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The Rental Affordability Curve – A Distribution of Affordability

A New Method of Comparing Rents and Income

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Rental affordability has been a growing issue in recent years with numerous researchers and stakeholders focused on how to address the affordability crisis, particularly at the lower end of the market. This research helps to inform stakeholders and to gain a better understanding of the breadth of the issue. But even with the continued attention given to this topic, there are areas to improve our understanding of where affordability issues are most acute. Therefore, in keeping with our commitment to advancing the understanding of rental affordability,[1] we developed a method of measuring rental affordability across the entire spectrum of income, called the Rental Affordability Curve.

Many factors have contributed to the growing affordability challenge across the nation, one of which is the shortage in housing. Several organizations have estimated the general shortage of housing units to be around 3.8 million housing units[2,3], across the entire housing market (including ownership and rentals). Additionally, the National Multifamily Housing Council estimates that the U.S. is short 600,000 apartment units as a result of the Great Recession and that the country needs to add 4.3 million new units by 2035.[4]

Meanwhile, that shortage is felt most acutely among the lowest income renters. The National Low-Income Housing Coalition estimates that there are only 36 units available and affordable per every 100 extremely low-income renters (those who make 30% of the area median income, or AMI).[5] These measurements provide valuable information in addressing the affordability gap, but there remain shortcomings in the granularity of information that can be used to focus efforts and support housing at different income levels.

The Rental Affordability Curve (which we refer to here as the Affordability Curve) calculates how much of the rental stock is affordable to households at every income percentile. This tool measures the magnitude of the surplus or deficit of affordable housing along the entire income spectrum. With this tool's granularity, we can identify specific household income levels that are most in need within every metro. While affordability is certainly difficult to measure, the Affordability Curve provides us with a method of comprehensively examining the balance between rents and income.

Rent and Income Distributions

Affordability is a function of household income and rent level. Both rents and incomes vary widely within any geography, but incomes tend to be more spread out than rents, creating greater inequality in incomes than rent.

Exhibit 1 compares the share of rental units at different price points with the share of households based on rent derived from income (a metric that converts income into a monthly rent equivalent for comparison purposes).[6] All data is sourced from the Census Bureau's 2021 American Community Survey (ACS) and

[1] Freddie Mac Multifamily publications on rental affordability include Rental Affordability Reexamined, Diminishing Affordability - Inescapable and Rental Burden by Metro

[2] Housing Supply: A Growing Deficit - Freddie Mac

[3] Up for Growth, 2022 Housing Underproduction in the U.S.

[4] NMHC, U.S. Apartment Demand Through 2035

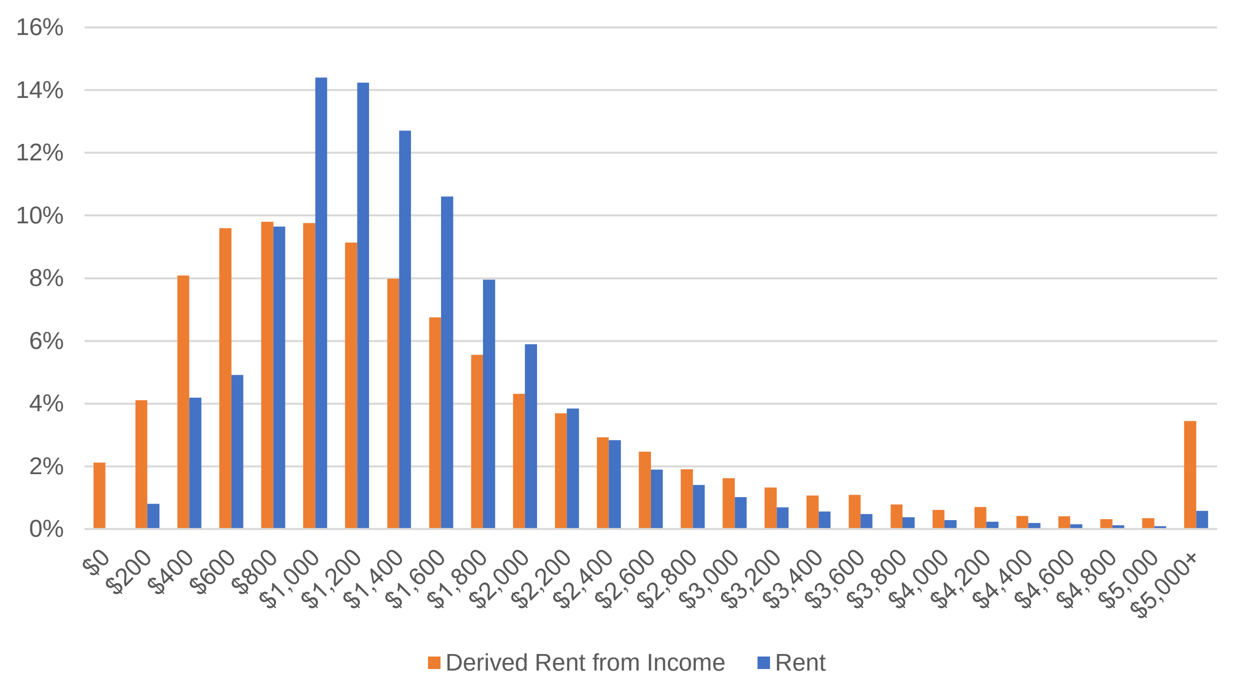
[5] National Low Income Housing Coalition, THE GAP: The Affordable Housing Gap Analysis 2022

[6] Rent derived from income is the portion of a household's monthly income that they can allocate to rent. The calculation assumes that a renter can spend up to 30% of their income on rent and is adjusted for number of earners and the cost of living (discussed more in the Appendix). Rent derived from income can be compared directly with rent. For a given household, if rent derived from income is higher than the rent payment, then the unit is affordable; if it is lower, then the unit is not affordable.

the Bureau of Economic Analysis's (BEA's) 2021 regional price parities dataset (see the Appendix for more detail on data sources).

While the rent distribution is mostly concentrated in the middle of the distribution, the share of the population by income is more spread out, with higher shares in the lower- and higher-income buckets.[7] At the lowest end of the income spectrum, there are more households than there are units affordable to them, which is illustrated with orange bars far exceeding blue bars at the left side of Exhibit 1.

Exhibit 1: National[8] Income and Rent Distribution



Source: Freddie Mac tabulations of 2021 American Community Survey (ACS) PUMS data and 2021 BEA regional price parities.

Many of the existing measures of affordability capture a sub-segment of the overall distribution depicted in Exhibit 1. In 2021, the median percentage of income spent on rent was 30.1%, which is almost exactly the typical industry benchmark of 30%. However, only about 19% of households fall within 5 percentage points of that median. Most high-income households do not struggle to pay rent while most low-income households will have rent burdens that far exceed 30%. Therefore, simple median measurements may not represent the realities for tens of millions of households.

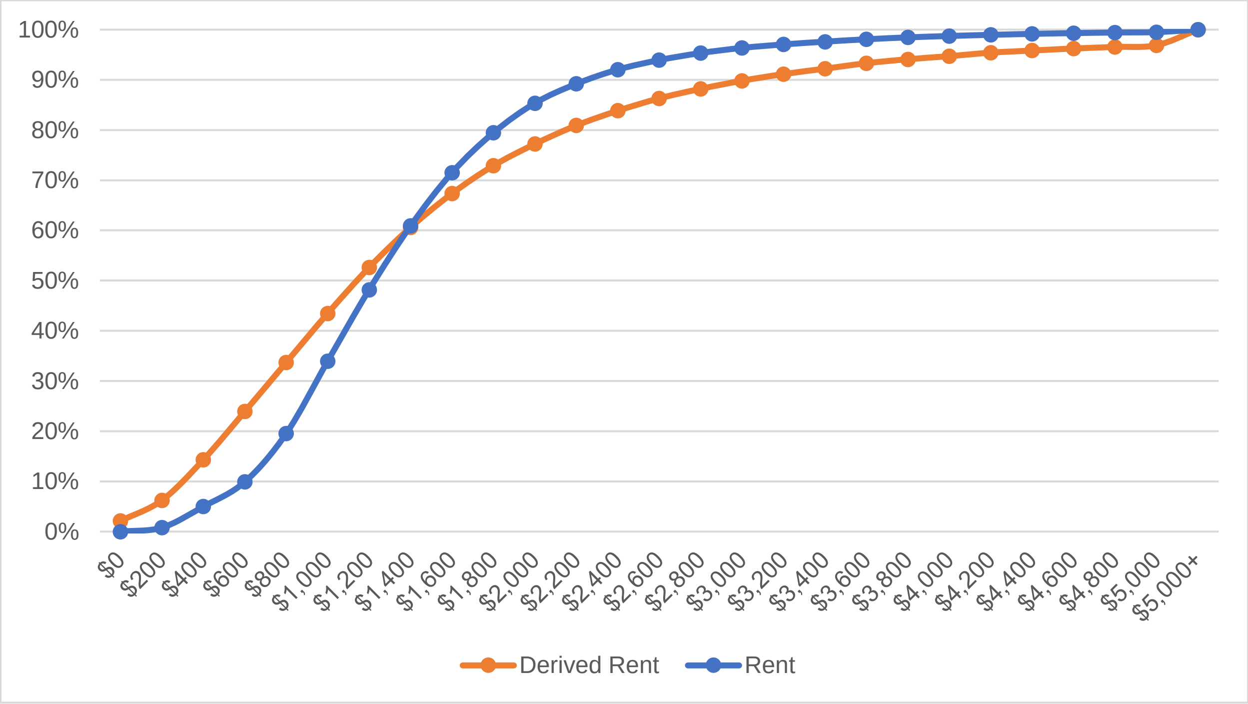
Exhibit 2 shows the same distribution but as the cumulative share. Rent below $800 is relatively uncommon despite a higher share of the population in that income range: 33.7% of renters' income would equate to a derived rent of $800 or less, compared with only 19.6% of actual rent rates. This shows the disparity among the availability of rental units relative to income levels that can afford these units. Where

[7] Note that the rents here come from Census data, where the range of multifamily rent levels is generally between $510 and $2,250 (10th and 90th percentiles). However, RealPage reports multifamily rents ranging from $850 to $2,300 during the same period. In this way, rents in this report are generally lower than rents reported by private data providers. However, the Census data is more comprehensive and is widely used in the industry.

[8] In this paper, national estimates refer to metro areas only, which contain the vast majority of the nation's rental housing. More information is provided in the "MSA Classification" section of the Appendix.

the income cumulative share is above the rent cumulative share, we classify this as a housing shortage. Higher up the distribution, where the rent curve values exceed that of the income curve, there exists a relative surplus of units at those income levels. This crossover occurs at an income and rent level of $1,400.

Exhibit 2: National Income and Rent Distribution – Cumulative



Source: Freddie Mac tabulations of 2021 American Community Survey PUMS data and 2021 BEA regional price parities.

The Rental Affordability Curve – The Basics

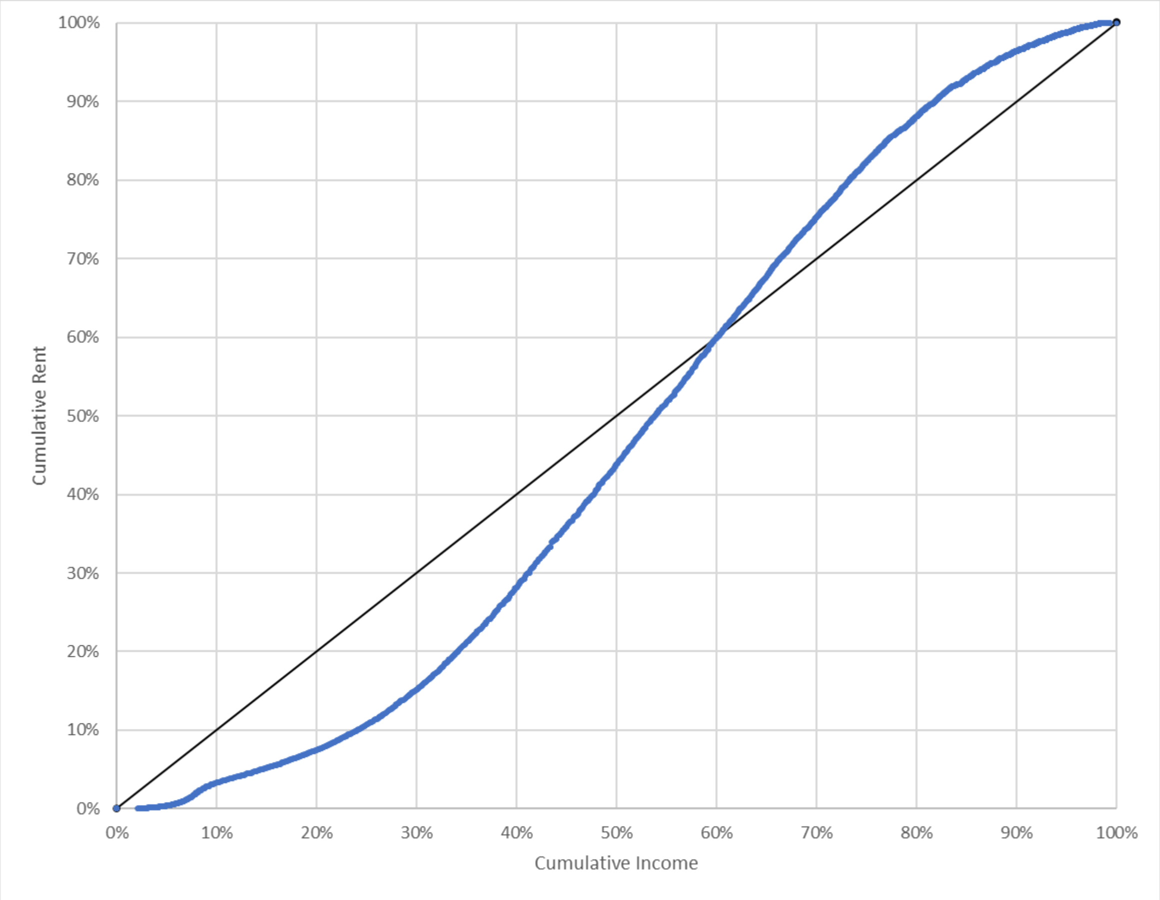
The Affordability Curve, shown in Exhibit 3, transforms the data in Exhibit 2 by capturing rent and income together in one curve.[9] In the curve, the cumulative share of renter household income runs along the horizontal axis, while the vertical axis tracks the percent of affordable rental housing at each income level. This illustrates affordability conditions across the entire income spectrum. From our example above in Exhibit 2, at the 33.7th percentile of income, only 19.6% of all rental units are affordable.

The goal of this curve is to illustrate where there is a relative deficit or surplus of affordable units at each income percentile instead of at specific income points, which don't address the variability within those ranges. It captures whether households are marginally unable to afford rent or if affordability is largely out

[9] Income and rent values come from the same set of households but are sorted from least to greatest and are independent of each other.

of reach. The Affordability Curve makes it visually apparent whether the need is isolated to the lowest end of the income spectrum or if the issue persists for workforce housing and further up the income curve.

Exhibit 3: National Rental Affordability Curve



Source: Freddie Mac tabulations of 2021 American Community Survey PUMS data and 2021 BEA regional price parities.

The black 45-degree line in Exhibit 3 is the parity line and represents a scenario in which incomes and rents move perfectly in tandem; for example, households at the 30th percentile of income can afford exactly 30% of rental units. The intersection point of the national affordability curve and the parity line is at the 60th percentile of income, which means that a renter household making the 60th percentile of income can afford 60% the rental units nationwide — an affordability equilibrium where, in theory, there should be an adequate amount of rental housing for households at that income level. All points of the Affordability Curve below the parity line represent- a shortage of housing at that income percentile, while a surplus is when the Affordability Curve is above the parity line.

All income percentiles that make up the Affordability Curve can be converted to AMI, which can be useful since AMI is the industry standard for understanding affordability limits. The 60th percentile of income represents a rent derived from income amount of $1,391, equating to 69% of AMI. This means that nationally, there is an aggregate shortage of rental units up to $1,391, or 69% of AMI, but that at higher AMI levels, there is an aggregate surplus.

The magnitude of the shortage or surplus is represented in the area between the two lines. At the national level, the largest disparity between the Affordability Curve and parity line occurs at the 29th percentile of income; at this point, a household making the 29th percentile of income (which represents 34% of AMI) can afford only 14% of rental units. Because households at this income percentile face a shortage of affordable units, they are left to compete for a small number of units, which will exacerbate affordability issues for lower-income earners.

While the intersection point shows the percent of renter households that face an insufficient number of affordable units, the area between the parity line and the Affordability Curve shows the severity of the affordability deficit or surplus across all income levels. The greater the area, the greater the severity. In this way, we can surmise that a larger area below the parity line implies worse affordability, whereas better affordability is associated with the Affordability Curve being above the parity line.

General Findings Along the Income Spectrum

The Affordability Curve starts below the parity line, where affordable rental rates, in general, are not available for the very lowest income households. For this subset of the population, income is the issue. The Housing Choice Voucher (HCV) program is meant to serve this population, but not all households receive a voucher since it is not an entitlement. Some housing researchers have cited the need for direct rental assistance for the lowest income renters, either as a cash payment or through the HCV program.[10] Additional supply is critical, but no amount of new market-rate supply could possibly address the needs of the lowest income renters since they cannot reasonably afford market-rate rent regardless of how much the price is driven down by competition.[11]

It is also intuitive that the highest income households can afford rent, which is why the Affordability Curve is above the parity line far to the right side of the distribution. For example, a household that earns $400,000 per year can afford a monthly rent of $10,000 including utilities, assuming that they spend up to 30% of their income on rent. A rental unit charging higher than $10,000 per month is extremely rare.

The middle section of the curve can shed light on the affordability challenges among the workforce housing segment of the population. The curve increases in slope after the 29th percentile of income (the greatest gap between the curve and parity line), indicating that at each additional income percentile, an outsized share of affordable rental housing is available. Eventually that stock catches up with income, and the Affordability Curve crosses the parity line.

Rent and Income Adjustments – Technical Details

The Affordability Curve incorporates adjustments to rent and income to create a normalized comparison across unit types and geographies. The raw values are gross rent (including utilities) and rental household income from the 2021 ACS. We apply a bedroom adjustment to the rent, and a cost of living and number of household earners adjustment to income.

By applying these adjustments, we can compare income per earner with a standardized rent amount, while acknowledging that geography plays a role in determining how much income can be allocated to rent. Adjusting for these factors allows for a more apples-to-apples comparison across units/households and across markets. For example, if a one-bedroom unit and a two-bedroom unit rent for the same amount, the two-bedroom unit is deemed to be more affordable since a renter gets more space for the same dollar amount.[12] Likewise, a one-bedroom unit occupied by a household with two earners may be

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[10] The New York Times, Transcript: Ezra Klein Interviews Jenny Schuetz

[11] Pitchfork Economics, How to repair the housing crisis (with Jenny Schuetz)

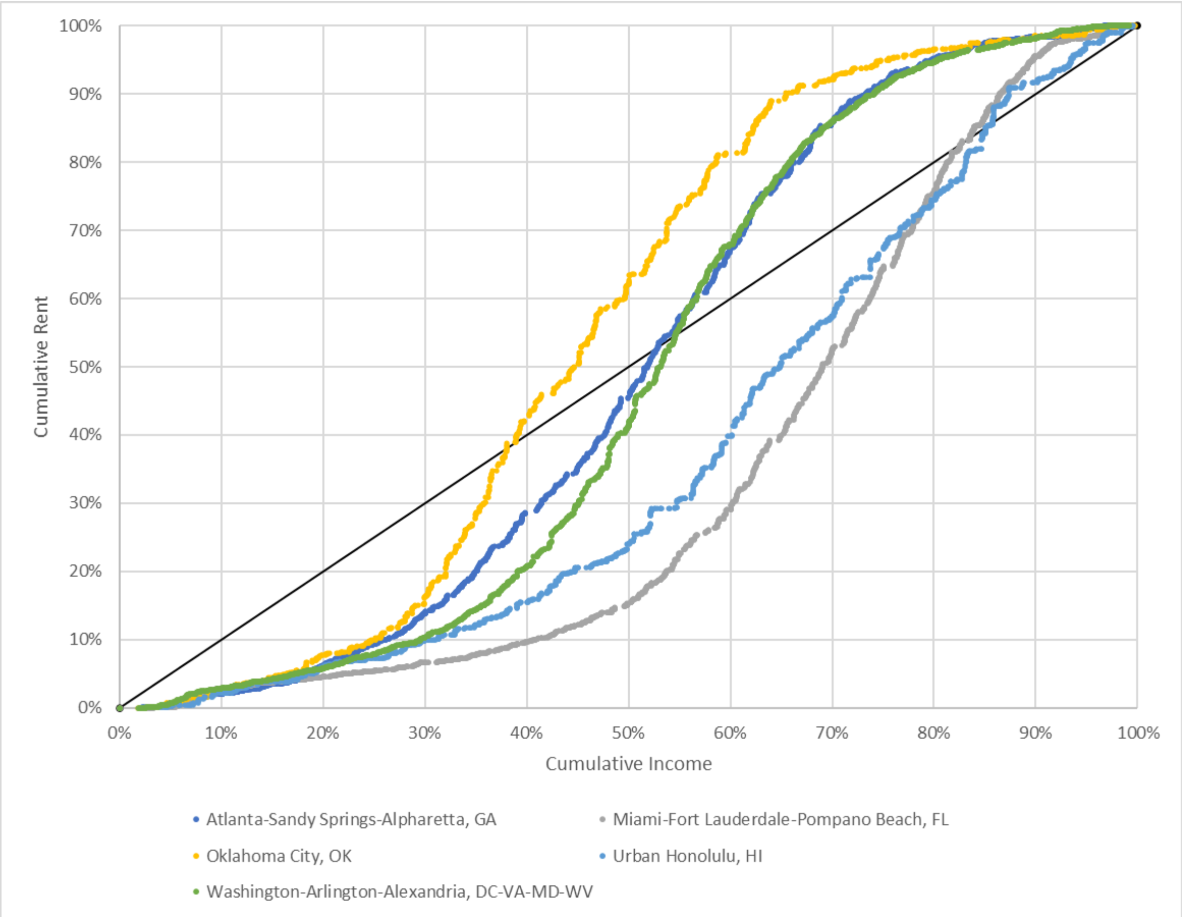
[12] Notably, we do not account for unit quality or location within a metro since we have limited ability to account for both of these.

less cost-burdened than a household with one earner. See the Appendix for additional calculations and rationale for these three adjustments.

Quantifying Affordability at the Metro Level

The curve also allows for easier comparison across different markets. In this section, we compare the Affordability Curve of numerous metro areas to show trends across geographies. Of course, even within a metro area, the balance of rents and incomes can vary considerably and as such, the analysis here shows broad trends. An interesting finding of our metro level examination is that the overall shape of the affordability curve is nearly universal, but the severity and intersection point of the curve varies drastically across geographies. Exhibit 4 shows the Affordability Curves of five large metropolitan areas: Atlanta, Miami, Oklahoma City, Honolulu and Washington, DC. The curve for Oklahoma City is furthest to the left for almost the entire distribution, implying that affordability is substantially better relative to the other four metros since a larger share of units are affordable at lower-income levels. Using the same logic, Miami, which is furthest to the right for most of the distribution, has the worst affordability among these five metros.

Exhibit 4: Metro Level Affordability Curves



Source: Freddie Mac tabulations of 2021 American Community Survey PUMS data and 2021 BEA regional price parities.

There is some uniformity across the metros at the lowest income levels, up until roughly the 20th percentile, because housing is not affordable for the lowest income households. This shows that even in metros with better affordability, such as Oklahoma City compared with Miami, the challenge at the very low end of the income spectrum is nearly universal.

Differences in the middle part of the income distribution are more easily discernable. Exhibit 5 shows the stark differences as you move up the Affordability Curve in each of these metros. The median-renter household (50th percentile) in Miami and Honolulu can only afford 15% and 23% of the rental units, respectively. This is an abnormally large deficit and signals a severe lack of affordable units for the median renter. In Oklahoma City, the median-renter household can afford 62% of the units, which is considerably better than the national average of 44%.

The Intersection Percentile represents the percentage of renters that face an insufficient supply of affordable units. In Miami, that intersection comes at the 83rd percentile of income, implying those making below the 83rd percentile of income do not have an adequate share of rental units affordable to them. The last column shows the point of largest disparity when the Affordability Curve is below the parity line, calculated as the largest difference between the two curves. Converting the income percentiles to AMI, we see that in Oklahoma City, the intersection occurs at 51% of AMI compared with 132% of AMI in Miami. Likewise, the largest disparity in Oklahoma City occurs at 38% of AMI but for Miami, that disparity is further up the curve at 68% of AMI.

Exhibit 5: Summary Statistics of Metro-Level Affordability Curve

	Percentage of Rental Units Affordable at…			Intersection Percentile / AMI %	Income Percentile of Largest Disparity / AMI %
Metro Areas	10th Percentile	50th Percentile	90th Percentile		
Atlanta	2%	45%	98%	53% / 69%	28% / 40%
Honolulu	2%	23%	92%	85% / 114%	50% / 57%
Miami	3%	15%	95%	83% / 132%	50% / 68%
Oklahoma City	2%	62%	98%	38% / 51%	27% / 38%
Washington DC	3%	41%	98%	55% / 62%	36% / 41%
National	3%	44%	96%	60% / 69%	29% / 34%

Source: Freddie Mac tabulations of 2021 American Community Survey PUMS data and 2021 BEA regional price parities.
Note: The AMI % is calculated by taking the income amount associated with the intersection percentile or percentile of the largest disparity and dividing by the metro's AMI. For example, the Affordability Curve crosses the parity line in Miami at the 83rd percentile of income and this income level corresponds to 132% of AMI.

Typically, affordable housing is broken into AMI buckets, such as for those with incomes up to 30% of AMI and 80% of AMI, the former usually requiring income verification to ensure it serves tenants making no more than 30% of AMI. Using Atlanta as an example, there is roughly enough affordable housing for renters earning 70% of AMI. Tenants earning 30% of AMI or less would most likely require a government subsidy. This analysis shows the greatest disparity is at 40% of AMI, which is outside the limits of some government subsidies but far below standard market affordability limits. The Affordability Curve can be used to help inform these disparities at specific incomes most in need.

Three Distinct Sections of the Affordability Curve

Each curve in Exhibit 4 has the same general shape and some shared characteristics despite having vastly different market characteristics. Regardless of metro, renters at the 10th percentile of income have very few affordable options (ranging from 2% to 3% of the rental stock). The same phenomenon can be seen at the other end of the spectrum, although differences are modestly more pronounced. The middle part of the distribution contains the most pronounced differences.

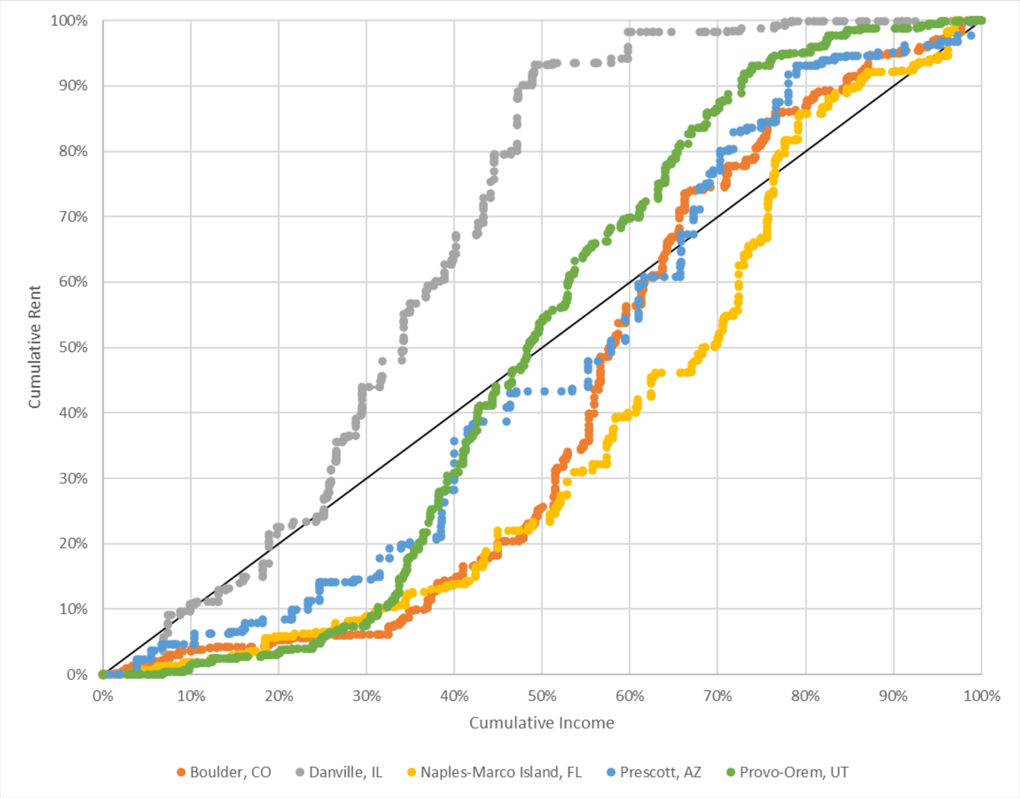
These observed differences are practically universal. Almost all metro areas that we examined, including those showcased in this paper and those not, have the same sinusoidal pattern, which provides us with insight into the fundamental nature of rental housing in affordable and expensive markets alike. Below is a breakdown of the general sections of the Affordability Curve:

1. **First Section**: Up until the 20th percentile or so is typically flat, with sizable housing deficits being the norm across metros. However, this is not universally the case; some small markets cross the parity line in this section of the curve, but this is rare.
2. **Middle Section**: Starting at around the 20th percentile and with an inconsistent end point shows a sharp rise in affordable units with increasing income. This area of the curve illustrates conditions for workforce housing. If units are affordable in this income range, that suggests there may be naturally occurring affordable housing in that metro (such as the case of Oklahoma City).
3. **Last Section**: At upper income levels when the Affordability Curve starts to flatten out again represents wealthier households whose incomes are so high that they are generally not priced out of any rental units.

This pattern is also evident in smaller metro areas. Exhibit 6 shows the Affordability Curves for Boulder, Colorado; Danville, Illinois; Naples, Florida; Prescott, Arizona; and Provo, Utah. Consistent with Exhibit 4, these curves all roughly resemble a sinusoidal pattern. Some curves cross over the parity line several times and have multiple intersection points. Due to fewer observations across all the income and rent levels, there are more jumps and gaps in the curve.

The convergence of the curves at the low and high end implies that very high-income earners have little to no difficulty finding affordable units regardless of the metro, but it also means that very low earners struggle to find affordable housing regardless of how affordable the metro is in general.

Exhibit 6: Metro Level Affordability Curves – Smaller Metros



Source: Freddie Mac tabulations of 2021 American Community Survey PUMS data and 2021 BEA regional price parities.

Income and Rent Inequality – Affordability Differences between Nashville and Austin

The behavior in the different sections of the Affordability Curve is symptomatic of higher-income inequality relative to rent inequality. As we saw in Exhibit 1, incomes are more spread out across the distribution, indicating greater inequality among incomes, while rents are more heavily concentrated in the middle. Using the Gini coefficient to measure income inequality, we see that income inequality is roughly 55% higher than rent inequality, 0.4460 and 0.2881, respectively.[13] Using the GINI coefficients, we can compute an income inequality to rent inequality ratio to compare income and rent inequalities between metro areas. The median ratio across all metros is about 1.84.[14] Values higher than this indicate that incomes are more spread out relative to the rent distribution compared with the national average, while lower values indicate that incomes are generally closer to the median.

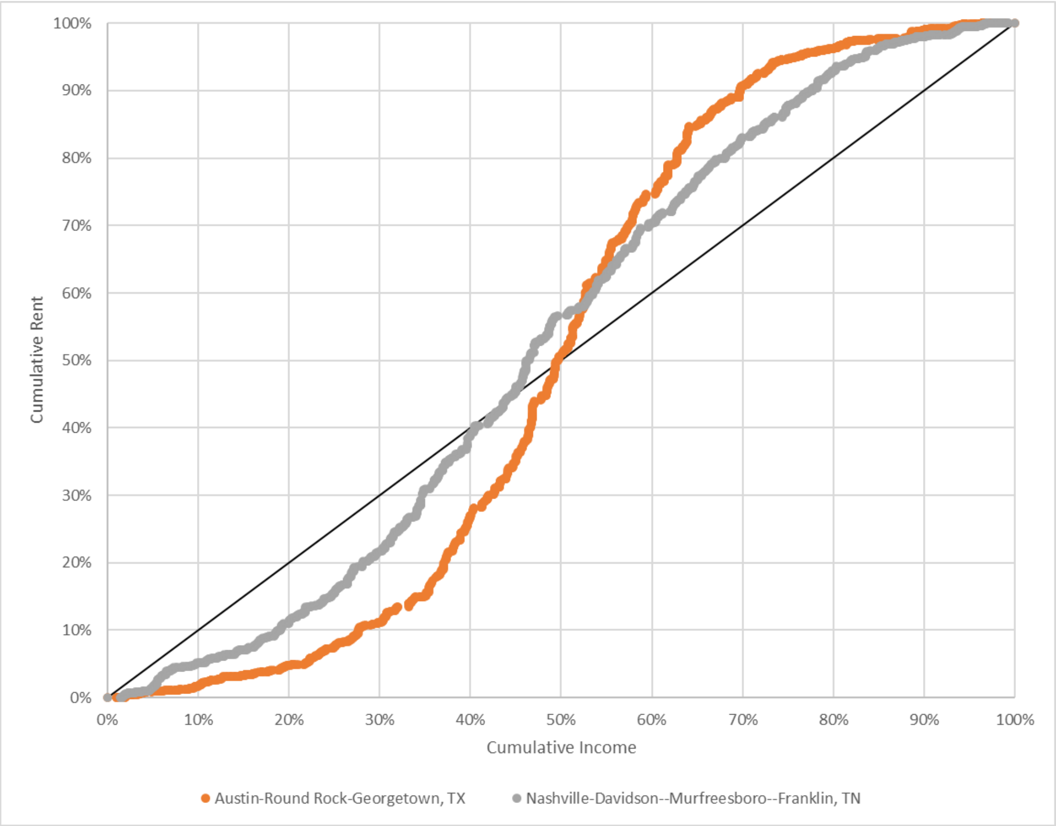
To make the relationship more apparent, Exhibit 7 shows the Affordability Curves of Nashville, Tennessee and Austin, Texas. Nashville has a lower ratio of income inequality relative to rent inequality at 1.64, while Austin has a comparatively high ratio at 2.16. Nashville's ratio indicates that rent and income are more closely distributed. As a result, Nashville's Affordability Curve is more linear than that of most other Affordability Curves among the larger metro areas, as seen in Exhibit 7. Austin's ratio indicates rent and

[13] The Gini coefficient compares the cumulative proportion of income against the cumulative proportion of the population and is a widely quoted measure of income inequality. Although Gini is often used with income, it can be used with any monetary metric, such as rent. The Gini coefficient ranges from 0 to 1; the higher the coefficient, the higher the inequality.

[14] 1.84 = (Median Income Gini) / (Median Rent Gini) ≈ 0.4099/0.2234. Median Ginis are computed as the median across all metros.

income are less evenly distributed and shows there is a relatively higher concentration of households in the tails of the distribution, creating a more pronounced sinusoidal curve shape.

Exhibit 7: Illustration of Income and Rent Inequality Differences



Source: Freddie Mac tabulations of 2021 American Community Survey PUMS data and 2021 BEA regional price parities.

The Affordability Curve exemplifies the importance of the income and rent distributions. For example, according to 2021 1-Year ACS summary statistics, the median rent burden in Nashville is 30.2% compared with 29.2% in Austin. Judging by this single measure, we could conclude that affordability generally is slightly better in Austin. As shown in Exhibit 7, above the parity line, Austin has a higher share of rental units affordable in those income percentiles compared with Nashville. However, when considering the whole distribution, Nashville has a clear advantage below the parity line, at the lower end of the income spectrum. For lower-income households, the Affordability Curve shows that in fact Nashville has more affordable units compared with Austin, which would not be picked up in the median rent-burdened figure.

Conclusion

There is no perfect way of evaluating affordability across geographies and demographics. There are too many moving parts and considerations, some of which are subjective in nature, leaving every method of calculating affordability with strengths and weaknesses. The primary benefit of the Affordability Curve is that it allows for a more comprehensive view of affordability. While deeply affordable units – typically those affordable to tenants making less than 30% of AMI – are difficult to support without government subsidies, this tool can help identify if that need is also experienced further up the income spectrum. As we've seen in the examples throughout this paper, distribution matters since households at different parts of the income spectrum experience rental housing affordability very differently. The distribution allows for a better approach to addressing the affordable housing challenges the nation faces. This analysis provides the ability to focus on the specific areas of the income spectrum most in need, which will have a greater impact on closing the housing shortages and helping those renters who need it the most.

Appendix

Exhibit A1: Summary Statistics of Metro-Level Affordability Curve (Top 50 Metros)

	Percentage of Rental Units Affordable at…			Intersection Percentile / AMI %	Income Percentile of Largest Disparity / AMI %
Metro Areas	10th Percentile	50th Percentile	90th Percentile		
New York City	3%	28%	96%	72% / 93%	45% / 47%
Los Angeles	2%	14%	95%	79% / 126%	51% / 60%
Chicago	3%	44%	98%	56% / 64%	33% / 38%
Dallas	2%	44%	99%	53% / 70%	31% / 45%
Houston	2%	40%	98%	59% / 71%	31% / 41%
Washington, D.C.	3%	41%	98%	55% / 62%	36% / 41%
Miami	3%	15%	95%	83% / 132%	50% / 68%
Philadelphia	3%	48%	98%	52% / 62%	36% / 41%
Atlanta	2%	45%	98%	53% / 69%	28% / 40%
Phoenix	2%	45%	97%	53% / 78%	31% / 51%
Boston	5%	31%	98%	69% / 81%	49% / 50%
San Francisco	3%	29%	98%	67% / 88%	43% / 47%
San Bernardino/ Riverside	2%	24%	98%	78% / 110%	46% / 59%
Detroit	2%	53%	98%	48% / 55%	32% / 37%
Seattle	3%	27%	99%	65% / 79%	44% / 50%
Minneapolis	4%	44%	98%	57% / 56%	32% / 34%
San Diego	2%	15%	97%	79% / 119%	51% / 64%
Tampa-St. Petersburg	2%	33%	98%	65% / 88%	35% / 52%

Denver	3%	33%	98%	66% / 77%	38% / 46%
St. Louis	4%	62%	98%	42% / 47%	25% / 28%
Baltimore	4%	35%	99%	59% / 62%	41% / 41%
Charlotte	4%	60%	99%	37% / 55%	20% / 33%
Orlando	1%	23%	98%	72% / 100%	41% / 57%
San Antonio	4%	45%	99%	54% / 69%	38% / 50%
Portland	3%	30%	98%	65% / 75%	39% / 44%
Sacramento	2%	23%	98%	70% / 88%	46% / 51%
Pittsburgh	6%	67%	99%	36% / 41%	18% / 23%
Las Vegas	1%	30%	99%	66% / 87%	37% / 52%
Austin	2%	51%	99%	49% / 65%	35% / 49%
Cincinnati	4%	65%	98%	40% / 44%	27% / 31%
Kansas City	4%	66%	98%	37% / 49%	25% / 36%
Columbus	4%	68%	99%	38% / 49%	23% / 33%
Indianapolis	4%	68%	98%	36% / 50%	22% / 35%
Cleveland	5%	67%	98%	38% / 45%	25% / 31%
San Jose	3%	31%	100%	59% / 81%	39% / 47%
Nashville	5%	57%	98%	44% / 61%	25% / 39%
Virginia Beach	3%	45%	98%	54% / 65%	34% / 42%
Providence	7%	38%	99%	61% / 64%	44% / 43%
Milwaukee	4%	73%	98%	38% / 47%	25% / 33%
Jacksonville	2%	46%	99%	52% / 73%	33% / 49%
Oklahoma City	2%	62%	98%	38% / 51%	27% / 38%
Raleigh	3%	53%	98%	46% / 55%	24% / 31%
Memphis	2%	58%	99%	44% / 58%	29% / 38%
Richmond	3%	42%	98%	55% / 63%	29% / 36%
New Orleans	1%	34%	97%	59% / 73%	39% / 46%
Louisville	6%	63%	98%	41% / 52%	28% / 38%

Salt Lake City	4%	50%	99%	50% / 61%	34% / 46%
Hartford	4%	41%	98%	60% / 57%	39% / 38%
Buffalo	2%	60%	98%	46% / 47%	29% / 30%
Birmingham	5%	58%	98%	44% / 51%	33% / 37%

Rent Adjustments

The raw rent and income figures are both adjusted in order to make a fairer comparison across unit types and geographies. We apply a bedroom adjustment to rent to equalize the effect of unit size. The intuition is that larger unit sizes naturally rent for higher than smaller unit sizes simply due to the size difference. Since the higher price is largely independent of affordability, we need to adjust for it in order to figure out which units are more or less affordable without regard to their size. Exhibit A2 shows the adjustment factors based on building and unit type.

We commonly use the industry standard bedroom adjustment, shown in Exhibit A2, but for this report we opted to use our own calculated adjustments. Our adjustment stratifies by type; we calculate average rent by bedroom and overall average rent for each single-family, multifamily and other, and then determine how much the rent for each bedroom count differs from the overall. The industry standard aligns well with single-family rentals, especially for small unit sizes, but does not line up well with the multifamily and other categories. We decided to use our own method to reduce skew that would arise from not factoring in unit type.

Exhibit A2: Bedroom Adjustment for Rent

<table>
<tr><th></th><th colspan="4">Adjustment Factor</th></tr>
<tr><th>Number of Bedrooms</th><th>Single-Family</th><th>Multifamily</th><th>Other</th><th>Industry Standard*</th></tr>
<tr><td>0</td><td>0.72</td><td>0.88</td><td>0.84</td><td>0.70</td></tr>
<tr><td>1</td><td>0.74</td><td>0.91</td><td>0.87</td><td>0.75</td></tr>
<tr><td>2</td><td>0.90</td><td>1.10</td><td>0.98</td><td>0.90</td></tr>
<tr><td>3</td><td>1.13</td><td rowspan="3">1.18</td><td>1.13</td><td>1.04</td></tr>
<tr><td>4</td><td>1.42</td><td rowspan="2">1.43</td><td>1.16</td></tr>
<tr><td>5+</td><td>1.56</td><td>1.28+</td></tr>
</table>

Source: Freddie Mac tabulations of 2021 American Community Survey PUMS data and 2021 BEA regional price parities.
Note: Industry standard bedroom adjustment is not used in this report.

Gross rent is divided by the relevant bedroom adjustment factor to give us adjusted gross rent. Formulaically, this is expressed as follows:

$$Adjusted\ Rent = \frac{Gross\ Rent}{Bedroom\ Adjustment}$$

Ideally, the new adjusted rents completely factor out the effect of unit size. The numbers in Exhibit A2 are computed using ACS rent data stratified by number of bedrooms. For example, one-bedroom units in multifamily buildings rent for 91% of the average for all multifamily while two-bedroom units rent for 10% more. Therefore, if the average rent in a metro is $1,000, the average one-bedroom and two-bedroom multifamily units will be adjusted as follows:

$$One\ Bedroom\ Unit\ (Multifamily): \frac{\$910}{0.91} = \$1,000 = Adjusted\ Rent$$

$$Two\ Bedroom\ Unit\ (Multifamily): \frac{\$1,100}{1.10} = \$1,000 = Adjusted\ Rent$$

In this way, the effect of unit size is equalized. This adjustment is computed using national level data, meaning all units of the same bedroom size get the same adjustment regardless of metro.

Income Adjustments

For income, we start with the renter household income as opposed to overall income. We then apply an earners adjustment to equalize the effect of the number of income earners in a household. The intuition is that households with more earners will typically be able to afford higher rent than households with fewer earners, with unit size being equal. If areas are very expensive, multiple earners might form a single household out of necessity. This could give the illusion that incomes are very high in this area, when in reality, the high incomes are simply the result of larger household sizes. We offset this effect by using an earners adjustment factor, as shown in Exhibit A3.

Exhibit A3: Earners Adjustment for Income

	Adjustment Factor		
Number of Earners	Single-Family	Multifamily	Other
1	0.62	0.73	0.68
2	1.30	1.54	1.41
3	1.66	1.85	1.76
4+	2.27	2.39	2.41

Source: Freddie Mac tabulations of 2021 American Community Survey PUMS data and 2021 BEA regional price parities.

Renter household income is divided by the relevant earners adjustment factor to give us adjusted household income. Formulaically, this is expressed as follows:

$$Adjusted\ Household\ Income = \frac{Household\ Income}{Earners\ Adjustment}$$

Ideally, the new adjusted incomes completely factor out the effect of number of earners in the household just like the bedroom adjustment factors out the effect of unit size.

Another adjustment that we make for income is cost of living (COL). Non-housing related expenses vary by state which means that not all households are able to allocate the same portion of their income to housing. We use 2021 regional price parity data from the Bureau of Economic Analysis to calculate the relative price differences across states and then use these numbers to adjust income up for areas with relatively low cost of living and adjust income down for areas with relatively high cost of living.

The intuition is that households in high-cost areas can't spend as much of their income on housing, so their income needs to be adjusted accordingly. The regional price parity data has multiple categories including goods, housing, utilities and other services. We are not able to accurately isolate the non-housing related expenses, so instead choose to use the goods category.

The COL multiplier is at the state level. A higher multiplier indicates a higher cost of living for non-housing related expenses. We assume that lower-income households are more impacted by higher cost of living while high-income households are not as affected (that is, their ability to afford housing is not as much a function of the COL). This assumption is reflected in the piecewise formula for incorporating COL into the adjusted household income.

$$MRI = Median\ Renter\ Income$$

$$\underline{\boldsymbol{For\ lower\ income\ households}}:$$

$$IF\ Renter\ Household\ Income < \boldsymbol{MRI}:$$

$$Cost\ of\ Living\ Multiplier = COL$$

$$\underline{\boldsymbol{For\ moderately\ higher\ income\ households}}:$$

$$IF\ MRI < Income < 2 * MRI:$$

$$Cost\ of\ Living\ Multiplier = \left(\frac{Income - MRI}{MRI}\right) * (1 - COL) + COL$$

$$\underline{\boldsymbol{For\ higher\ income\ households}}:$$

$$IF\ Income > 2 * MRI:$$

$$Cost\ of\ Living\ Multiplier = 1$$

Put simply:

- Renter households with income below MRI get the full COL adjustment.
    - These households are assumed to be the most sensitive to non-housing related COL differences.
- Renter households with incomes greater than MRI but less than 2*MRI get a prorated adjustment.
    - These households are assumed to be materially impacted by non-housing related COL differences, but to a lesser degree compared with households below MRI.
- Renter households with income above 2*MRI get no adjustment.
    - These households are assumed to be impacted by non-housing COL, but not enough to have an impact on their ability to afford rent.

We can add the COL multiplier in the prior formula to arrive at our final income formula:

$$Adjusted\ Renter\ Household\ Income = \frac{Household\ Income}{Earners\ Adjustment * COL\ Multiplier}$$

The COL adjustment is small compared with the bedroom and earners adjustment and does not impact all households. In addition, a state's average household income and its COL are positively correlated, so it's often the case that a household in a high-cost area will receive a higher salary than if they were in a lower-cost area with the same occupation. To better calibrate the COL adjustment, we may explore this relationship more in the future and determine if a refinement is necessary.

Data Source and MSA Classification

All data used in this report is sourced from the Census Bureau's 2021 ACS dataset and the BEA's 2021 regional price parities dataset. The latter data is used solely for the COL adjustment; all other data comes from the 2021 ACS dataset. Because we need to analyze patterns at the household and unit level, we leverage the ACS's Public Use Microdata Sample, which is released annually and contains unit-level data across the entire country. However, to protect privacy, the Census will randomize data to a small degree and top and bottom code certain numeric data points.

The geographic regions associated with PUMS are called Public Use Microdata Areas (PUMAs). There are over 2,300 PUMAs and each one contains at least 100,000 people. PUMAs are often not coterminous with county and metropolitan statistical area (MSA) boundaries, and as a result, PUMA regions cannot perfectly align with all MSA boundaries, which creates a mismatch in data. We attempted to match MSAs with PUMAs as best as possible, but inexact results were unavoidable. To correct for this, we started by finding all intersections between PUMAs and MSA boundaries. For example, if a PUMA falls inside of two MSAs, then we'll generate two records for that PUMA for final determination of inclusion for either metro. A PUMA will be included for the calculation of an MSA if either of these criteria are true:

1. The intersection area of the PUMA and MSA accounts for at least 20% of the PUMAs' population
2. The intersection area of the PUMA and MSA accounts for less than 20% of the PUMAs' population, but at least 20% of the intersection area's population is included in the MSA

There are rare cases where this will result in two PUMAs being assigned to the same MSA. In this case, the one with the higher percentage composition gets assigned to the MSA, with preference given to first criteria. In all cases, if the intersection area is less than 100%, the weight of observations in those areas will be prorated by the intersection area percentage.

As an example, there are 22 PUMAs that fall within the Baltimore MSA boundaries. All but one of those PUMAs fall entirely in Baltimore and are therefore wholly counted. The one that is left has 27.9% of its population living in the Baltimore MSA. This PUMA is included but the weight of each observation is lessened to 27.9% of its value because it is less likely for a household in this region to actually be in this MSA. However, we don't want to completely exclude this area because it can still be informative of market conditions in this area and more observations make for a more robust sample. Ideally, we could isolate the portion of this PUMA that is in Baltimore, but due to data constraints, we cannot.

Construction of the Affordability Curve

To compare rent to income, the income is put into monthly terms and we only use the portion that is allocated to rent. In keeping with the industry standard, we use 30% of income as the benchmark for income spent on rent.

Given the above adjustments, each household has an adjusted rent and an adjusted income. Both variables are sorted from least to greatest and their cumulative percentage of the total is calculated. The Affordability Curve is constructed by plotting the cumulative percentage of adjusted income on the horizontal axis and the cumulative percentage of adjusted rent on the vertical axis. The Combined Values Series comprises all the unique rent and income values.

$$a = Unique\ Adjusted\ Rent\ Observations$$

$$b = Unique\ Adjusted\ Income\ Observations$$

$$c = Deduplicated(a, b)$$

$$Combined\ Value\ Series = \ Combined\ _1 \leq \cdots \leq \ Combined\ _i \leq \ \ldots \leq \ Combined\ _c$$

Each value in this series represents an adjusted rent and/or adjusted income value. For example, if the lowest value in the Combined Values Series is an adjusted rent of \$100 and the highest value is an adjusted income of \$3,000, then $Combined\ _1$ would be \$100 and $Combined\ _c$ would be \$3,000.

We can use the Combined Value Series to calculate the cumulative number of households at each adjusted rent/adjusted income level.

$$HH\ Rent\ \ = Number\ of\ Households\ At\ Given\ Combined\ _i$$

$$HH\ Income\ \ = Number\ of\ Households\ At\ Given\ Combined\ _i$$

$$Adjusted\ Rent\ Series = \left(HH\ Rent\ _{Combined\ _1}, \ldots, HH\ Rent\ _{Combined\ _i}, \ldots,\ HH\ Rent\ _{Combined\ _c}\right)$$

$$Adjusted\ Income\ Series = \left(HH\ Income\ _{Combined\ _1}, \ldots, HH\ Income\ _{Combined\ _i}, \ldots,\ HH\ Income\ _{Combined\ _c}\right)$$

For the Rent Series, $HH\ Rent\ _{Combined\ _i}$ is the summation of all households that have an adjusted rent equal to $Combined\ _i$. Because part of the Combined Value Series comes from adjusted income observations, there will be some $Combined\ _i$ for which there are no adjusted rent values. In those cases, the $HH\ Rent\ _{Combined\ _i}$ is simply equal to zero. For example, if there is an adjusted income value for \$750 but there is not an adjusted rent value at this point, then the value for the Rent Series at $HH\ _{Combined\ _{750}}$ is zero. Similarly, the Income Series contains, at each point in the series, a summation of all households that have an adjusted income equal to $Combined\ _i$.

The cumulative adjusted rent percentile and cumulative adjusted income percentile metrics measure the sum of households at each level of $Combined\ _i$ divided by the total number of households. The result at any point of $Combined\ _i$ is therefore between 0% and 100%.

$$Cumulative\ Adjusted\ Rent\ Percentile\ _{Combined\ _i} = \sum_1^i HH\ Rent\ _{Combined\ _i} \Big/ \sum_1^c HH\ Rent$$

$$Cumulative\ Adjusted\ Income\ Percentile\ _{Combined\ _i} = \sum_1^i HH\ Income\ _{Combined\ _i} \Big/ \sum_1^c HH\ \ Rent$$

Each observation on the Affordability Curve is plotted as:

$$(Cumulative\ Adjusted\ Income\ Percentile_{Combined\ i},\ \ Cumulative\ Adjusted\ Rent\ Percentile_{Combined\ i})$$

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