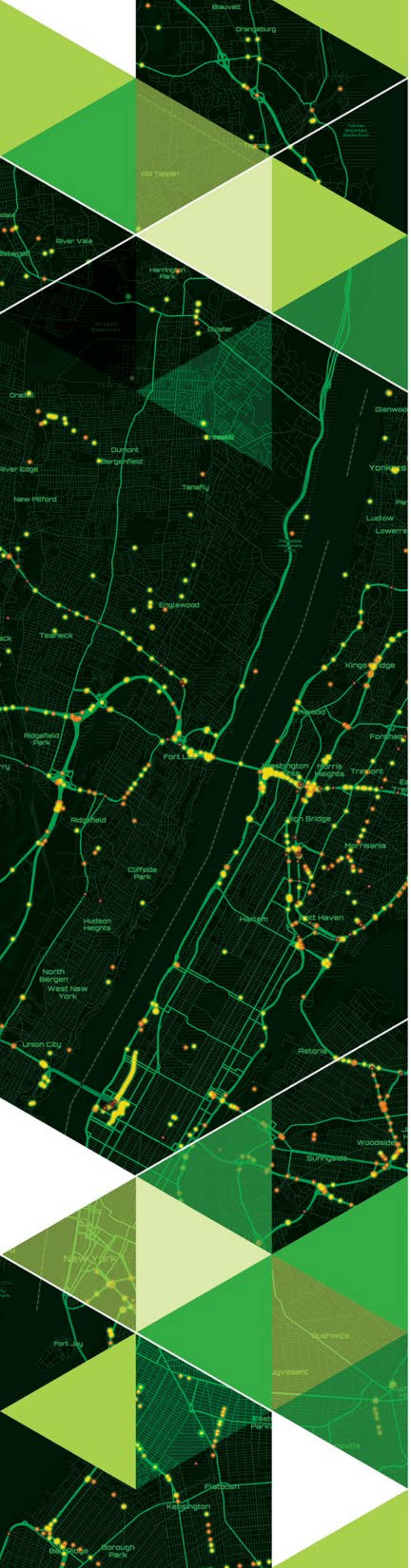

AN ESRI
TECHNICAL PAPER

JUNE 2024

Methodology statement: 2024/2029 income tiers and measures of income inequality

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Introduction

Household income survey data is commonly reported as an ordered categorical distribution, along with summary measures of median and average household income. These summary measures provide a description of an area's income profile but give limited information about the shape of the income distribution. The shape, or dispersion of this data, is what can be quantified to define levels or degrees of income inequality. Fundamentally, income inequality measures the disparity of incomes across households. To better characterize and compare income distributions, Esri has quantified lower, middle, and upper tiers of households by income and provided a full suite of income inequality measures. All metrics are built upon Esri Updated Demographics current and forecast year estimates of households by income.

Income tiers

Esri's approach to income tiers is an adaptation of Robert Solow's quintile approach to defining the middle-class population[1]. The Nobel Laureate economist Robert Solow defines the middle class as the middle 60 percent of earners. This definition has the additional benefit of being symmetric around the median. It follows that the top 20 percent can be considered upper class and the bottom 20 percent lower class. Hence, the size of the middle class can never change, but the range of incomes defining middle class can. Esri's methodology builds on this country-level definition to classify households into tiers of income for small-area analysis.

Esri's method measures the household income distribution. Therefore, this estimate is labeled the middle tier of income. Households not identified as middle income are classified into lower-tier and upper-tier categories. Evaluating the tails of the income distribution provides insight into income dispersion in an area (see the Income inequality measures section below). Evaluating the change in the size of the lower- and upper-income tiers over time is an expedient way to understand shifts in the middle-income population. Growth in the middle class will shift households from the lower or upper tiers, or both. Where the middle class is in decline, you can begin to answer policy questions such as "Are the rich getting richer?" or "Are the poor getting poorer?" Where local economies create job growth, and government policies to support low-income households are favorable, a shift of households up the income ladder is expected over time. In areas experiencing gentrification, shifts in incomes could erode the low- and middle-income tiers and expand the upper-income tier.

Esri's methods establish Census division-level quintile limits as criteria to define the range of household incomes considered middle income/tier. Employing division-level limits (versus U.S. limits) accounts for geographic variability in the cost of living. Therefore, households earning the same income in the more relatively expensive Pacific division versus the East South-Central division are not necessarily classified using the same thresholds. By way of Esri's household income estimates, these division-level criteria are updated annually. At the division level of geography and above, the size of the lower, middle, and highest tiers do not change over time. This database captures shifts in the size of each income tier for underlying smaller areas.

Esri has developed a methodology to estimate middle-tier households at any level of geography and is amenable to trending over time. Households by income tiers are first established at the Census block group level using Pareto interpolation to distribute households into each grouping. Estimates of income tiers for other geographic summary areas are aggregated from this foundational level. A nuance of this method is that the percent of households in the middle tier at the national level will not sum to exactly 60 percent. Estimates for user-defined polygons use established techniques for geometric retrieval. Criteria for the assignment of households to the lower, middle, and upper tiers for the 2024 estimates are listed in Table 1 below:

[1] Estache, Antonio and Danny Leipziger. eds. 2009. Stuck in the Middle: Is Fiscal Policy Failing the Middle Class? Washington, DC: Brookings Institution Press.

Division	Lower tier	Middle tier	Upper tier
New England	<$36,281	$36,281 - $185,152	>$185,152
Middle Atlantic	<$32,267	$32,267 - $173,511	>$173,511
East North Central	<$30,818	$30,818 - $142,953	>$142,953
West North Central	<$32,108	$32,108 - $144,092	>$144,092
South Atlantic	<$32,025	$32,025 - $153,749	>$153,749
East South Central	<$25,675	$25,675 - $126,001	>$126,001
West South Central	<$29,286	$29,286 - $146,126	>$146,126
Mountain	<$35,692	$35,692 - $155,374	>$155,374
Pacific	<$38,174	$38,174 - $191,474	>$191,474

Table 1: Household income ranges for definition of income tiers

Figure 1 shows an example of two sample areas X and Y with bottom- and top-heavy income distributions, respectively. Both show very different distributions across income tiers. With these extreme examples, it is obvious that area X has a dominant upper tier and area Y has a dominant middle tier.

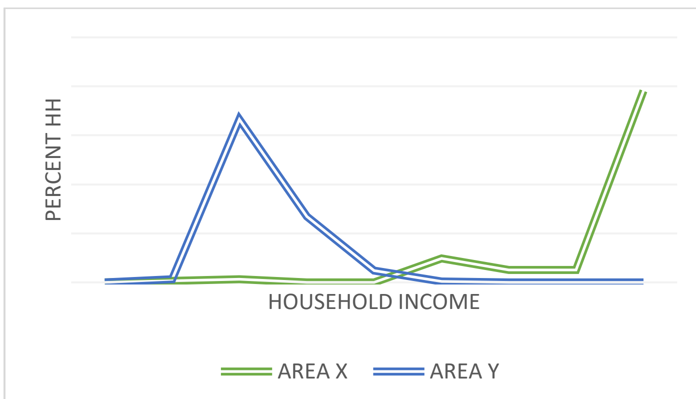


Figure 1: Households by income for areas X and Y.

Tier	Area X (% HHLDS)	Area Y (% HHLDS)
Lower	1.0	25.1
Middle	15.1	74.9
Upper	83.9	0.0

Table 2: Percent of households by income tier for areas X and Y.

In more concentrated income distributions, one income tier is dominant. When the income range in an area is broad or less concentrated in and around one income interval, quantifying the spread of incomes across tiers is more valuable for comparative analyses. The following examples show income distributions and tiers for the largest counties in the Northern Virginia area.

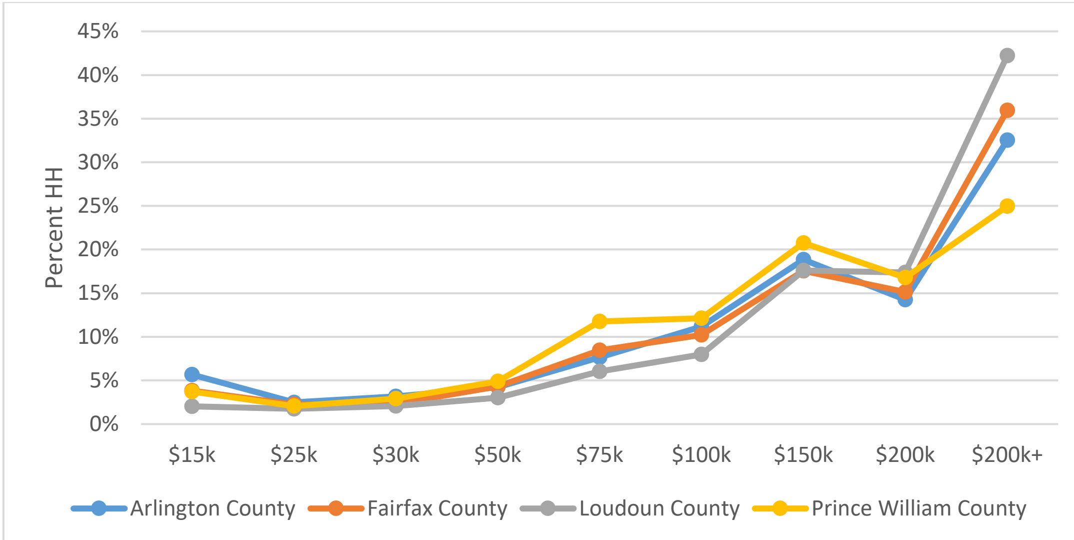
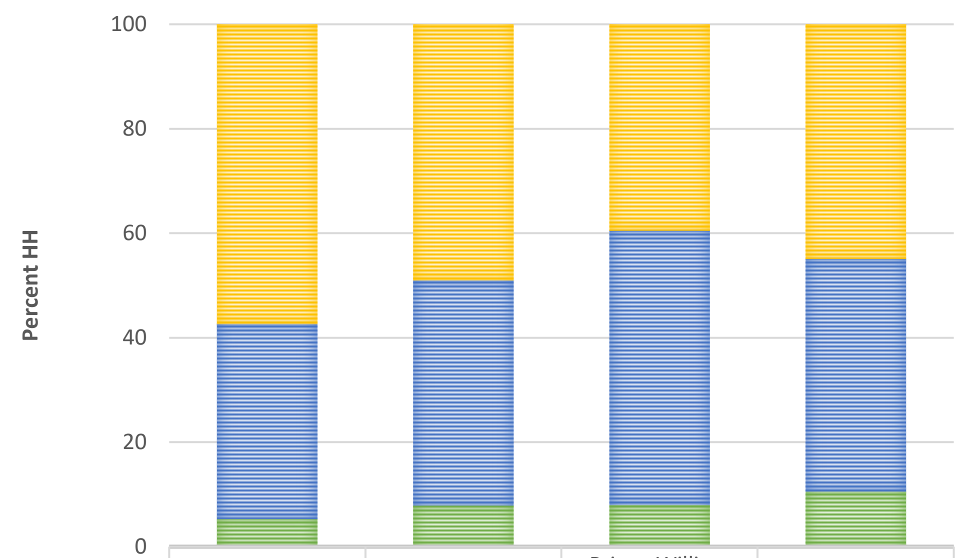


Figure 2: Households by income for select Virginia counties.



	Loudoun County	Fairfax County	Prince William County	Arlington County
UpTierPct	57	49	40	45
MidTierPct	37	43	53	45
LowTierPct	5	8	8	11

Figure 3: Income tiers for select Virginia counties.

Summarizing the households by income into three tiers puts the information in a simpler, more interpretable, and comparative format. Income distributions for these four counties exhibit the same general pattern, with higher income tiers representing the largest share in three of the four counties. The income tiers not only reveal sociodemographic groupings but are also comparative between areas. Prince William County has the largest portion of middle-tier households, while Loudoun County, a county with relatively newer development, is predominantly upper-tier households. Arlington County and Fairfax County show a relatively better balance between middle- and upper-tier households. Studying income inequality provides further insight, allowing the analyst to understand the dispersion of incomes across tiers by quantifying the income divide.

Income inequality measures

Evaluating the tails of an area's income distribution provides insight into the unevenness or spread of household incomes—or in other words, income inequality. Inequality measures are most often developed to study relative differences across countries. Esri applies the same principles to provide a full suite of inequality-focused metrics geographically available from the neighborhood level and broader to complement an analysis. All measures are designed to compare inequality across different markets regardless of size; they are scale independent.

- Gini Index
- Interdecile ratios
    - 90–10
    - 50–90
    - 50–10
- Share ratios
    - 80–20
    - 90–40 (Palma ratio)

Gini Index

The Gini Index is a measure of income dispersion. It is independent of income levels. Specifically, the calculation measures deviation from a hypothetical 45-degree line representing perfect equality where every household in an area earns the same income. In theory, the calculation is developed using the Lorenz curve shown below, which plots the cumulative share of income against the cumulative share of households. The computation of the Gini Index evaluates the area between the diagonal line representing equality and the Lorenz curve capturing the aggregate income distribution for the area being evaluated. Referring to figure 4 below, the Gini Index is the ratio of area A divided by the sum of areas A and B. The range of the Gini Index is 0 to 100, where 0 is perfect equality and 100 is complete inequality. Varying levels of the Gini Index are demonstrated graphically on the Lorenz curve in figure 5 below. Figure 6 displays the Lorenz curve and Gini Indices for the four Northern Virginia counties in our example.

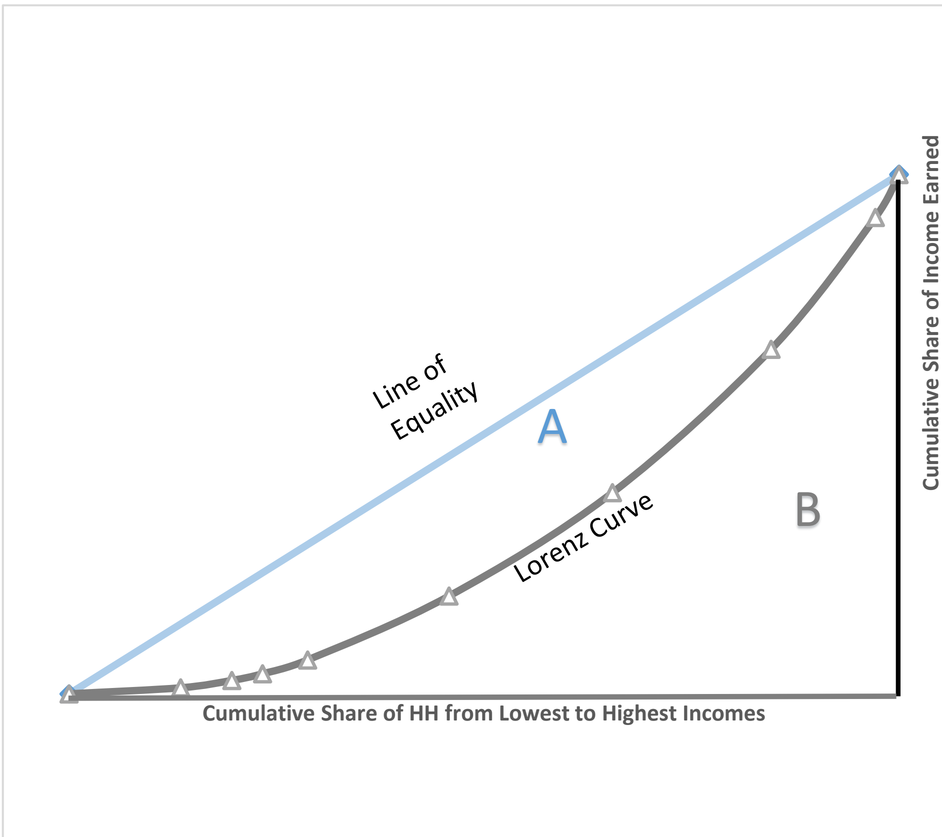


Figure 4: Gini Index calculation.

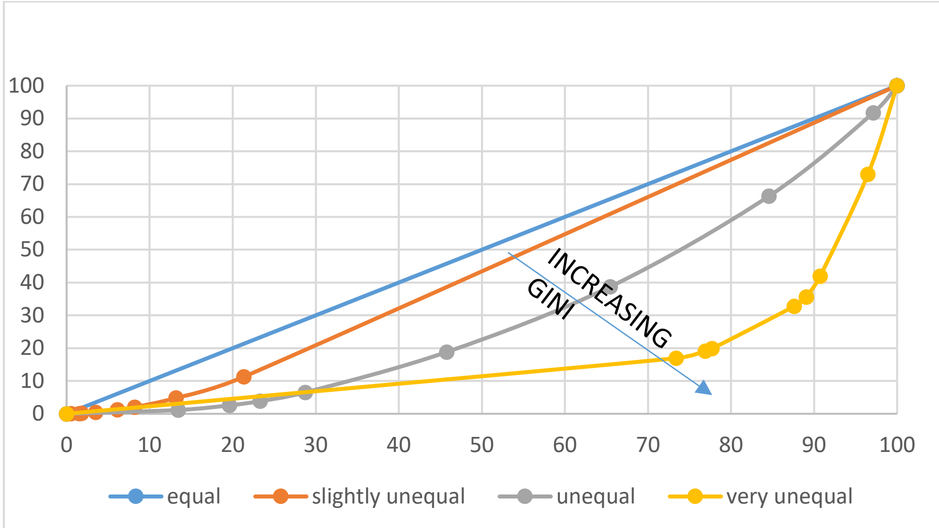


Figure 5: Lorenz curves for a range of Gini Indices.

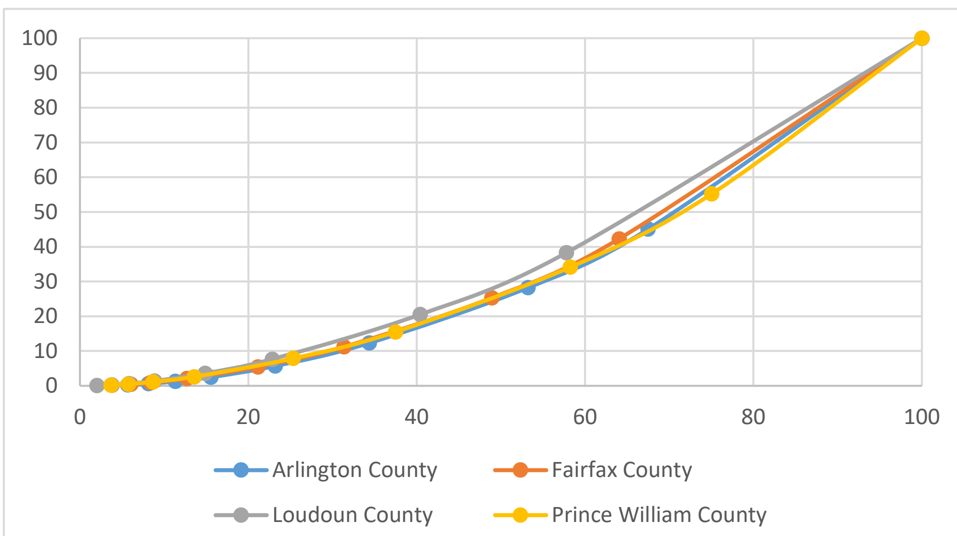


Figure 6: Lorenz curves for select Virginia counties.

Gini Index is one of the most frequently used measures to track income inequality; however, it does not indicate which part of the income distribution is contributing most to income inequality. Two areas can have the same Gini Index but differing income distributions. In the example of two areas X and Y, both areas have a Gini Index of approximately 10, but the underlying distributions are very different. The Northern Virginia counties show a little more variation in the Gini Index with Loudoun County showing the lowest inequality with a Gini Index of 25.2 and Fairfax County marginally more unequal with a Gini Index of 29.7. Arlington County and Prince William County exhibit similar inequality with Gini

Indices of 31.8 and 31.6, respectively. These patterns are clearly visible in the Lorenz curves for these counties. What we do learn is that areas with the most affluent populations are not necessarily the most unequal. The Gini Index measures deviation from equality in the aggregate; it does not capture differences in the shape of the income distribution. As a stand-alone statistic, the Gini Index has limited use; however, it is a stable measure that is amenable to time series analysis.

Interdecile ratios

Interdecile ratios highlight income inequalities of a distribution. These measures quantify the spread of incomes across households in any area and are derived from income limits by percentile. Esri provides three common ratios:

- P90-10 ratio–Dollars earned by the household at the 90th percentile to the dollars earned by the household at the 10th percentile
  - Compares the top 10 percent of the distribution to the bottom 10 percent
- P90-50 ratio–Dollars earned by the household at the 90th percentile to the dollars earned by the household at the 50th percentile
  - Compares the top 10 percent of the distribution to the median of the distribution
- P50-10 ratio–Dollars earned by the household at the 50th percentile to the dollars earned by the household at the 10th percentile
  - Compares the median to the bottom 10 percent of the distribution

The P90-10 ratio quantifies an area's equality gap, but it provides little information about the middle section of the income distribution. The P90-50 and P50-10 ratios provide more information; the P90-50 ratio summarizes inequality above the median, while the P50-10 ratio summarizes inequality below the median. The product of the P90-50 and P50-10 ratios is the P90-10 ratio.

At the foundation of this method is the computation of percentile limits for the underlying income distribution. Esri's measures rely on a categorical distribution: households by income intervals. Like our median estimation methods, a percentile limit is calculated from the income intervals of the distribution using Pareto interpolation unless the limit falls in the lowest (<$15,000) or highest (>$200,000) interval. For the lowest interval, linear interpolation is used. Figure 7 below demonstrates the relationship between percentile limits and households. The diagram displays the estimated U.S. quintile limits (the 20th, 40th, 60th, and 80th percentile limits). These dollar values divide total U.S. households into equal bins representing 20 percent of the population.

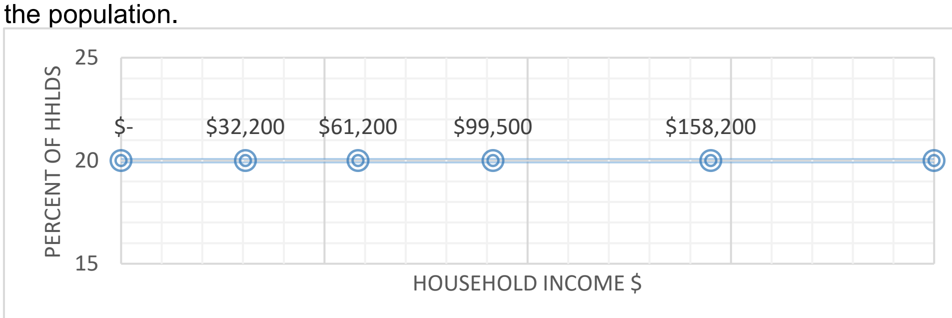


Figure 7: U.S. income scale and percentile limits.

The shape of the income distribution determines the scale, and the spread of quintiles is demonstrated in the quintile charts for area X and area Y shown in figures 8 and 9. Regardless of the dollar value of the quintile limits, the same number of households is in each of the five quintile groups. The concentration of household incomes in area Y is illustrated by the quintile limits falling within a very small range.

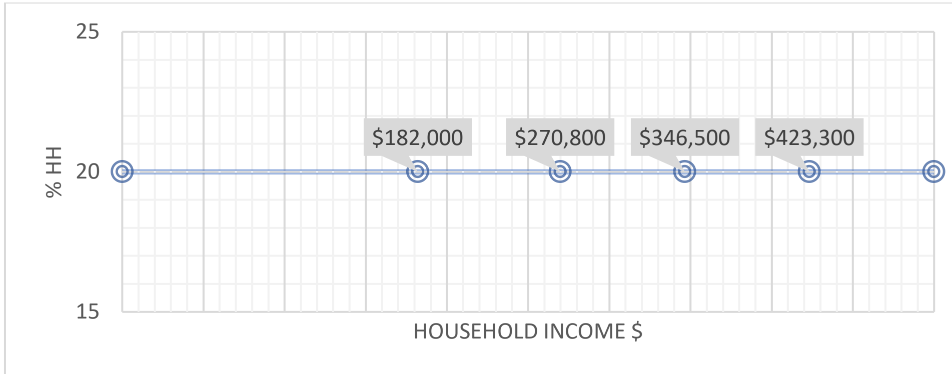


Figure 8: Income scale and percentile limits for area X.

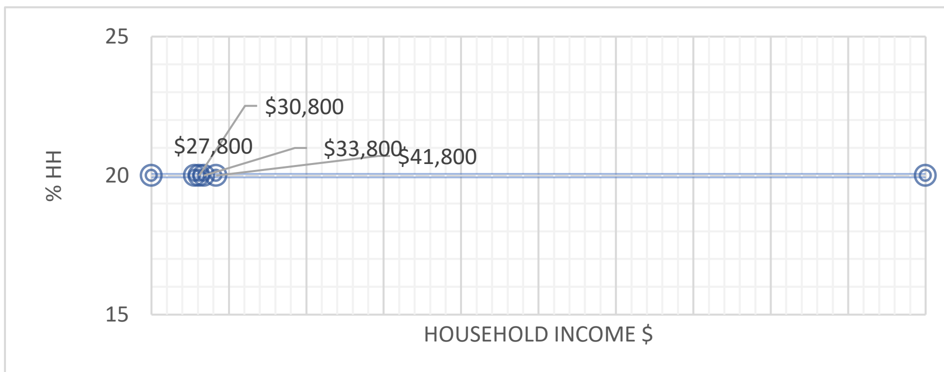


Figure 9: Income scale and percentile limits for area Y.

Though both areas have similar Gini Index values, interdecile ratios (Table 3) shed more light on the shape of the distribution. Interdecile ratios capture the relationship between percentile limits into one comparative metric. The P90-10 ratio for area X exceeds that of area Y by more than a factor of 2.5, indicating that there is a wider range household incomes in area X than in area Y. Area X is more unequal than area Y, as indicated by the P90-10 ratio. Breaking this down into the P90-50 and P50-10 ratios confirms that the difference in inequality for these two areas is driven by inequality below the median. This shows that area X has a larger gap or spread between incomes of households earning the median compared to the households earning at the 10th percentile of the distribution. Inequality above the median is the same between the two.

Measure	Area X	Area Y
P90-10 ratio	4.8	1.8
P90-50 ratio	1.5	1.5
P50-10 ratio	3.2	1.2

Table 3: Interdecile ratios for areas X and Y.

Revisiting the Northern Virginia counties example, the P90-10 ratio provides more interpretable metrics for inequality. As indicated by the Gini Index, Loudoun County is also the least unequal by this measure. This is driven by the relative concentration of income in the upper tier, resulting in a smaller range between income of households earning at the 90th percentile limit and those earning at the 10th percentile. The concentration in income in the upper tier is reflected in the lowest P90-50 ratio—in other words, inequality above the median is low. Interdecile ratios determine that Arlington County is more unequal than Prince William County (where the Gini Index did not show a difference) with a 1.9 percent point difference in the P90-10 ratio. All these counties show a sizeable difference in inequality above and below the median, as indicated by the P90-50 ratios being about half of the P50-10 ratios.

Measure	Loudoun County	Fairfax County	Prince William County	Arlington County
P90-10 ratio	4.6	6.1	6.0	7.9
P90-50 ratio	1.4	1.6	1.9	1.7
P50-10 ratio	3.2	3.8	3.3	4.6

Table 4: Interdecile ratios for select Virginia counties.

Share ratios

Interdecile ratios are positional measures while share ratios also reflect aggregate income earned by the highest earners relative to the lowest earners. Two share measures are developed by Esri:

S80-20 share ratio—Total income of households earning at or above the 80th percentile limit to the total income of households earning at or below the 20th percentile limit. Definitionally, this statistic is the ratio of the income earned by the upper tier to income earned by the lower tier, in other words, a comparison of incomes earned by households not in the middle tier.

S90-40 share ratio—Total income of households earning at or above the 90th percentile limit to the total income of households earning at or below the 40th percentile limit. This ratio is commonly referred to as the Palma ratio, proposed by Alex Cobham and Andy Sumner following the work of Gabriel Palma[2]. His research concluded that, across countries in the study, 50 percent of households (between the 40th and 90th percentile) earned 50 percent of national income. The stability of this middle income share over time, and the relative instability of the lowest 40 percent and uppermost 10 percent of earners is the foundation of this inequality measure.

To derive both measures, Esri applies Pareto interpolation techniques to distribute aggregate income using subinterval midpoints to above and below the defined limit of income.

Share ratios can describe a much different picture of income dispersion. Whereas interdecile ratios are strictly positional, share ratios accommodate both aggregate (embedded in the Gini Index calculation) and positional criteria. The S80-20 share ratio is a symmetric measure that exaggerates income inequality compared to the S90-40 share ratio. This is demonstrated by the share ratios for area X, which has a top-heavy distribution and reflects higher values in the S80-20 share than the S90-40 share. The S80-20 share ratio widens the gap between areas X and Y, while the difference in the S90-40 share ratio is significantly muted.

Measure	Area X	Area Y
S80-20 ratio	12.6	1.7
S90-40 ratio	3.3	0.6

Table 5: Share ratios for areas X and Y.

Again, referring to the Northern Virginia counties, the 80-20 and 90-40 share ratios describe a different picture of inequality, ranking Prince William County as the least unequal over Loudoun County. Share ratios are much more sensitive to differences in the uppermost income category, as is the case in these two counties. This is best explained by the change in aggregate income when one

[2] Cobham, Alex and Sumner, Andy, Is It All About the Tails? The Palma Measure of Income Inequality (September 16, 2013). Center for Global Development Working Paper No. 343, Available at SSRN: https://ssrn.com/abstract=2366974 or http://dx.doi.org/10.2139/ssrn.2366974

household moves into an area. The presence of one additional household earning $200,000 adds 10 times the income versus the addition of a household earning $20,000. This multiple is built directly into share ratios.

Measure	Loudoun County	Fairfax County	Prince William County	Arlington County
S80-20 ratio	10.0	12.9	9.2	14.1
S90-40 ratio	3.6	4.1	2.9	4.3

Table 6: Share ratios for select Virginia counties.

Limitations of the data

Esri follows the U.S. Census Bureau's practice of top-coding median household income. When the median falls in the upper interval, it is reported as $200,001 because households in the upper interval are top coded to $200,000. This will add a negative bias to all income inequality measures computed for areas with any households earning $200,000 or more. To reduce this bias in the computation of inequality statistics, Esri's methods apply Pareto interpolation to households in this income group assuming an upper limit of $500,000. Error is also introduced because Esri's methods must rely on ordinal data (ordered and grouped households by income).

To understand bias in the data, it is useful to examine income inequality measures in reported national survey data. Below are U.S. level income inequality statistics compared against American Community Survey (ACS) and Current Population Survey (CPS) figures. The ACS only provides the Gini Index measure; other metrics are calculated internally by Esri based on a nine-interval income distribution comparable to Esri's distribution. Esri employs ACS estimates as a base for household income estimates; this is therefore the best source to compare Esri measures to. This also means that ACS estimates are subject to the same top-coding limitations as Esri income inequality measures.

Income inequality measures reported directly from the CPS are also presented here. ACS and CPS survey methodology, including the household income definition, are significantly different and will impact comparability of these sources. It is worth reviewing CPS income inequality metrics because they are not subject to the same top-coding restrictions. Note that all Esri and internally calculated ACS ratios run lower than the CPS, further proving the negative bias that is assumed in Esri computed metrics. (The exception is of course the 50-10 ratio, which is not impacted by top-coding at the national level.) Caution must therefore be used when comparing metrics across sources.

Measure	2022 ACS[3]	2022 CPS	Esri 2024 US
Gini	41.8[4]	48.8	41.0
P90-10 ratio	12.5	12.6	12.5
P90-50 ratio	2.7	2.9	2.6
P50-10 ratio	4.6	4.4	4.7
S80-20 ratio	11.3	17.4	12.0
S90-40 ratio	2.9	n/a[5]	3.0

Table 7: National income inequality measures for ACS, CPS, and Esri

All survey data is subject to sampling and nonsampling errors, and derived metrics have inherent limitations even with the benefit of detailed income data. Esri income metrics are subject to top coding and categorical data bias, but with an understanding of these assumptions, when used together, the inequality metrics provide users with a more holistic portrait of income disparities.

[3] All ratio calculations follow Esri's practice of disaggregating households and their aggregate income into percentile bins at the block group level. Ratio computation is based on aggregated BG data.

[4] Esri internal calculation based on ACS one-year collapsed nine-interval distribution. Reported ACS 2022 Gini Index is 0.486.

[5] Not published by CPS.

Esri's Data Development team

Led by chief demographer Kyle Cassal, and economist Douglas Skuta, Esri's Data Development team uses sophisticated quantitative methods to produce small area demographic and socioeconomic data to support informed decision-making. The team builds on a rich history of market intelligence to produce trusted independent estimates and forecasts for the United States based on innovative methodologies that use public and private data sources with the power of ArcGIS. Esri's Data Development team provides more than 7,000 proprietary data items to better understand the characteristics of people and places across multiple statistical and administrative boundaries and custom trade areas.

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