04
Miami	-1.06	-0.97	-1.32	-1.79	-2.27	-3.32	-2.27	-1.31	-0.72	-0.42	-0.58	-0.58	-0.76	-0.89	-1.10	-1.60	-1.99	-2.19
Minneapolis	-1.12	-1.25	-1.56	-1.69	-1.86	-1.95	-1.45	-1.11	-1.06	-0.84	-0.76	-0.79	-0.89	-0.98	-1.06	-1.16	-1.25	-1.39
New York City	-1.59	-1.50	-2.26	-3.00	-3.87	-4.76	-3.93	-2.96	-2.43	-2.19	-2.19	-2.17	-2.27	-2.46	-2.72	-2.97	-3.36	-3.74
Orlando	-0.74	-0.67	-1.00	-1.40	-1.91	-2.20	-1.45	-0.75	-0.47	-0.38	-0.48	-0.65	-0.88	-0.95	-1.12	-1.47	-1.74	-1.94
Philadelphia	0.03	0.29	0.22	-0.08	-0.37	-0.98	-0.44	-0.25	-0.34	-0.26	-0.24	-0.02	-0.07	-0.14	-0.14	-0.31	-0.50	-0.74
Phoenix	-0.23	-0.21	-0.31	-0.38	-0.53	-0.68	-0.20	0.12	0.21	0.24	0.13	0.03	-0.17	-0.32	-0.47	-0.66	-0.72	-0.82
Pittsburgh	-0.26	0.06	-0.25	-0.41	-0.49	-0.73	-0.21	0.01	-0.19	0.06	-0.10	0.13	0.12	0.05	0.12	-0.03	-0.12	-0.23
Portland	-0.38	-0.34	-0.61	-0.65	-0.83	-1.19	-0.75	-0.72	-0.74	-0.54	-0.63	-0.51	-0.70	-0.88	-1.09	-1.34	-1.60	-1.69
Riverside	-0.11	0.01	-0.13	-0.63	-1.28	-1.42	-0.49	-0.03	0.15	0.19	0.02	0.02	-0.23	-0.46	-0.75	-0.88	-1.09	-1.25
Sacramento	0.29	0.04	-0.49	-1.06	-1.17	-0.94	-0.11	0.14	0.01	0.16	0.02	-0.04	-0.45	-0.62	-0.87	-1.04	-1.03	-1.05
San Antonio	-1.37	-1.22	-1.39	-1.46	-1.43	-1.77	-1.31	-1.01	-0.94	-0.79	-0.67	-0.57	-0.61	-0.68	-0.82	-1.09	-1.37	-1.61
San Diego	-0.86	-1.04	-2.40	-3.00	-3.12	-3.16	-1.68	-0.71	-0.83	-0.95	-1.11	-1.42	-1.77	-1.87	-2.02	-2.18	-2.02	-2.10
San Francisco	-1.42	-1.77	-2.53	-3.12	-3.53	-3.49	-2.19	-1.54	-1.49	-1.27	-1.21	-1.41	-1.80	-1.98	-2.09	-2.45	-2.71	-2.55
Seattle	-0.83	-0.80	-1.00	-1.22	-1.47	-1.91	-1.29	-1.05	-0.90	-0.59	-0.45	-0.32	-0.54	-0.68	-0.76	-0.92	-1.01	-1.33
St. Louis	-0.46	-0.39	-0.70	-0.94	-1.16	-1.38	-1.01	-0.65	-0.57	-0.36	-0.33	-0.12	-0.28	-0.09	-0.02	-0.14	-0.25	-0.39
Tampa	-0.86	-0.71	-0.94	-1.19	-1.55	-1.85	-1.15	-0.71	-0.48	0.03	0.01	0.05	-0.05	-0.26	-0.36	-0.68	-0.88	-1.06
Washington	-0.45	-0.28	-0.48	-0.86	-1.67	-2.09	-1.65	-0.93	-0.39	-0.14	-0.28	-0.57	-0.83	-1.04	-1.27	-1.44	-1.63	-1.67

FIGURE 32. PRICE/INCOME SLOPE IN SELECTED MSAS (ADJUSTED FOR PROPERTY TAX RATES)



The correlations between the adjusted price/income slope and international and domestic migration (see appendix 2) are the same, directionally, as with the unadjusted slope. The coefficients are lower, which is partly due to the lower variance in price/income slopes after adjusting for property taxes and partly due to the tendency of property taxes to be low in the supply-constrained metropolitan areas. The correlations are still significant, but a bit weaker:

	Coefficient	p-value
International Migration	−0.069	0.041
Net Domestic Migration	0.025	0.041

Correlations between price/income slopes and migration measures in table 2, table 3, and table 4 show similar results, but generally with slightly weaker significance, when adjusted for property taxes. The results with property tax–adjusted price/income slopes are shown in table 6, table 7, and table 8.

Figure 33, a reproduction of figure 13 adjusted for property taxes, provides an interesting result. Comparing Phoenix, Austin, and Boston using unadjusted prices (figure 13), Boston was the outlier, with home price/income ratios systematically higher in ZIP codes with low incomes, while Phoenix and Austin displayed less steep price/income slopes. Property taxes in Phoenix and Boston are lower than average, while in Austin they are higher than average. Adjusting for property taxes moves tax-equivalent prices in Phoenix and Boston down and

TABLE 6. REGRESSION COEFFICIENTS OF FILTERING, INCOME, AND PRICE/INCOME SLOPE WITH VARIOUS MIGRATION VARIABLES (PRICE/INCOME SLOPES ADJUSTED FOR PROPERTY TAX RATES)

	Dependent Variable			
	Outmigration Rate	Outmigrant Income	Inmigration Rate	Inmigrant Income
Filtering Rate	**0.59**	**–5.70**	0.22	–0.34
	0.018	*0.0002*	*0.54*	*0.80*
Income Growth	0.45	**–5.40**	0.27	–1.14
	0.057	*0.008*	*0.52*	*0.55*
Price/Income Slope	**–0.0062**	**0.040**	–0.0008	–0.0096
	0.0001	*0.0024*	*0.74*	*0.45*
Observations	30	30	30	30

Notes: p-values in italics. Migration rates are adjusted for MSA size. Migrant income is relative to the MSA average. Statistically significant ($p<0.05$) coefficients in bold. Results are for 12 individual bivariate regressions.

TABLE 7. MULTIVARIATE REGRESSION COEFFICIENTS OF PRICE/INCOME SLOPE AND HOUSING PERMITS WITH VARIOUS MIGRATION VARIABLE (PRICE/INCOME SLOPES ADJUSTED FOR PROPERTY TAX RATES)

	Dependent Variable			
	Outmigration Rate	Outmigrant Income	Inmigration Rate	Inmigrant Income
Price/Income Slope	**–0.0062**	**0.041**	**–0.0026**	–0.0076
	0.00038	*0.004*	*0.1648*	*0.56*
Permits per Capita	0.000	–0.22	**0.27**	–0.31
	0.99	*0.66*	*0.000003*	*0.47*
Observations	30	30	30	30
Adjusted R^2	0.26	0.19	0.48	–0.04

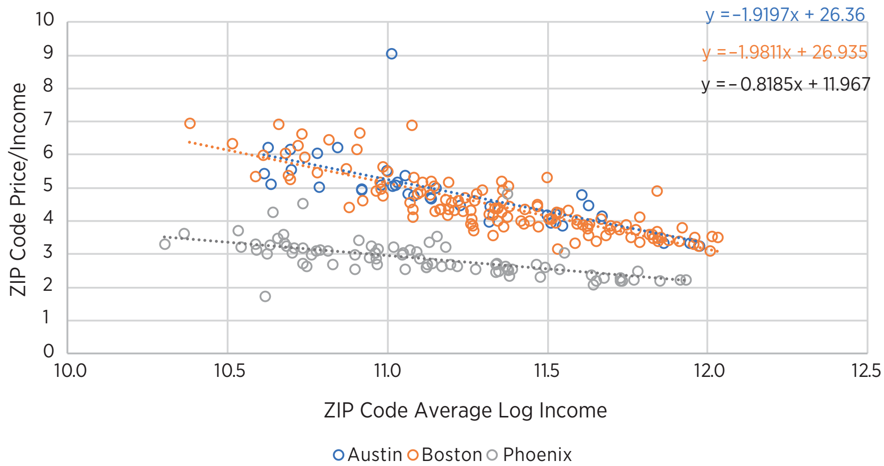
Notes: p-values in italics. Migration rates are adjusted for MSA size. Migrant income is relative to the MSA average. Statistically significant ($p<0.05$) coefficients in bold. Results are for 12 individual bivariate regressions.

TABLE 8. MULTIVARIATE REGRESSIONS BETWEEN FILTERING, PRICE/INCOME SLOPE, AND INCOME GROWTH (PRICE/INCOME SLOPES ADJUSTED FOR PROPERTY TAX RATES)

	Dependent Variable		
Independent Variables	Price/Income Slope	Filtering Rate	
Filtering Rate	-1.040 *0.446*		
Avg Price/Income Slope		−0.372 *0.128*	−0.161 *0.069*
Annual Income Growth	−0.507 *0.241*		0.909 *0.101*
Observations	30 MSAs	30 MSAs	30 MSAs
Adjusted R^2	0.21	0.21	0.79

Note: Standard errors below coefficients.

FIGURE 33. 2019 PRICE/INCOME IN AUSTIN, BOSTON, AND PHOENIX (ADJUSTED FOR PROPERTY TAXES)



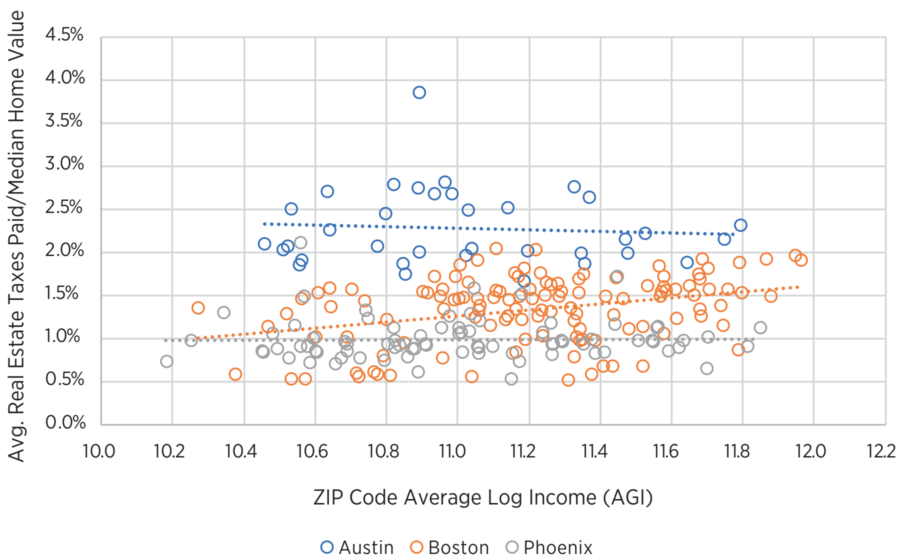
prices in Austin higher. Figure 33 shows that, after adjusting for taxes, Austin lines up as well with Boston as it had aligned with Phoenix in figure 13, before the adjustment.

Of the metropolitan areas that have been outliers in terms of low housing supply, high income growth, and high rates of outmigration, Boston is not the worst offender—its price/income slope is less steep than those of the California coastal metropolitan areas and New York City. And Austin has had especially strong demand pressures on its housing supply. Yet from 2010 to 2020, Boston grew by only 7 percent while Austin grew by 33 percent. That difference is largely bridged by voluntary migration rates.[68] If property taxes are a relevant factor leading to different housing costs between metropolitan areas, then it is surprising that fast-growing Austin has a price/income pattern similar to that of slow-growing and expensive Boston when property taxes are adjusted for.

One way to check the causes of price/income differences in Austin, Phoenix, and Boston is to compare rental costs. In figure 1, I compared ZIP code rent/income ratios in Boston to Atlanta, and Boston rental costs compared unfavorably. In New York City, it appears from figure 26 that income/rent differences are roughly arbitraged away through moves within the metropolitan area, as income/rent patterns are similar in New Jersey and New York. But, as shown in figure 26, price/rent ratios are generally lower in New Jersey, presumably because of its higher property taxes.

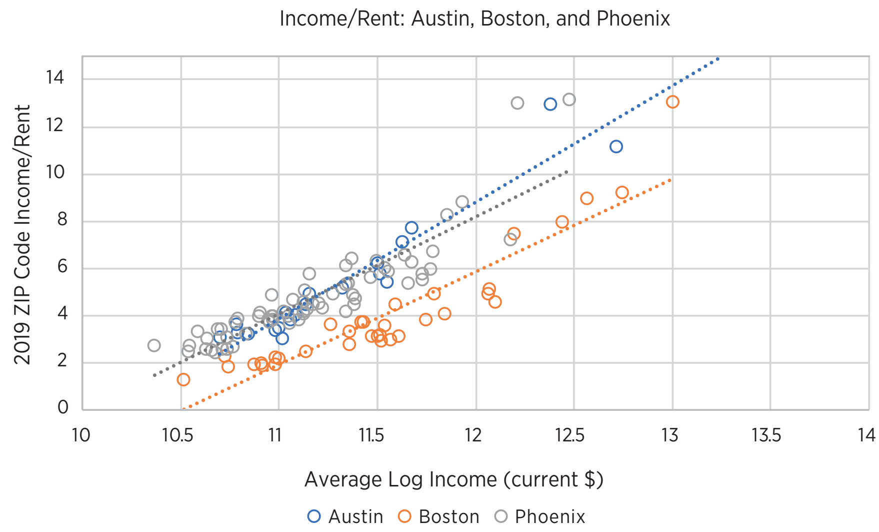
Figure 34 shows that property taxes are relatively high in Austin and low in Phoenix.[69] Boston has moderate property taxes that appear to be progressive across ZIP codes (higher where incomes are higher). As figure 35 shows, income/rent ratios look similar in Austin and Phoenix at any given income level.

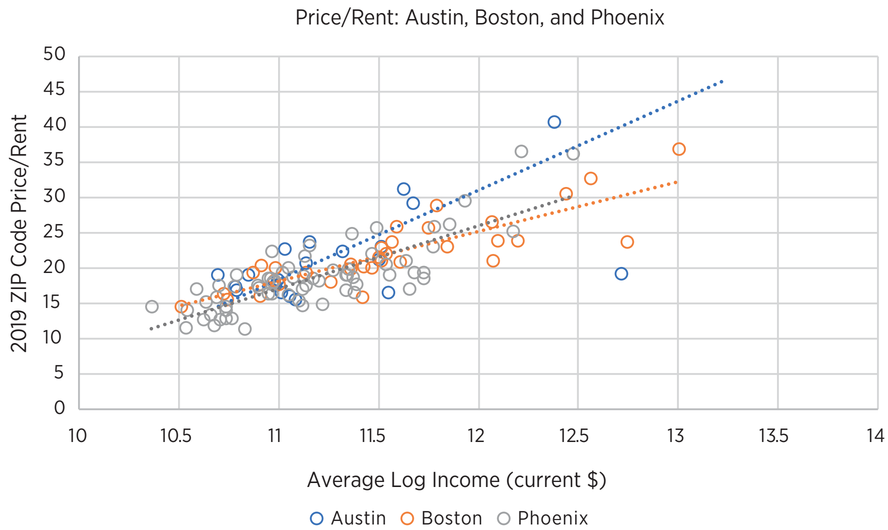
FIGURE 34. PROPERTY TAX RATES IN AUSTIN, BOSTON, AND PHOENIX



68. Population estimates from the US Bureau of Economic Analysis. See appendix 5.
69. Property tax rates have been estimated using ZIP code IRS data and Zillow ZHVI home price estimates from 2016.

FIGURE 35. INCOME/RENT AND PRICE/RENT BY ZIP CODE INCOME IN AUSTIN, BOSTON, AND PHOENIX





In Boston, rents are universally higher (here, shown in the inverse income/rent to produce a more linear relationship). Similar rents along with lower price/rent ratios (because of high property taxes) should make price/income ratios and price/rent ratios lower in Austin than in Phoenix. But as the bottom panel of figure 35 shows, price/rent ratios are *not* lower in Austin. They are higher, even without adjusting for property taxes.

In figure 33, after adjusting for property taxes, Austin price/income ratios should be similar to Phoenix. In figure 13, Austin price/income ratios should be lower than in Phoenix, because owners in Austin collect similar rents but must pay higher taxes. They are not. Austin prices appear to be anomalously high when accounting for property taxes.

There are several reasons why the property tax adjustment would not produce the expected result in Austin. It could be that my specification for the effect of taxes is biased or miscalibrated—that could be true in any case. But surely the *sign* of the effect of taxes on property values is negative. If it was the driving factor in this particular comparison, we should still expect unadjusted price/rent ratios in Austin to be lower than those in other cities. But the surprise in valuations here is clear in unadjusted valuations. It could be that even 3 to 4 percent annual growth rates aren't enough to accommodate the demand for moving to Austin. Possibly the forward-looking nature of prices suggests that Austin rents remain affordable today but that home buyers do not expect them to remain that way.

Though some outliers, like Austin, produce new mysteries when prices are adjusted for property taxes, the adjustment does generally appear to reduce the noise in cost measures such as prices, price/rent ratios, and price/income ratios, both within and across metropolitan areas.

Concluding Discussion

The differential in housing costs across incomes in each MSA can be a useful proxy for housing supply constraints. There are at least three possible approaches.

1. *The approach I have used earlier, using price/income ratios from raw price estimates*. This approach is relatively easy to compute, minimizes biases and model calibration issues, and produces results that are correlated with other evidence of housing supply constraints.
2. *Using rents instead of prices*. This approach would reflect a more fundamental measure of housing affordability. However, there are drawbacks: Rent data are still not as ubiquitous and easily retrieved as price data are. For owned homes, which are the majority of units, rents must be estimated. Rents reflect current conditions, but paid rents are somewhat sticky in practice. They also do not reflect expectations and likely trends as well as market prices can.
3. *Using prices with adjustments and controls, as with the property tax–adjusted measure I have used in this appendix*. This can ideally produce

a more relevant and accurate proxy for supply constraints. As a measure of metropolitan area supply constraints, this, ideally, would be the most useful and informative approach. However, it is not as easily reproducible, and it creates additional model risk as each control and adjustment must be estimated imperfectly. Depending on the application, the control may create more potential bias than it is intended to avoid, but where universal linearity is useful, the property tax adjustment does appear to produce a more universally linear price/income pattern across metropolitan areas.

Of course, there are additional challenges. For instance, in terms of the cost of living and migration patterns, housing costs can trigger policy reactions, such as Proposition 13 in California, which limits property tax rates. And where property taxes are lower, other taxes or costs may arise in their place. If a state has a high property tax but low income taxes or consumption taxes, perhaps higher rents or prices would not be associated as sharply with distress-producing costs.

There may not be a perfect measure for estimating the effects of housing supply constraints, but I hope the methods described in this paper can provide additional tools for that task.

APPENDIX 5: DATA SOURCES

The data sources I use in the foregoing analysis include the following:

- Home prices are Zillow Home Value Index (ZHVI) by ZIP code, accessed March 16, 2022, https://www.zillow.com/research/data/.
- Where rents are referenced, the Zillow Observed Rent Index (ZORI) by ZIP code is used, accessed March 16, 2022, https://www.zillow.com/research/data/.
- Incomes are taken from IRS estimates, by ZIP code, accessed March 16, 2022, https://www.irs.gov/statistics/soi-tax-stats-individual-income-tax-statistics-zip-code-data-soi. The average ZIP income is estimated by dividing total reported AGI by the number of filers.
- Permit data for each metropolitan area is available from US Census Bureau, accessed March 16, 2022, https://www.census.gov/construction/bps/historical_data/.
- MSA populations for per capita measures are taken from the US Bureau of Economic Analysis, "Table CAINC1. (Personal Income, Population, and Per Capita Personal Income) for Metropolitan Areas," accessed April 2022,

https://apps.bea.gov/iTable/index_regional.cfm. Data from Table CAINC1 is also used for per capita income growth where noted.

- Outmigrant average income, outmigration rate, inmigrant average income, and inmigrant rate data were taken from the US Census Bureau's American Community Survey. Migrating households were identified as households who had lived outside their current MSA in the previous year. Within each MSA in each year, the average household income of migrants was compared to the average household income of nonmoving residents. The figures used for each MSA were the unweighted averages of each measure for each of the years 2005 to 2014.
- Where noted, IRS migration data were taken from Internal Revenue Service, "SOI Tax Stats—Migration Data" (dataset), accessed September 15, 2022, https://www.irs.gov/statistics/soi-tax-stats-migration-data. Other data, such as filtering rates and some migration estimates, were taken from the sources cited where shown.

ABOUT THE AUTHOR

Kevin Erdmann is the author of two books about the importance of housing supply in the 21st-century American economy. *Shut Out* questions the widely believed notion that a credit bubble led to excessive housing construction in the 2000s before the Great Recession and details a variety of problems that are exacerbated by inadequate housing. *Building from the Ground Up* details how the myth of oversupplied housing was a primary cause of the Great Recession and the 2008 financial crisis. Before turning his attention to the housing market, Erdmann was a small business owner in the construction sector in Arizona. He has a master's degree in finance from the University of Arizona.

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