Introducing the
"More Accurate Consumer Price Index"

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Abstract

Particularly since the 1990s, federal statistical agencies have worked to improve the ability of various price indexes to measure changes in the cost of living. However, in recent years, some have sent mixed signals to researchers about the relative merits of different measures. As a result, academic and policy researchers routinely use theoretically and empirically inferior price indexes in their analyses of real income changes.

Moreover, a cumulative body of research has identified and estimated the magnitude of a number of biases that affect all of today's widely used price indexes. These biases remain due to data inadequacy, methodological uncertainty, bureaucratic inertia, and political considerations. Nevertheless, there is little dispute about the direction of the overall bias in these indexes, and considerable consensus as to the magnitudes of the individual biases. It is very likely that all the most commonly used price indexes overstate the rise in the cost of living by a substantively important amount.

This paper summarizes the evidence on these biases and translates it into a new "More Accurate Consumer Price Index" (MACPI). It provides annual index values from 1973 to 2023 and illustrates the importance of bias correction by showing a number of long-term trends in wages, earnings, income, and wealth. While the most widely cited inflation measure, the Consumer Price Index for All Urban Consumers (CPI-U) suggests that the average hourly wage of production and nonsupervisory workers rose by 2 percent from 1973 to 2023, and the superior Personal Consumption Expenditures price index (PCEPI) indicates a rise of 30 percent, using the MACPI, wages rose by 61.5 percent. The median wage of prime-age male workers fell by 15 percent using the CPI-U and rose by 9 percent using the PCEPI, but it rose by 35 percent using the MACPI. Other comparisons are similarly striking.

1. Introduction

A dollar today buys less than a dollar in the past. Incomes and spending tend to rise over time, but because prices also tend to rise, the "real" increase in these amounts is smaller than the "nominal" increase. Therefore, if we want to assess how fast the economy is growing, how much median earnings are rising, or any number of other questions related to change over time, we need to adjust nominal amounts for inflation.

Since the 1990s, the federal statistical agencies that produce price indexes intended to apply to consumer purchases have targeted the changing price of maintaining constant utility from the consumption of goods and services available for purchase at market prices. This approach is in contrast to earlier efforts to measure the changing price of a set of goods and services purchased in fixed relative quantities. The modern approach accounts for the ability of consumers to substitute—to change what they buy and where they buy things as some goods and services at some places become more or less expensive than other goods and services at other places.

For short-term questions—assessing month-to-month changes in inflation, for instance—the best of our contemporary price indexes usually suffice. The monthly workhorse Consumer Price Index for All Urban Consumers (CPI-U) is produced quickly by the Bureau of Labor Statistics (BLS) and is available for over 200 product categories in over 30 geographic areas. It has been improved regularly over more than a century. It also feeds into the Personal Consumption Expenditures price index (PCEPI), produced monthly by the Bureau of Economic Analysis (BEA) and similarly available at lower levels of geographic aggregation.

However, research involving longer periods—say, looking at 50-year trends in real wages—involves significant challenges. For one, even our best contemporary measures overstate inflation, and over time that bias accumulates in ways that matter substantively. Second, in the past we measured price changes less well than we do today.

Over the years, a small number of specialized academic and government economists have studied the strengths and weaknesses of how federal statistical agencies have measured price changes. The various studies have been synthesized in occasional efforts to assess the magnitude of individual and overall biases in price indexes. Most prominent was the Advisory Commission

to Study the Consumer Price Index, appointed by the Senate Finance Committee in June 1995 and commonly referred to as the "Boskin Commission," after its chair, Michael Boskin.[1] Building on the Boskin Commission's 1996 report and subsequent research, Federal Reserve Board economists David E. Lebow and Jeremy B. Rudd summarized the extent of CPI-U bias in a 2003 paper.[2] Most recently, Brent R. Moulton, a senior researcher at BLS and BEA for decades, updated the Lebow and Rudd analyses in a 2018 paper for the Brookings Institution.[3]

This research has resulted in fundamental changes to the technical methodologies by which existing price indexes are computed, improved data collection, better accounting for quality improvement, and the development of new and superior indexes. Some of these alternative indexes carry methodological improvements further back in time for research involving trends. Others improve on the workhorse indexes retrospectively and prospectively, with the intent of measuring aggregate change better, at the expense of timeliness and the ability to disaggregate across geographic areas or product categories.

For the past 40 years, federal statistical agencies have led the way in developing price indexes and adopting improved ones. However, in the past two decades, BLS and the Census Bureau have been slower to promote and use the most accurate price indexes. Researchers have followed their lead, and the result has been a body of academic and policy studies that overstate the rise in the cost of living and correspondingly understate increases in wages, earnings, income, and wealth. Moreover, data inadequacy, methodological uncertainty, bureaucratic inertia, and political considerations have prevented federal agencies from reducing known biases remaining even in the best contemporary indexes, extending such improvement back to earlier years, or extending the improvements already implemented in the best indexes further back in time.

This paper surveys the research conducted on bias in the leading price indexes developed and used by federal statistical agencies (primarily the CPI-U). It then applies this research toward the

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[1] Advisory Commission to Study the Consumer Price Index, "Toward a More Accurate Measure of the Cost of Living," Final Report to the Senate Finance Committee, December 4, 1996, https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB97197164.xhtml.

[2] David E. Lebow and Jeremy B. Rudd, "Measurement Error in the Consumer Price Index: Where Do We Stand?" *Journal of Economic Literature* 41, no. 1 (2003): 159-201, https://www.aeaweb.org/articles?id=10.1257/002205103321544729.

[3] Brent R. Moulton, "The Measurement of Output, Prices, and Productivity: What's Changed Since the Boskin Commission?" Brookings Institution, July 2018, https://www.brookings.edu/wp-content/uploads/2018/07/Moulton-report-v2.pdf.

end of creating an improved price index that more accurately measures the long-term change in the cost of living.[4]

I build the case for this "More Accurate Consumer Price Index" (MACPI) in two ways. Section 2 provides an overview of the most important consumer price indexes and describes various biases affecting them over different time periods. I include estimates from the research literature of the magnitudes of these biases. In Section 3, I summarize which indexes are used by a variety of federal agencies (including the most relevant statistical agencies) and document statements endorsing or recommending some indexes over others. Both the research on price index bias and the pattern of agency adoption of price indexes informed by it suggest the need for an index that more fully captures what we know about bias in price measurement. Section 4 describes the construction of the MACPI. I provide applications in Section 5, presenting several long-term trends in hourly wages, annual earnings, income, and wealth. Section 6 concludes.

2. Consumer Price Indexes and their Biases

A brief look at the history and development of the most important consumer price indexes over the years offers a useful way of summarizing the biases that have afflicted indexes in the past and, in some cases, continue to do so.

The CPI-U

The first BLS-created consumer price index eventually became known as the "Consumer Price Index for Urban Wage Earners and Clerical Workers," or "CPI-W." In 1978, BLS introduced the

[4] I draw inspiration from the research on poverty trends of Bruce Meyer, James Sullivan, and their colleagues over the years. Meyer and Sullivan introduced their own price index based on the R-CPI-URS (an index described below) in a 2011 working paper for the American Enterprise Institute and a published 2012 paper and have used it in a variety of papers since. See Bruce D. Meyer and James X. Sullivan, "The Material Well-Being of the Poor and the Middle Class Since 1980," AEI Working Paper #2011-04, American Enterprise Institute, October 25, 2011, https://www.aei.org/wp-content/uploads/2011/10/Material-Well-Being-Poor-Middle-Class.pdf?x85095; Bruce D. Meyer and James X. Sullivan, "Winning the War: Poverty from the Great Society to the Great Recession," *Brookings Papers on Economic Activity*, Fall 2012, 133-200, https://www.brookings.edu/articles/winning-the-war-poverty-from-the-great-society-to-the-great-recession/.
See also Salim Furth's similarly motivated analysis based on a "bias-adjusted PCE" index. Salim Furth, "Measuring Inflation Accurately," Heritage Foundation Backgrounder No. 3213, Heritage Foundation, July 23, 2017, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3653230.
Note that the discussion in the current paper does not address related issues of geography- or group-specific cost-of-living indexes, instead focusing on building a better aggregate index.

CPI-U, which covered a broader subset of Americans than did the CPI-W.[5] The published CPI-U values prior to 1978 essentially change at the same rate as the CPI-W did.[6]

The CPI-U is computed in two stages. In the first, outlets (where people buy products) are sampled probabilistically, along with products within them. The resulting sample of products, outlets, and geographic areas reflect national patterns. Product price changes are tracked monthly. Price indexes for product categories within geographic areas are created by weighting individual product price changes within the category and geographic area in accord with their importance. In the second stage, these product category indexes are combined into aggregate indexes—the national CPI-U but also geographic-area indexes that span product categories and product category indexes that span geographies. (Shelter services are treated somewhat differently by BLS, and most of the discussion of CPI methods that follows focuses on goods and services other than shelter.)

Since 1978, the CPI-U has gradually improved. Five enhancements are especially worth noting.

Treatment of Homeowner Costs. The first improvement, introduced in 1983, was a modification of the way that changes in homeowners' costs were calculated.[7] Up to that time, BLS's price estimates for owner-occupied housing incorporated data on home prices and mortgage interest rates. However, the home price data was confined to purchases involving mortgages insured by the Federal Housing Administration. Even more problematic, mortgage interest rates were based on long-term fixed-rate mortgages, which became relatively less popular over time. Moreover, under the earlier methods, changing prices reflected not just the cost of consuming the shelter services provided by housing but, to some ambiguous extent, the cost of investing in the asset that homes represent (including the opportunity cost of alternative

[5] Darren Rippy, "The First Hundred Years of the Consumer Price Index: A Methodological and Political History," *Monthly Labor Review*, April 2014, https://www.bls.gov/opub/mlr/2014/article/the-first-hundred-years-of-the-consumer-price-index.htm.

[6] The actual published values change at slightly different rates because the two measures were later indexed so that their 1982-1984 monthly average equaled 100, and the earlier values were rounded to the nearest tenth. Since the two indexes increased at different rates from December 1977 to 1982-84, the rebased December 1977 values were different for the two, and given the rounding of the rebased values, the pre-1978 changes were also slightly different. (Communication with Steve Reed, Economist, Bureau of Labor Statistics, October 2, 2024.)

[7] See Bureau of Labor Statistics, "CPI Detailed Report, January 1980," March 1980, p. 148, https://fraser.stlouisfed.org/files/docs/publications/cpidr/1980s/cpi_011980.pdf. See also, Robert Gillingham and Walter Lane, "Changing the Treatment of Shelter Costs for Homeowners in the CPI," *Monthly Labor Review*, June 1982, https://www.bls.gov/opub/mlr/1982/06/art2full.pdf.

investments). The resulting price index not only departed from the core goal of tracking the price of *consumption*, it was unduly volatile, reflecting interest rate fluctuations.

The 1983 improvement to the CPI-U was carried back to 1967 in the "CPI-U-X1" index, one of five experimental indexes BLS had been testing featuring alternative treatments of homeownership costs.[8] While the CPI-U increases 7.33 percent per year from 1967 to 1982, the CPI-U-X1 increases by only 6.67 percent, a difference of 0.66 points per year.[9]

Elimination of Formula Bias. The second improvement to the CPI-U involved the elimination, over the course of 1995 and 1996, of what was known as "formula bias," or "functional form bias."[10] This problem arose from the introduction in 1978 of probability sampling of outlets and products to build the indexes for broader product categories. Specific products in specific retail outlets were sampled for five years, then replaced, with one-fifth of the outlet sample rotated out every year. This created a problem that went unrecognized for years, caused by the need to impute base-period prices in the CPI-U.

The CPI-U, at the time, compared *spending* on products in the most recent month with *spending* on products in the previous month. It multiplied prices in both months by the quantities consumed during an earlier reference (or base) period. It then summed these quantity-weighted prices within a product category and geographic area, and finally compared the month-to-month change. The price changes of products, then, were effectively weighted by their quantity share during the base period. However, in the base period, only expenditures were observed, not quantities (or prices for that matter). To estimate base-period quantities, BLS imputed base-period prices and divided base-period expenditures by these prices.

This price imputation assumed that the price of a newly introduced product had changed since the base period proportionally in line with the price of other products within the same broader category and geographic area. But if a newly sampled product happened to be temporarily on

[8] The index values are given in Council of Economic Advisers, *Economic Report of the President* (Washington, DC: United States Government Printing Office, February 2010), Appendix B, Table B-62, https://obamawhitehouse.archives.gov/sites/default/files/microsites/economic-report-president-appendix-b.pdf.
[9] CPI-U estimates are from https://www.bls.gov/cpi/data.htm (accessed 10/26/24); CPI-U-X1 estimates are from Council of Economic Advisers, *Economic Report of the President*.
[10] See Brent R. Moulton, "Bias in the Consumer Price Index: What Is the Evidence?" Bureau of Labor Statistics, Office of Prices and Living Conditions, Working Paper 294, October 1996, https://www.bls.gov/osmr/research-papers/1996/pdf/ec960170.pdf.

sale, this imputation understated the base-period price (in effect, assuming the product was always on sale) and thereby overstated the base-period quantity (weight) of the product. If the product was no longer on sale the next month, the price increase would be weighted too heavily (and the price decline of any product that went on sale that month would be weighted too lightly). Thus, the combination of the sample rotation and the base-period price imputation created an upward bias in the CPI-U that wasn't present in the pre-1978 CPI-W.

The Boskin Commission estimated that formula bias caused annual CPI-U growth to be overstated by 0.24 percentage points per year between 1979 and 1995.[11] For reference, the CPI-U grew at an annual rate of 4.74 percent over this period (and by 3.61 percent from 1983 to 1995, after the change in the treatment of housing costs).

Near Elimination of Lower-Level Substitution Bias. The third major enhancement to the CPI-U was the relatively complete incorporation of "lower-level substitution" into the index construction methods beginning in 1999. Prior to 1999, the CPI-U tracked the monthly prices of products within broader categories and geographic areas, holding the base-period product weights constant to build the product category indexes.

This method assumed that no substitution between products within a category was possible when relative prices changed each month. In reality, however, consumers can mitigate the impact on their wellbeing of increases in the prices of specific products. When, for instance, the price of gala apples increases, consumers have options beyond buying fewer of them at the same cost or spending more money on the same number of them. They can spend less money on gala apples and increase their spending on other apples. This is known as lower-level substitution. Consumers who substitute purchases when prices change are worse off than before—just not as much as if they didn't have the option. The same points hold when thinking about outlet substitution—consumers can switch between outlets if the price of something they want to buy goes on sale somewhere.

After 1998, the aggregation of the price changes within a broader product category and geography was done in such a way as to acknowledge substitution in most of the product categories. The monthly price changes of products are now aggregated holding the relative

[11] Advisory Commission to Study the Consumer Price Index, "Toward a More Accurate Measure of the Cost of Living."

weights constant at base-period *spending* shares instead of quantity shares. When a product's price increases, people are assumed to buy less of it relative to other products.[12]

The Boskin Commission estimated lower-level substitution bias to be 0.25 percentage points per year as of 1996, prior to the 1999 methodological change. Another study, comparing the CPI-U to a version resembling its pre-1995 methods, found a difference of 0.28 points per year over five years, with 0.18 points due to lower-level substitution bias.[13] Lebow and Rudd concluded that by 2003 only 0.05 points of lower-level substitution bias remained, reflecting the methodological improvements that had been implemented in 1999.[14] Moulton retained this estimate as of 2017.[15] For comparison, the 1983-to-1998 annual change in the CPI-U was 3.34 percent, and the change from 1999 to 2017 was 2.17 percent.[16]

However, there is a problem with these bias estimates. They are based on a comparison of the CPI-U to a version that addresses lower-level substitution bias but does so in a way that creates a new kind of upward bias. This new bias is called small-sample bias and is discussed further below. The point for now is that estimating lower-level substitution bias the way that the Boskin Commission did, understates its magnitude. And the Lebow and Rudd estimate of 0.05 points per year as of 2003 is actually just a residual constituting small-sample bias after assuming that BLS changes in 1999 eliminated lower-level substitution bias. The true amount of lower-level

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[12] See Kenneth V. Dalton, John S. Greenlees, and Kenneth J. Stewart, "Incorporating a Geometric Mean Formula into the CPI," *Monthly Labor Review*, October 1998, https://www.bls.gov/opub/mlr/1998/10/art1full.pdf. For the formulas involved in the two different approaches, see the Laspeyres and geometric mean formulas in Bureau of Labor Statistics, "Consumer Price Index," in *Handbook of Methods*, "Calculation" section, "Price relatives" subsection, https://www.bls.gov/opub/hom/cpi/home.htm.

[13] David S. Johnson, Stephen B. Reed, and Kenneth J. Stewart, "Price Measurement in the United States: A Decade after the Boskin Report," *Monthly Labor Review*, May 2006, https://www.bls.gov/opub/mlr/2006/05/art2full.pdf. That was similar to an analysis over an earlier 6-year period in the 1990s comparing the same two measures. See Bureau of Labor Statistics, "The Experimental CPI Using Geometric Means," in *CPI Detailed Report, Data for March 1997*, May 1997. See also Brent R. Moulton and Kenneth J. Stewart, "An Overview of Experimental U.S. Consumer Price Indexes," *Journal of Business & Economic Statistics* 17, no. 2 (1999): 141-151, https://www.jstor.org/stable/1392469.

[14] Lebow and Rudd, "Measurement Error in the Consumer Price Index: Where Do We Stand?"

[15] Moulton, "The Measurement of Output, Prices, and Productivity: What's Changed Since the Boskin Commission?"

[16] It is worth noting that at least one study has estimated that lower-level substitution bias remains a bigger problem than any of these estimates suggests. It finds that the PCEPI (discussed below) is upwardly biased on the order of 0.6 or 0.7 points per year, with most of that due to lower-level substitution bias. See Jessie Handbury, Tsutomu Watanabe, and David E. Weinstein, "How Much Do Official Price Indexes Tell Us About Inflation?" Working Paper, 2017, http://www.jessiehandbury.com/papers/HWW_currentpublic.pdf.

substitution bias prior to 1999 was likely to be greater than the 0.18 to 0.25 points per year found in the studies before 2003.

Reduced Quality Change Bias. A fourth improvement to the CPI-U has entailed accounting for products' improved quality over time through a series of product-specific approaches over the years. These changes have likely reduced upward bias modestly in the CPI-U by addressing "quality change" bias.

Quality change bias occurs because as products improve over time and come to replace older, lower-quality versions, they are only incorporated into price indexes once they become more popular with consumers than the older version. Moreover, except for a very small number of products for which explicitly-quality-adjusted prices are tracked, a new version of an item is treated as essentially providing the same utility as the older version.

Because it was unobserved in the previous month, the new version of an item is generally assumed to have increased in price similarly to related products. But if it is better than the old version, the one-time improvement in material well-being from switching from the obsolete version to the new one is missed. BLS applies quality adjustment here only in the sense that it does not simply compare the price of the new version to the previous month's price of the old version.

Note that at the time the new version of a product is introduced to the sample, the estimated price change for that month may be biased upward or downward depending on how well the imputation reflects the true (unobserved) past-month price change of the new version. But even if the imputation perfectly captures the true price change, the new version is likely to be better than the old version, and it is this one-time utility gain from the better version of the product becoming visible while the older version disappears that is missed.

Of course, quality can deteriorate over time as well, a point to which we will return. But most analysts who have attempted to quantify quality change bias have concluded that any understatement of the increase in the cost of living caused by quality declines is swamped by overstatement caused by quality improvement. By attempting to adjust a relatively small number of specific products for improved quality, BLS has made today's CPI-U somewhat less biased than it was in the past, but most analysts believe that a substantial amount of upward bias

remains. Before turning to estimates of the magnitude of this bias, it is worth describing the final major improvement to the CPI-U and the two biases—related to quality change bias—it addresses.

Reduced New Goods and New Outlet Bias. That final notable improvement to the CPI-U involves the increased frequency with which new outlets and new products are incorporated. As noted above, in the past, BLS created indexes for categories of products in specific geographic areas by updating one-fifth of the sample of outlets (and the products within them) every year. This delay and staggering meant that new goods and new outlets were incorporated only gradually, with products' base-period quantity weights updated slowly and incompletely. Starting in 2002, one-fourth of the sample of outlets (and the products priced within them) was rotated out every year, rather than one-fifth of the sample.[17] This change has reduced the magnitude of "new goods bias" and "new outlet bias."

New goods bias is closely related to quality change bias. When a fundamentally new product comes on the market, it takes some time for it to be added to the sample of products for which prices are tracked. It must be purchased at an outlet that has been newly sampled and be sufficiently popular with consumers that it gets sampled within that outlet. Once it enters the sample, it will not be fully represented for several years, after the other older samples have been rotated out.

By the time a new product is popular enough with consumers to be included in pricing, the price often has already come down significantly. The first mobile phone, the Motorola DynaTAC 8000x, introduced in 1984, cost about $4,000.[18] It wasn't until 1998 that the CPI-U included cell phones, and by that time one could purchase a Nokia 6110 for under $1,000 (and for $200 if combined with the purchase of a cell service plan).[19] The price of cell phones had already

[17] Daniel E. Sichel and Christopher Mackie, eds., *Modernizing the Consumer Price Index for the 21st Century* (Washington DC: National Academies Press, 2022). See also Bureau of Labor Statistics, "Consumer Price Index," in Handbook of Methods, "History" section, https://www.bls.gov/opub/hom/cpi/home.htm.
A sixth CPI-U enhancement in 2002 is also significant but has ambiguous implications for bias. Before that year, the base-period weights of product categories (for combination into the overall CPI-U) were updated only about once a decade, causing the CPI-U to fail to keep up with consumption patterns. Since then, the weights have been updated more frequently—every two years beginning in 2002, and annually since 2023.
[18] See https://www.mobilephonemuseum.com/phone-detail/dynatac-8000x.
[19] Jerry Hausman, "Cellular Telephone, New Products, and the CPI," *Journal of Business and Economic Statistics* 17, no. 2 (1999): 188-194, https://economics.mit.edu/sites/default/files/2022-09/Cellular%20Telephone%2C%20New%20Products%20and%20the%20CPI.pdf. Dennis Peng, "Cell Phone Cost

massively declined by the time the CPI-U acknowledged their existence, reflecting an improvement in material well-being completely missed in the data. By increasing the frequency with which it updates consumer expenditure patterns, BLS has reduced the amount of time that a new product is invisible. However, it still must be sufficiently popular with consumers before it enters into the sample of products that get priced.

New outlet bias involves a similar issue. It takes time for new outlets to make it into the sample that informs the CPI-U. When they do enter, they often sell products at lower prices than incumbent outlets, which is why market share has shifted to them. Amazon.com is perhaps the most illustrative example over the past 25 years, with Walmart a prominent example dating further back.

Just as the introduction of a new good to the sample of products that get priced involves the neglect of the increased utility it brings, so too does the CPI-U miss the increased utility from lower prices at a new outlet. Rather than recognizing that the lower price at a new outlet is for the same product, holding quality constant, the CPI-U methods effectively assume that the product in question is a different, lower quality one that has seen price changes similar to related observed products.

Because new goods bias and quality change bias are so closely related, analysts tend to estimate the bias that they create together. The Boskin Commission put the annual bias at 0.60 percentage points per year as of 1996. Robert Gordon, who was a member of the commission, later suggested 0.43 was more appropriate, due to subsequent research indicating that the CPI indexes for shelter and apparel were *downwardly* biased.[20] By 2003, the Lebow and Rudd study estimated that new goods and quality change biases caused the CPI-U to overstate inflation by 0.37 points per year (in part reflecting improvements to the index since 1996), and Moulton retained that estimate in 2017.[21]

Comparison Timeline," Ooma Home Phone Blog, September 16, 2019, https://www.ooma.com/blog/home-phone/cell-phone-cost-comparison/.

[20] Robert J. Gordon, "The Boskin Commission Report: A Retrospective One Decade Later," *International Productivity Monitor*, No. 12 (Spring 2006), https://www.csls.ca/ipm/12/IPM-12-Gordon-e.pdf. That estimate was closer to another 1996 estimate from outside the Commission (0.45). See Matthew D. Shapiro and David W. Wilcox, "Mismeasurement in the Consumer Price Index: An Evaluation," *NBER Macroeconomics Annual* 11 (1996): 93-142.

[21] Using a different approach than these papers, Mark Bils has estimated quality change bias to be significantly higher: around 2 points per year. See Mark Bils, "Do Higher Prices for New Goods Reflect Quality Growth or

The Boskin Commission estimated new outlet bias at 0.10 points per year, while Lebow and Rudd estimated it to be 0.05 points. Moulton put new outlet bias at 0.08 points per year.

The R-CPI-U-RS

In 1999, BLS created a new index, the "CPI-U-RS," later renamed the "R-CPI-U-RS," to try and carry back most of the 1978-to-1999 improvements in the CPI-U all the way to 1978.[22] (Of note, most of these revisions are simulated or modeled rather than recalculated, since the necessary data is unavailable in earlier years.) This "Consumer Price Index for All Urban Consumers Retroactive Series" continues to be updated and extended. When improvements to the CPI-U are made that can be retroactively estimated for earlier years, the R-CPI-U-RS is revised accordingly (while the earlier CPI-U values never change).[23]

From 1978 to 2023, the CPI-U increased at a rate of 3.49 percent per year, while the R-CPI-U-RS rose by 3.30 percent, a difference of 0.19 points per year.[24] From 1978 to 1998, however, the difference is 0.46 points per year, reflecting the deficiencies of the earlier CPI-U. That is a bit lower than Moulton's estimates of the non-substitution and non-small-sample sources of bias in the CPI-U (0.55 points per year). From 1999 to 2023, the annual difference is just 0.03 points per year, reflecting retroactive improvements to the R-CPI-U-RS.

The R-CPI-U-RS retains the same new outlet, quality change, and new goods biases present in today's CPI-U, and it suffers from the small-sample bias that Lebow and Rudd (and Moulton) characterize as lower-level substitution bias (discussed below). It also retains another important bias, "upper-level substitution bias," which brings us to the newest member of the CPI family.

Inflation?" *Quarterly Journal of Economics* 124, no. 2 (2009): 637-675; Mark Bils and Peter J. Klenow, "Quantifying Quality Growth," *American Economic Review* 91, no. 4 (2001): 1006-1030.
In contrast, another paper cited reasons to think quality change bias was negligible and reasons to think it was biased upward by more than the Boskin Commission concluded. See Charles R. Hulten, "Quality Change in the CPI," *Federal Reserve Bank of St. Louis Review* 79, no. 3 (1997): 87-100. I find Robert Gordon's rejoinders to this paper compelling. See Robert J. Gordon, "Commentary," *Federal Reserve Bank of St. Louis Review* 79, no. 3 (1997): 101-105. For Hulten's response, see Charles R. Hulten, "Hulten's Reply to Gordon," *Federal Reserve Bank of St. Louis Review* 79, no. 3 (1997): 105-106, https://fraser.stlouisfed.org/files/docs/publications/frbslreview/rev_stls_1997_v79_no3.pdf?utm_source=direct_download.

[22] Kenneth J. Stewart and Stephen B. Reed, "Consumer Price Index Research Series Using Current Methods, 1978-98," *Monthly Labor Review*, June 1999, https://www.bls.gov/opub/mlr/1999/06/cpimlr.pdf.

[23] For an updated list of improvements, see https://www.bls.gov/cpi/research-series/r-cpi-u-rs-changes.htm.

[24] R-CPI-U-RS values are from https://www.bls.gov/cpi/research-series/r-cpi-u-rs-home.htm, accessed 10/26/24.

The C-CPI-U

The C-CPI-U, or "chained CPI," is available from 2000 to the present.[25] It is the best BLS-produced consumer price index we currently have, in the sense that it most closely approximates the ideal cost-of-living index. It improves on the CPI-U and CPI-U-RS in two ways: it incorporates upper-level substitution, and it fixes small-sample bias.[26]

Elimination of Upper-Level Substitution and Small-Sample Bias. As discussed above, consumers can switch between different products within product categories when their relative prices change, mitigating the extent to which rising prices reduce their material well-being. In the same way that they can exercise such lower-level substitution, consumers can also, through upper-level substitution, switch between products in different categories. They can buy fewer apples and more oranges, for instance. The C-CPI-U is the only BLS index that incorporates such substitution.

Small-sample bias causes the CPI-U to be overstated because of the way that the price indexes for product categories are computed, which involves taking geometric means of product price changes within a category. (This is the methodological approach that addresses lower-level substitution bias.) When sample sizes are smaller, the geometric mean is biased upward relative to what it would be if the population of interest (in this case price changes) could be observed. In the case of the C-CPI-U, the aggregation of product category indexes into an overall index also involves taking a geometric mean. Not only does that address upper-level substitution bias, it effectively increases the sample size of product price changes to the point where the small-sample bias is negligible. Small-sample bias only affects the CPI-U from 1999 forward because that was the year that it began using geometric means to address lower-level substitution. But the R-CPI-U-RS carries that bias back to 1978.

[25] Robert Cage, John Greenlees, and Patrick Jackman, "Introducing the Chained Consumer Price Index," paper presented at the Seventh Meeting of the International Working Group on Price Indices, Paris, France, May 2003, https://www.bls.gov/cpi/additional-resources/chained-cpi-introduction.pdf.

[26] Jeffrey Kling, "Using the Chained CPI to Index Social Security, Other Federal Programs, and the Tax Code for Inflation," testimony before the Subcommittee on Social Security, Committee on Ways and Means, U.S. House of Representatives, April 18, 2013, https://www.cbo.gov/sites/default/files/113th-congress-2013-2014/reports/04-18-ChainedCPI-One-Column.pdf.

From 2000 to 2023, the CPI-U increased at an annual rate of 2.51 percent, while the C-CPI-U rose 2.25 percent per year—a difference of 0.27 points per year.[27] Estimates of earlier upper-level substitution bias include the Boskin Commission's 0.15 points per year for 1988 to 1995, Lebow and Rudd's 0.30, Johnson, Reed, and Stewart's 0.30, Shapiro and Wilcox's 0.20-0.30, and Moulton's 0.25 (an explicit adjustment downward of the Lebow and Rudd estimate due to new evidence).[28]

The latter is in line with the observed gap between the C-CPI-U and CPI-U. However, the difference between these two indexes (which was the basis for the Lebow and Rudd; Johnson, Reed, and Stewart; and Moulton estimates) reflects not just upper-level substitution bias but small-sample bias.

A paper by Ralph Bradley estimated that 62 percent of the difference between the two indexes between 1998 and 2003 was due to small-sample bias.[29] If the annual difference from 2000 to 2023 reflected that division, then annual bias due to small-sample bias would be 0.17 points per year and upper-level substitution bias would be just 0.10 points. This conclusion is consistent with an earlier study by Bradley that argued that previous estimates of upper-level substitution bias ranging from 0.2 to 0.3 should actually be more like 0.1 to 0.2 due to small-sample bias.[30]

The smaller Boskin Commission estimate for upper-level substitution bias of 0.15 in 1996 is also consistent with the Bradley research in that small-sample bias does not affect the CPI-U before 1999. Shapiro and Wilcox, looking at the same BLS evidence as the Boskin Commission, put the estimate of upper-level substitution bias at 0.2 around 1996 in their paper from that year. In a subsequent paper, they updated this to 0.30 for the period between December 1986 and

[27] C-CPI-U values are from https://fred.stlouisfed.org/series/SUUR0000SA0#0, accessed 10/26/24.
[28] The Johnson, Reed, and Stewart estimate discards 1999-to-2000 as an outlier and uses the difference between the C-CPI-U and the CPI-U from 2001 to 2004. A 2002 table published by the Bureau of Labor Statistics indicated that the increase in a C-CPI-U-like measure from December 1989 to December 1997 was lower than the increase in the CPI-U by 0.27 points per year. See https://web.archive.org/web/20030606213413/http:/stats.bls.gov/cpi/superchart2.htm.
[29] Ralph Bradley, "Analytical Bias Reduction for Small Samples in the U.S. Consumer Price Index," *Journal of Business & Economic Statistics* 25(3): 337-346, 2007, https://www.tandfonline.com/doi/abs/10.1198/073500106000000639.
[30] Ralph Bradley, "Finite Sample Effects in the Estimation of Substitution Bias in the Consumer Price Index," *Journal of Official Statistics* 17(3): 369-390, 2001, https://www.proquest.com/docview/1266842048?sourcetype=Scholarly%20Journals.

December 1995 but suggested that 0.20 was more likely in future years.[31] Finally, an earlier study by Marilyn Manser and Richard McDonald estimated upper-level substitution bias to be 0.11 points per year from 1972 to 1985.[32]

Despite its superiority over the CPI-U, the C-CPI-U suffers from the same new goods, quality change, and new outlet biases. Most importantly, it is unavailable before 2000.

The PCEPI

The other major price index for consumer purchases is the PCEPI, produced by BEA. It is built from price indexes of product categories that are largely based on CPI-U product category indexes. (Some category indexes are based on the Producer Price Index (PPI), which tracks the prices of what domestic producers sell rather than the prices of what domestic consumers pay.) The PCEPI product category indexes are aggregated to obtain the overall PCEPI.

In 1996, BEA began doing so using geometric means as a way to account for upper-level substitution, and it revised the PCEPI for earlier years accordingly. That is, like the C-CPI-U, the PCEPI is a "chained" index, meaning that it aggregates the product category indexes by taking the geometric mean of price changes obtained from using the initial product category weights and the updated weights, where weights reflect product category expenditures in each year. Therefore, upper-level substitution bias is minimal for the entire PCEPI series from 1929 to the present (and small-sample bias is not an issue).

However, because of its reliance on CPI-U product category indexes, the PCEPI is subject to other biases affecting the product category indexes. The PCEPI does incorporate the improvements reflected in the R-CPI-U-RS. Thus, while it is subject to new goods, quality change, and new outlet biases, from 1978 forward the PCEPI is free of both lower-level substitution bias and formula bias. It also extends backward to 1978 various other improvements to the CPI-U made over the years. For years prior to 1978, lower-level substitution bias remains

[31] See Matthew D. Shapiro and David W. Wilcox, "Alternative Strategies for Aggregating Prices in the CPI," *Federal Reserve Bank of St. Louis Review* 79, no. 3 (1997): 113-127, https://fraser.stlouisfed.org/files/docs/publications/frbslreview/rev_stls_1997_v79_no3.pdf?utm_source=direct_download.

[32] The study compared the (existing) pre-chained PCEPI to a chained version (not yet used by BEA). See Marilyn E. Manser and Richard J. McDonald, "An Analysis of Substitution Bias in Measuring Inflation, 1959-85," *Econometrica* 56, no. 4 (1988): 909-930, Table III, https://www.jstor.org/stable/1912704.

unchecked, but the PCEPI avoids the problematic treatment of homeownership costs used by the CPI-U.

BEA sometimes implements its own quality adjustments when it feels they are needed (extending them back to earlier years as well).[33] Moulton concluded that new goods and quality change bias in the PCEPI amounted to only 0.34 percentage points per year (versus 0.37 in the CPI-U), but mainly due to its use of PPI-based category indexes.

However, it is difficult to translate estimates of CPI-U bias to the PCEPI. The PCEPI differs from the CPI indexes in a variety of ways, three of which are most important.[34] Its use of geometric means to deal with upper-level substitution bias distinguishes it from the CPI-U and R-CPI-U-RS (and the specific calculation it uses differs, insubstantially, from that used in the C-CPI-U). Second, it is expanded in scope relative to the CPI indexes in that it includes spending on behalf of consumers by employers and government (such as for health insurance) and non-profit organizations, and it includes spending by rural consumers. Finally, it uses different data to weight the product category indexes, relying on surveys of what domestic businesses sell while the CPI indexes use surveys of domestic consumers indicating what they buy.[35]

Scope and weighting differences, on net, cause the PCEPI to grow more slowly relative to the C-CPI-U.[36] That means simply transferring, say, an estimate of new goods and quality change bias

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[33] Bureau of Economic Analysis, *Concepts and Methods of the U.S. National Income and Product Accounts*, Chapters 4 and 5, https://www.bea.gov/resources/methodologies/nipa-handbook/pdf/all-chapters.pdf.

[34] Clinton P. McCully, Brian C. Moyer, and Kenneth J. Stewart, "Comparing the Consumer Price Index and the Personal Consumption Expenditures Price Index," *Survey of Current Business*, November 2007, https://apps.bea.gov/scb/pdf/2007/11%20November/1107_cpipce.pdf.

[35] Lebow and Rudd concluded that the weights in the PCEPI are more accurate, suggesting that the CPI indexes are afflicted by "weighting bias" that overstates inflation by about 0.1 percentage points per year. I do not treat this difference as indicating the CPI indexes are biased, as the question of which set of weights are more accurate seems unsettled to me. Moreover, my choice is an appropriately conservative decision given that the biggest difference in the PCEPI and CPI-U weights is the greater importance of housing in the CPI-U. As already noted, Gordon has concluded that the CPI index for rent is actually biased downward due to quality change. If true, down-weighting housing in the CPI-U to remove its 0.1-point "upward weighting bias" would also reduce downward quality change bias by making a downwardly biased part of the index smaller. That would then require increasing the estimate of upward bias in the re-weighted CPI-U due to quality change. See Robert J. Gordon and Todd vanGoethem, "Downward Bias in the Most Important CPI Component: The Case of Rental Shelter, 1914-2003," in Ernst R. Berndt and Charles R. Hulten, eds., *Hard-to-Measure Goods and Services: Essays in Honor of Zvi Griliches* (Chicago: University of Chicago Press, 2007).

[36] McCully, Brian C. Moyer, and Kenneth J. Stewart, "Comparing the Consumer Price Index and the Personal Consumption Expenditures Price Index"; David S. Johnson, "Comparison of Movements in the CPI and PCE Price Indexes," paper presented at the Federal Economic Statistics Advisory Committee Meeting at the Bureau of Labor Statistics in Washington, DC, March 21, 2003; Dennis Fixler and Ted Jaditz, "An Examination of the Difference Between the CPI and the PCE Deflator," Bureau of Labor Statistics Working Paper no. 361, June 2002,

of 0.34 points per year from the CPI-U to the PCEPI is unwarranted. PCEPI bias should be estimated directly from examination of the PCEPI. Moreover, the overall magnitude of new goods and quality change bias depends on the weights put on specific product category indexes that include products adjusted for such bias.

From 2000 to 2023, the PCEPI increased at an annual rate of 2.15 percentage points per year, compared with 2.25 for the C-CPI-U. (For comparison, the CPI-U increased 2.51 points.) Because the PCEPI extends further back in time than the C-CPI-U, it is the most useful and accurate consumer price index for most applications. However, without direct estimates of PCEPI bias, it is difficult to use the PCEPI to create a bias-adjusted price index.

Summary of Biases

Table 1 summarizes the various sources of bias discussed above and how they affect each of the major indexes in the CPI family. (Parentheses indicate the years for which the estimates were made or to which they apply.) For lower-level substitution bias, I start with 0.20 points per year, which is less than the 0.215 average of the Boskin Commission and Johnson, Reed, and Stewart estimates. I assume that this figure reflects the net result of estimating substitution bias in such a way as to introduce small-sample bias. To back into a more accurate estimate, I first estimate small-sample bias. I put that at 0.10, based (imprecisely) on the Boskin Commission estimate of upper-level substitution bias being that much smaller than the Lebow and Rudd estimate of upper-level substitution bias (which also reflects small-sample bias). Then I add that 0.10 to my 0.20 initial estimate of lower-level substitution bias, for a final estimate of 0.30. I then assume that the 1999 changes to the CPI-U eliminated true lower-level substitution bias.

For upper-level substitution bias, the C-CPI-U estimates cited above have been reduced by 0.04, consistent with Lebow and Rudd, citing John Greenlees, who argued that the way these types of indexes account for substitution bias ends up biasing estimated price changes downward slightly.[37] The CPI-U and R-CPI-U-RS estimates use the 0.15 estimate from the Boskin

https://www.bls.gov/osmr/research-papers/2002/pdf/ec020100.pdf. These studies cover the years 1992 to 2007. For earlier years, see Jack E. Triplett, "Reconciling the CPI and the PCE Deflator," *Monthly Labor Review* (September 1981): 3–15.

[37] John S. Greenlees, "Random Errors and Superlative Indexes," BLS Working Paper 343, Office of Prices and Living Conditions, Bureau of Labor Statistics, March 2001, https://www.bls.gov/osmr/research-papers/2001/pdf/ec010110.pdf.

Commission, which is higher than implied by Bradley and by Manser and McDonald but lower than implied by Shapiro and Wilcox. It's also consistent with Moulton's estimate of 0.25 reduced by the 0.10 I assume for small-sample bias.

The available evidence suggests that the contemporary CPI-U and R-CPI-U-RS overstate inflation by around 0.70 percentage points per year, while the chained indexes are upwardly biased by roughly 0.40 points per year. The CPI-U's upward bias increases as one goes back in time, approaching 2 points per year around 1980. The pre-1978 CPI-U, however, may be less biased than the immediate post-1978 index, since it does not suffer from formula bias.

Table 1. Sources of Bias in Consumer Price Indexes and Estimated Annual Magnitudes

Source	**CPI-U (1913-present)**	**R-CPI-U-RS (1978-present)**	**C-CPI-U (2000-present)**
Lower-level substitution	0.00 (2003, 2017), 0.30 (1996)	0.00	0.00
Upper-level substitution	0.15	0.15	-0.04
Small-sample bias	0.10 (2003, 2017), 0.00 (1996)	0.10	0.00
Quality change & new goods	0.37 (2003, 2017), 0.43 (1996)	0.37	0.37
New outlet bias	0.08 (2017), 0.05 (2003), 0.10 (1996)	0.08	0.08
Formula bias	0.00 (1996-present), 0.24 (1978-95), 0.00 before 1978	0.00	0.00
Homeowner costs	0.00 (1983-present), 0.66 (1967-82)	0.00	0.00
Total	**0.70 (present), 0.98 (1996), 1.88 (1979), 1.64 (1977?)**	**0.70**	**0.41**

Source: Studies reviewed in this section.

3. Federal Statistical Agencies' Use and Endorsement of Consumer Price Indexes

Over the years, as price indexes have been improved and newer ones created, it has perhaps been unclear to many users of data which indexes are clearly superior for research purposes. In part, this reflects an understandable reticence on the part of government statisticians and administrators of statistical agencies to wade into a debate with the potential for politicization. To a significant extent, the ambiguity reflects interagency siloing and, in at least one important respect, the constraint of political rules.

BLS and BEA Statements Regarding Indexes

The formal statements of BLS on the relative merits of its various price indexes have been laden with all the cautious ambiguity that might be expected of a public bureaucracy. The official BLS statement on the CPI-U-X1 was issued in July 1989, which "recommend[ed] the use of the CPI-U-X1 to those who need to use a CPI series that treats homeowner costs consistently over time."[38] While that left things somewhat open-ended for users who desired an index that was *inconsistent* over time in its treatment of homeowner costs, BLS did call the newer CPI-U with the revised treatment of homeownership costs "a superior measure" to the pre-1983 version.

The agency's March 2000 statement on the R-CPI-U-RS (then called the CPI-U-RS) noted that, "The Bureau of Labor Statistics has made numerous improvements to the Consumer Price Index (CPI) over the past quarter century. While these improvements make the present and future CPI more accurate, historical price index series are not adjusted to reflect the improvements."[39] Again avoiding an outright endorsement, the statement observed that, "the CPI-U-RS can serve as a valuable proxy for researchers needing a historical estimate of inflation using current (1999) methods. The direct adjustment of individual CPI index series makes this the most detailed and systematic estimate available of a consistent CPI series."

[38] See US Bureau of the Census, "Money Income and Poverty Status in the United States: 1988 (Advanced Data From the March 1989 Current Population Survey)," Current Population Reports, Series P-60, No. 166, 1989, Appendix E, https://www2.census.gov/library/publications/1989/demographics/p60-166.pdf.
[39] Randy E. Ilg and Steven E. Haugen, "Earnings and Employment Trends in the 1990s," *Monthly Labor Review*, March 2000, p. 22, https://www.bls.gov/opub/mlr/2000/03/art2full.pdf.

BLS maintains a "frequently asked questions" website about the C-CPI-U, which explains that the index "is designed to be a closer approximation to a cost-of-living index than other CPI measures."[40] It hedges as to the superiority of the index, disclaiming agnostically that, "As different users have different needs, BLS cannot say which index is necessarily better than another" before continuing with the telling statement that, "As such, BLS takes no position on what the Congress or the Administration should use to make adjustments to Social Security or any other federal program." Pegging annual increases in Social Security benefits to the C-CPI-U would reduce the growth of those benefits—a politically unpopular consequence of what might follow from an outright BLS endorsement of the index.

In contrast, BEA has embraced the methodological improvements it has made to the PCEPI, in particular the 1996 change to address upper-level substitution bias. A 2003 article in BLS's Survey of Current Business emphasized that,

> BEA's introduction of chain-weighted indexes in 1996 significantly improved the accuracy of the U.S. estimates of the growth in real gross domestic product (GDP) and prices. These indexes use up-to-date weights in order to provide a more accurate picture of the economy, to better capture changes in spending patterns and in prices, and to eliminate the bias present in fixed-weighted indexes. A measure of their success is the widespread adoption of such indexes in economic measurement in other U.S. economic statistics and the near-universal movement by other industrial nations toward the use of such indexes for computing real GDP.[41]

In 2019, the White House Office of Management and Budget (OMB) convened an Interagency Technical Working Group on Consumer Inflation Measures (ITWG) to advise the agency as to the merits of the different consumer price indexes produced by the federal government. The working group was co-chaired by BLS and included federal staff from seven agencies. The ITWG noted that, "The C-CPI-U is considered a more accurate measure of the change in the cost of living since it is based on current consumer

[40] Bureau of Labor Statistics, "Frequently Asked Questions about the Chained Consumer Price Index for All Urban Consumers (C-CPI-U)," March 14, 2024, https://www.bls.gov/cpi/additional-resources/chained-cpi-questions-and-answers.htm.
[41] J. Steven Landefeld, Brent R. Moulton, and Cindy M. Vojtech, "Chained-Dollar Indexes: Issues, Tips on their Use, and Upcoming Changes," *Survey of Current Business*, November 2003, https://apps.bea.gov/scb/pdf/2003/11November/1103%20Chain-dollar.pdf.

behavior and is free of the substitution bias that arises in the other measures from the assumption of unchanged consumer behavior." Later, it reiterated that, "A formula measuring price change based on the current behavior of consumers is superior to one based on consumer behavior from several years ago." And its report concluded the C-CPI-U "is preferred over the CPI-U in general based on formula and mitigation of substitution bias."[42]

Finally, the report included "proposed guidance" for use of price index alternatives in different applications, providing a flowchart and illustrating it for the "use case example" of examining trends in median household income. The flowchart yields the recommendation to use the C-CPI-U from 2000 to the present, the PCEPI from 1959 to 2000, and the CPI-U prior to 1959.[43]

Census Bureau Use of Indexes

For analyses of income trends and for most other non-political purposes, federal agencies have tended to adopt the PCEPI or the versions of the CPI that improve on the CPI-U and that extend enhancements to it back in time. The Census Bureau began incorporating estimates using the CPI-U-X1 in its analyses of income trends soon after the BLS released its statement on the CPI-U-X1. A 1991 report noted, "Technical staff at the Census Bureau think that the CPI-U-X1 experimental index is technically superior to the CPI-U during the 1967 to 1982 period for use as a deflator of income statistics."[44] Beginning in 1992, the Census Bureau used the CPI-U-X1 exclusively in its reports on long-term income trends, citing "a consensus among economists consulted."[45] Starting in 2001, the Census Bureau switched to using the R-CPI-U-RS for

[42] Interagency Technical Working Group, "Report to the Office of Management and Budget; Consumer Inflation Measures," June 16, 2021, https://www.bls.gov/evaluation/technical-recommendations-for-the-consumer-inflation-measure-best-suited-for-conducting-annual-adjustments-to-the-official-poverty-measure.pdf, p. 19, 29, 34.
[43] The suggestion to use the CPI-U prior to 1959 seems misguided, however. The PCEPI is available on a monthly basis back to 1959, but it is available on an annual basis back to 1929.
[44] US Bureau of the Census, "Money Income of Households, Families, and Persons in the United States: 1990," Current Population Reports, Series P-60, No. 174, 1991, p. 10, https://www2.census.gov/library/publications/1991/demographics/p60-174.pdf.
[45] US Bureau of the Census, "Measuring the Effect of Benefits and Taxes on Income and Poverty: 1979 to 1991," Current Population Reports, Series P-60, No. 182-RD, 1992, p. x, https://www2.census.gov/library/publications/1992/demographics/p60-182-rd.pdf. See also US Bureau of the Census, "Money Income of Households, Families, and Persons in the United States: 1991," Current Population Reports, Series P-60, No. 180, 1992, p. ix, https://www2.census.gov/library/publications/1992/demographics/p60-180.pdf.

presenting income trends, linking it to the CPI-U-X1 from 1967 to 1978 (and the CPI-U for years prior to 1967).[46] It began presenting results based on C-CPI-U in its annual income report in 2020.[47]

In 2023, following the guidance of the ITWG, and after a period soliciting feedback from experts and the general public, the Census Bureau switched to exclusively using the C-CPI-U for price changes from 2000 forward and the R-CPI-U-RS for earlier price changes (linked to the CPI-U-X1 and CPI-U further back in time).[48] It had also been considering a series that linked the C-CPI-U to the PCEPI.[49] This choice would have been more consistent with the Census Bureau's recognition of the C-CPI-U's superiority in accomodating upper-level substitution, a featured shared with the PCEPI. As the Bureau's request for public comments noted,

> Despite the improvements made to the CPI-U and incorporated into the R-CPI-U-RS, both of these measures have weights that are based on a base period of consumer expenditures that are a few years old, and therefore both measures risk overstating increases in the cost of living. Inflation measures that use weights contemporaneous to the months involved in the calculation better account for consumer substitution and are known as "chained" measures. Examples include the C-CPI-U produced by BLS and the PCEPI produced by BEA.[50]

The request also acknowledged that "By relying solely on chained indices," the option of linking the C-CPI-U to the PCEPI "may best align with [the ITWG's] principles." Nevertheless, it

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[46] Carmen DeNavas-Walt, Robert W. Cleveland, and Marc I. Roemer, "Money Income in the United States: 2000," Current Population Reports P-60, No. 213, September 2001, footnote 1, https://www2.census.gov/library/publications/2001/demographics/p60-213.pdf.

[47] Jessica Semega, Melissa Kollar, Emily A. Shrider, and John F. Creamer, "Income and Poverty in the United States: 2019," Current Population Reports P-60, No. 270 (RV), September 2020 (Revised September 2021), Appendix C, https://www.census.gov/content/dam/Census/library/publications/2020/demo/p60-270.pdf.

[48] Gloria Guzman and Melissa Kollar, "Income in the United States: 2022," Current Population Reports P-60, No. 279, September 2023, p. 1, https://www.census.gov/content/dam/Census/library/publications/2023/demo/p60-279.pdf. See https://www.census.gov/topics/income-poverty/income/guidance/alternative-inflation.html.

[49] US Bureau of the Census, "Summary of Comments Submitted to Census Bureau's Federal Register Notice Regarding Alternative Inflation Measures for Adjusting Historical Income Estimates," May 6, 2022, https://www2.census.gov/programs-surveys/demo/guidance/income-poverty/record-layouts/data-extracts/Inflation_frn_response.pdf.

[50] See https://www.federalregister.gov/documents/2022/09/01/2022-18938/request-for-comment-on-inflation-measures-for-adjusting-historical-income.

declined to adopt use of the PCEPI, primarily citing its different scope relative to the CPI family of indexes.

If we take seriously the Census Bureau's concern that the PCEPI's scope should resemble that of the CPI-U, then linking the C-CPI-U to a PCEPI with a CPI-like scope would show even slower price growth before 2000 than would linking the C-CPI-U to the published PCEPI. (In contrast, linking the C-CPI-U to a PCEPI with CPI-like weighting would show faster price growth before 2000. The net effect of scope and weighting effects is to make the PCEPI grow only somewhat more slowly than the C-CPI-U.)

The decision not to link the C-CPI-U to the PCEPI also ignored the fact that the PCEPI and C-CPI-U estimates of price change are much more similar to each other than to the R-CPI-U-RS estimates over the same years.

There is one other way the Census Bureau's use of price indexes has failed to keep up with the state of knowledge about their biases. The Bureau has continued using the CPI-U throughout these past decades to update poverty thresholds for inflation. While government uses of official poverty estimates are governed by a longstanding directive from OMB dictating use of the CPI-U, that does not preclude the Census Bureau from creating and analyzing research series that leverage the strengths of the better price indexes. Rather than doing so, it has focused on developing a "Supplemental Poverty Measure" that is updated annually based on relative spending patterns rather than using changes in a price index. Researchers outside the Census Bureau have shown that adjusting the official poverty measure so that it is updated using a better price index results in measured poverty falling much more than indicated by the official measure.[51]

Other Federal Government Uses of Consumer Price Indexes

Congressional Budget Office. In a February 1988 report on family income trends, the Congressional Budget Office (CBO) used the CPI-U-X1, deeming it "a better indicator of

[51] Meyer and Sullivan, "Winning the War: Poverty from the Great Society to the Great Recession"; Scott Winship, "Poverty after Welfare Reform," Manhattan Institute, August 2016, https://media4.manhattan-institute.org/sites/default/files/R-SW-0816.pdf; Richard V. Burkhauser, Kevin Corinth, James Elwell, and Jeff Larrimore, "Evaluating the Success of the War on Poverty since 1963 Using an Absolute Full-Income Poverty Measure," *Journal of Political Economy* 132, no. 1 (2024): 1-47, https://www.journals.uchicago.edu/doi/abs/10.1086/725705.

changing living costs than the CPI[-U]" and citing its "greater accuracy."[52] By September 2001, CBO's reports on effective federal tax rate trends were using the CPI-U-RS.[53]

That index was also used in its income trend reports until July 2012, when CBO began using the PCEPI.[54] Since the CBO reports have used 1979 as a base year, the PCEPI is an obvious choice relative to the C-CPI-U, which only goes back to 2000. However, CBO analysts have also written and testified on the superiority of the C-CPI-U relative to the modern CPI-U as a cost-of-living index.[55]

Finally, CBO's economic projections emphasize the PCEPI (while secondarily including CPI-U projections).[56]

Social Security Administration. The Social Security Administration (SSA) produces long-range economic forecasts, based in part on projecting historical inflation trends into the future.[57] Since the annual cost of living adjustment to Social Security benefits is based on the CPI-W, the forecasts begin with that index. But SSA adjusts the CPI-W from 1967 to 1977 using the difference between the CPI-U-X1 and the CPI-U, and it is adjusted from 1978 to 2019 using the CPI-U-RS. This adjustment reflects SSA's recognition that the CPI-W and CPI-U overstated inflation significantly in the past and thus cannot be used to project future inflation. (Proposals to use the C-CPI-U for cost-of-living adjustments have proved politically controversial due to the implied slower growth of benefits, hence the continued use of the CPI-W for Social Security benefit updates and the inapplicability of the C-CPI-U for SSA's forecasting.)

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[52] Congressional Budget Office, "Trends in Family Income: 1970-1986," February 1988, https://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/104xx/doc10408/1988_02_trendsinfamilyincome.pdf.
[53] Congressional Budget Office, "Effective Federal Tax Rates, 1979-1997," October 2001, Appendix D, https://www.cbo.gov/sites/default/files/112th-congress-2011-2012/reports/12-29-2005FedTaxRates.pdf.
[54] Congressional Budget Office, "The Distribution of Household Income and Federal Taxes, 2008 and 2009," July 2012, https://www.cbo.gov/sites/default/files/cbofiles/attachments/43373-06-11-HouseholdIncomeandFedTaxes.pdf.
[55] Rob McClelland, "Differences between the Traditional CPI and the Chained CPI," Congressional Budget Office, April 19, 2013, https://www.cbo.gov/publication/44088. Jeffrey Kling, "Using the Chained CPI to Index Social Security, Other Federal Programs, and the Tax Code for Inflation."
[56] See Congressional Budget Office, "The Budget and Economic Outlook: 2024 to 2034," February 2024, https://www.cbo.gov/system/files/2024-02/59710-Outlook-2024.pdf.
[57] Office of the Chief Actuary, Social Security Administration, "The Long-Range Economic Assumptions for the 2024 Trustees Report," https://www.ssa.gov/oact/TR/2024/2024_Long-Range_Economic_Assumptions.pdf.

Federal Reserve Board. The Federal Reserve Board (FRB) began, in February 2000, to use the PCEPI rather than the CPI-U for its economic forecasts. In its report to Congress, the Board of Governors justified their reasoning as follows:

> The PCE chain-type index is constructed from a formula that reflects the changing composition of spending and thereby avoids some of the upward bias associated with the fixed-weight nature of the CPI. In addition, the weights are based on a more comprehensive measure of expenditures. Finally, historical data used in the PCE price index can be revised to account for newly available information and for improvements in measurement techniques, including those that affect source data from the CPI; the result is a more consistent series over time.[58]

The C-CPI-U was not yet developed at the time of the decision, but presumably FRB continues to favor the PCEPI due to the 10- to 12-month delay in the publication of final C-CPI-U values and the PCEPI's availability and consistency beyond 2000. In 2012, the Federal Reserve Board declared its policy of targeting a two percent annual inflation rate as measured by the PCEPI.[59]

Internal Revenue Service. Since 2018, federal income tax brackets and other parameters have been annually adjusted using the C-CPI-U rather than the CPI-U. Federal spending programs generally continue to be adjusted for inflation using the CPI-U. In 2013, President Barack Obama proposed using the C-CPI-U for annual Social Security benefit updates as part of his 2014 budget request.

4. Building the More Accurate Consumer Price Index

Having summarized the strengths and weaknesses of different consumer price indexes, presented the evidence as to their biases, and documented the adoption of better indexes over time by various federal agencies, I turn to the creation of a new, more accurate price index for assessing

[58] Board of Governors of the Federal Reserve System, "Monetary Policy Report to the Congress Pursuant to the Full Employment and Balanced Growth Act of 1978," February 17, 2000, https://www.federalreserve.gov/boarddocs/hh/2000/February/FullReport.pdf.
[59] Federal Open Market Committee, Board of Governors of the Federal Reserve System, "Statement on Longer-Run Goals and Monetary Policy Strategy," January 24, 2012, https://www.federalreserve.gov/monetarypolicy/files/fomc_longerrungoals.pdf.

long-term trends in income, earnings, poverty, and wealth. My goal is to use the best estimates of year-to-year changes in prices to the extent I can, but to adjust the estimates from different periods in accord with the research on known biases affecting different indexes at different times.

2000-2023

I start with the 2000-2023 C-CPI-U, which is the index of the CPI family that best approximates a cost-of-living index. I begin with the published 2023 value and then reduce the year-to-year changes by 0.41 percentage points. This adjustment accounts for bias due to upper-level substitution, new products, quality change, and new outlets (see Table 1, Column 3 total).

Compared with the published CPI-U, my correction from 2000 to 2023 is 0.68 points per year, which is very close to the estimated 0.70 points per year bias from Table 1 (Column 1 total). The closeness of these two estimates means that the estimates in the table of CPI-U small sample bias (0.10 points per year) and of upper-level substitution bias in the CPI-U and C-CPI-U (0.15 and -0.04) are relatively accurate given the observed difference between C-CPI-U and CPI-U growth.[60] My estimate of annual CPI-U bias is conservative relative to earlier estimates of CPI-U bias, such as Moulton's 0.85 as of 2017. It is significantly more than the difference between the CPI-U and the C-CPI-U (0.27 points per year) or the PCEPI (0.36 points per year), because all of these indexes suffer from quality change, new goods, and new outlet biases.

The difference between MACPI and PCEPI growth from 2000 to 2023 amounts to 0.32 points per year. As noted, this difference is not a good estimate of PCEPI bias because scope and weighting differences between PCEPI and the CPI family of indexes affect it.

1978-2000

While the C-CPI-U is unavailable before 2000, we can use the R-CPI-U-RS to extend the MACPI from 1978 to 2000. The R-CPI-U-RS corrects the published 1978-1998 CPI-U for lower-level substitution bias and incorporates other previous and subsequent improvements to

[60] The assumed amount by which CPI-U bias exceeds C-CPI-U bias in Table 1 due to small-sample and upper-level substitution bias is 0.10+(0.15-(-0.04))=0.29. The difference between CPI-U and C-CPI-U growth from 2000 to 2023 is 0.27 points per year. The difference between these two estimates (0.02) is the same as the difference between Table 1's estimate of CPI-U bias (0.70) and the implied bias comparing the MACPI to the CPI-U (0.68).

the CPI-U. I adjust the annual change in the R-CPI-U-RS by 0.70 points to account for the remaining biases affecting both indexes (Table 1, Column 2 total).

My correction amounts to 1.12 points per year relative to the CPI-U from 1978 to 2000. (For comparison, the difference between the CPI-U and the PCEPI from 1978 to 2000 amounts to 0.68 points per year.)

From 1983 to 1998, during which time the CPI-U incorporated the improved treatment of homeowner costs but did not yet address lower-level substitution bias, the annual correction is 1.05 points per year. This is quite close to the estimate in Table 1 (Column 1 total) for 1996, which is 0.98 points per year. In this case, the similarity of these two estimates means that the estimates in the table of CPI-U lower-level substitution bias, R-CPI-U-RS small-sample bias, and quality change, new goods, and new outlet bias in the CPI-U and R-CPI-U-RS are relatively accurate given the observed difference between R-CPI-U-RS and CPI-U growth.[61] From 1978 to 1982, my estimate of bias is 1.97 points per year, again close to the 1.88 points estimated in Table 1 for 1979.[62] The fact that the bias implied by the MACPI is higher both from 1978 to 1982 and from 1983 to 1998 indicates that Table 1 understates the biases shared by the CPI-U and R-CPI-U-RS.

These estimates of bias implied by the MACPI are larger than the point estimates of Moulton (0.85) and Lebow and Rudd (0.87), Robert Gordon's 2006 estimate of 0.80, and the estimates that four of five members of the Boskin Commission gave in 2000, which ranged from 0.73 to 0.90.[63] However, we would expect the adjustment to be higher than in those studies, given that the CPI-Us that they evaluated (from 2000 to 2017) were better measured than the CPI-U from

[61] The assumed amount from 1983 to 1998 by which CPI-U bias exceeds R-CPI-U-RS bias in Table 1 due to these five types of bias is (0.30-0.00)+(0.00-0.10)+(0.43-0.37)+(0.10-0.08)=0.28. The difference between CPI-U and R-CPI-U-RS growth from 1983 to 1998 is 0.35 points per year. The difference between these two estimates (0.07) is the same as the difference between Table 1's estimate of CPI-U bias (0.98) and the implied bias comparing the MACPI to the CPI-U (1.05).

[62] Table 1's assumed amount by which CPI-U bias exceeds R-CPI-U-RS bias from 1978 to 1982 is (0.30-0.00)+(0.00-0.10)+(0.43-.037)+(0.10-0.08)+(0.24-0.00)+(0.66-0.00)=1.18). The difference between CPI-U and R-CPI-U-RS growth from 1978 to 1982 is 1.27 points per year. The difference between these two estimates (0.09) is the same as the difference between Table 1's estimate of CPI-U bias (1.88) and the implied bias comparing the MACPI to the CPI-U (1.97).

[63] Robert J. Gordon, "The Boskin Commission Report: A Retrospective One Decade Later"; United States General Accounting Office, "Consumer Price Index: Update of Boskin Commission's Estimate of Bias," Report to the Ranking Minority Member, Committee on Finance, U.S. Senate, February 2000, https://www.gao.gov/assets/ggd-00-50.pdf.

1978 to 1998 (when there was no correction for lower-level substitution and when homeowner costs were, for a time, treated problematically).

A better assessment of my correction is to compare it to earlier estimates. The Boskin Commission's report estimated annual CPI-U bias at 1.1 points as of 1996 and 1.3 points through 1994, making my estimate of bias (1.05) somewhat conservative. Other estimates of CPI-U bias made between 1994 and 1996 ranged from 0.8 to 1.7 points.[64]

The difference between MACPI and PCEPI growth from 1978 to 2000 is 0.44 points per year, reflecting PCEPI bias and scope and weighting differences between the MACPI and PCEPI.

1973-1978

Because the bias estimates are increasingly uncertain the further back in time we go, I extend the MACPI only as far back as 1973. That year is important in that it is a business cycle peak (albeit one due in part to President Richard Nixon's price controls), in that hourly wages are available in the Current Population Survey beginning in 1973, and because many contemporary analyses take 1973 as a jumping off point for the slowdown in GDP and income growth.

The R-CPI-U-RS starts in 1978, so for earlier years, the MACPI adjusts the CPI-U-X1. This is the experimental BLS series that adjusted the CPI-U to extend the improved treatment of homeowner costs back to 1967. I reduce the annual increase in prices by 0.98, which is the total bias before 1978 in the CPI-U (1.64 points per year, from Table 1, Column 1 total) less the 0.66-point annual bias due to the homeowner cost problem (which is absent from the CPI-U-X1).

The CPI-U bias implied by my estimates amounts to 1.50 points per year from 1973 to 1977 (a period not affected by the 1978 changes to the CPI-U). This is lower relative to Table 1's 1.64 points, which uses an estimate of the bias from the homeowner cost problem based on 1967 to 1982 data (the difference between the CPI-U and CPI-U-X1 from 1973 to 1977 is 0.52 points per year, which, added to the 0.98 points of bias I assume is 1.50).

[64] See Brent R. Moulton, "Bias in the Consumer Price Index: What Is the Evidence?" His Table 1 lists 13 studies other than the Boskin Commission. Eight provide point estimates, with six exceeding 1.0 points per year. Of the five that provide ranges, one puts the range entirely above 1.0, two provide ranges that include 1.0, and two estimate ranges entirely below 1.0.

The MACPI-PCEPI difference over these four years is 1.08 points per year, again reflecting not just PCEPI bias but scope and weighting differences.

While there are no direct estimates of the extent to which the pre-1978 CPI-U overstates inflation, there are indirect estimates. These appear unreliable, however. They come from studies that look at the share of household spending accounted for by food, comparing it between people in different years with the same CPI-adjusted real spending or income and the same demographics. Individuals' food shares of spending are predicted, holding constant CPI-adjusted income and the CPI-measured price of food relative to the CPI-measured price of non-food products. The discrepancy between the actual mean food share of spending in a given year and the mean predicted food share is attributed to biased measurement of price changes in the CPI. There are reasons, a priori, to think the bias estimates from the indirect method may be too high or too low.[65]

Using such methods, Bruce Hamilton provides annual bias estimates for 1974-1991.[66] From 1974 to 1977, a period predating 1978 revisions to the CPI-U methods, his estimates imply CPI-U bias of 3.3 points per year, while mine indicate it is only 1.3 points annually. For comparison, from 1978 to 1982, after the 1978 revisions but before the incorporation of improved treatment of homeownership costs, Hamilton's estimate of CPI-U bias is 2.5 points per year, while mine is 2.0 points. Hamilton finds greater bias earlier in the 1970s than around 1980, while my estimates suggest lower bias in the earlier period.[67]

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[65] On the one hand, they do not capture CPI-U bias due to the introduction of new goods or quality improvements. That would make them underestimates of CPI-U bias. On the other hand, the estimates essentially involve residuals from a regression model predicting households' food expenditure shares from measured price changes, measured real income change, and a set of demographics. The model assumes that the extent to which food and nonfood prices are well-measured relative to each other is constant. For a critique of this indirect approach, see Angus Deaton, "Measuring and Understanding Behavior, Welfare, and Poverty," *American Economic Review* 106, no. 6 (2016): 1221-1243.

[66] Bruce W. Hamilton, "Using Engel's Law to Estimate CPI Bias," *American Economic Review* 91, no. 3 (2001): 619-630, https://www.jstor.org/stable/pdf/2677883.pdf.

[67] Hamilton provides estimates after 1982, but I believe they are less accurate because of the change in the treatment of homeowner costs in the CPI-U. Hamilton notes that his estimates of cumulative CPI-U bias, which derive from the parameters in his model related to the relative cumulative price change of food and nonfood products and the change in real income, depend on the assumption that "the relative bias as between food and nonfood is constant across all years." (p. 623) That is, even if his model parameters are unbiased, his ultimate CPI-U bias estimates require this assumption. However, prior to 1983 bias in nonfood price changes is greater than it is from 1983 forward, because of the way BLS measured shelter costs of homeowners. Food price bias is relatively larger than nonfood price bias from 1974 to 1982 than from 1983 to 1991 (and in the opposite direction compared with nonfood price bias from 1982 to 1983). Hamilton shows that the larger the difference in how well measured food prices are

Dora Costa estimated CPI-U bias from 1972 to 1982 using the same indirect methods as Hamilton but a different data source.[68] She estimates annual bias of 2.7 points per year from 1972 to 1982. My estimates imply an annual bias of 1.7 points from 1973 to 1982. (Hamilton's estimates suggest annual bias of 3.0 points from 1974 to 1982.)

Bruce Sacerdote also used this indirect method to estimate CPI-U bias.[69] He estimated upward bias of 3.6 points per year from 1972 to 1986, an understatement of 0.3 points from 1986 to 1996, upward bias of 1.7 points from 1996 to 2006, and no bias from 2006 to 2015. My estimates indicate annual upward biases of 1.4 points from 1973 to 1986, 1.1 points from 1986 to 1996, 0.8 points from 1996 to 2006, and 0.6 points from 2006 to 2015.

Whatever their strengths and weaknesses, the Hamilton and Costa estimates suggest that my adjustments for 1973 to 1977 are conservative, though the Sacerdote estimates offer reason to distrust the method entirely.

To summarize, the MACPI suggests that CPI-U bias is 1.50 points per year from 1973 to 1977, 1.97 points from 1978 to 1982, 1.05 points from 1983 to 1998, and 0.7 points from 2000 to 2023. These estimates derive partly from the assumed amounts of bias over broad periods as summarized in Table 1 and partly from leveraging BLS improvements in the year-to-year measurement of price change as reflected in its various non-CPI-U indexes. The relatively high

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relative to nonfood prices, the more his estimates understate CPI-U bias. Thus, we would expect the 1983 estimate of cumulative bias to be less understated than the 1982 estimate of cumulative bias, meaning that the estimated change in bias from 1982 to 1983 will be too large. This will also be true of cumulative bias estimates from 1984 to 1991. Though the annual CPI-U bias for these years will not be affected, the estimated cumulative change in bias from years before 1983 will be too large.

I believe there is a second issue caused by the 1983 change in BLS methods. Hamilton's approach models the food expenditure share of spending as a function of the difference in the cumulative CPI-measured price change for food and the cumulative measured change for non-food products. From 1982 to 1983, the shelter share of expenditures in the CPI-U declines for reasons not related to price changes, raising the food expenditure share at the same time that the cumulative price change of food relative to non-food products shifts. That is a separate issue from the change in how well price changes in food and nonfood products are measured. Between 1983 and 1987, the Hamilton-implied cumulative price change since 1978 gradually converges to my estimate, and the two are very close in 1990 and 1991. (Hamilton cannot estimate bias for 1988 and 1989.)

[68] Dora L. Costa, "Estimating Real Income in the United States from 1888 to 1994: Correcting CPI Bias Using Engel Curves," *Journal of Political Economy* 109, no. 6 (2001): 1288-1310.

[69] Bruce Sacerdote, "Fifty Years of Growth in American Consumption, Income, and Wages," NBER Working Paper No. 23292 (Cambridge, MA: National Bureau of Economic Research, March 2017), https://www.nber.org/system/files/working_papers/w23292/w23292.pdf. See also Bruce Sacerdote, "Is the Decline of the Middle Class Greatly Exaggerated?" in Melissa S. Kearney and Amy Ganz, eds., *Securing Our Economic Future*, (Washington, DC: The Aspen Institute, 2020) https://www.economicstrategygroup.org/wp-content/uploads/2020/12/2.-Sacerdote.pdf.

pre-1983 estimates reflect the inferior measurement of homeowner costs, which had a greater impact from 1978 to 1982 than from 1973 to 1977. The bias not due to this issue amounted to 1.0 points from 1973 to 1977 and 0.8 points from 1978 to 1982.

Appendix Table 1 provides the MACPI values, setting 1973 to equal 100. It is straightforward to deflate existing estimates from the literature using other price indexes to put them into nominal dollars, then to use the values in the table to apply the MACPI to put them in constant 2023 dollars. The table includes the equivalent values of the other indexes used in the following analyses.

5. Application: Trends in Hourly Wages, Annual Earnings, Household Income, and Wealth, 1973 to 2023

To illustrate the difference made by bias in existing consumer price indexes, I provide estimates of long-term trends in hourly wages, annual earnings, annual household income, and annual wealth. All dollar amounts are presented in constant 2023 dollars (using different price indexes).

Average Hourly Earnings, Private Production and Nonsupervisory Workers

Figure 1 is based on published estimates from BLS's Current Employment Statistics program, displaying average hourly earnings of private production and nonsupervisory workers.[70] This series is often used to represent the hourly wages of the median worker.[71]

Using the CPI-U, wages drop as much as 18 percent from their 1973 level (in 1995) before rebounding. Only in 2020 did the average exceed what it was in 1973, and in 2023 wages were just 1.9 percent higher than they were 50 years earlier. This unambiguously inaccurate series has served as the basis for populist claims that wages have "stagnated."[72] (Even this series, however, rises 24 percent from 1995 to 2023.)

[70] See https://www.bls.gov/ces/data/.
[71] The median is actually better tracked by the series that includes supervisory workers. See Scott Winship, "Understanding Trends in Worker Pay Over the Past 50 Years," American Enterprise Institute, May 14, 2024, https://www.aei.org/research-products/report/understanding-trends-in-worker-pay-over-the-past-50-years/.
[72] See, e.g., Oren Cass, "Foreword: What Happened to Capitalism?" in *Rebuilding American Capitalism: A Handbook for Conservative Policymakers*, American Compass, June 2023, https://americancompass.org/wp-content/uploads/2023/06/AC-Rebuilding-American-Capitalism_Digital.pdf.

The next line up in Figure 1 adjusts wages for inflation using perhaps the most common series adopted by researchers (the Census Bureau's preferred series until 2023). It links the R-CPI-U-RS (from 1978 to 2023) to the CPI-U-X1 (from 1973 to 1978). This series reaches a low of -9.5 percent relative to its 1973 level, in 1993. From there it rises 26 percent, exceeding the 1973 level for good in 2007, but by 2023 the average is still only 13.6 percent higher than in 1973.

Next, average wages increase by 21.3 percent if we follow current Census Bureau methods and link the C-CPI-U to the R-CPI-U-RS (and then the CPI-U-X1). By this measure, wages have been higher than the 1973 level since 2002. If we link the C-CPI-U to the PCEPI (next line up), the 50-year increase is 27.6 percent. Wages bottom out in 1992 and then rise 39 percent, exceeding the 1973 level starting in 1999. The story is much the same if we use the PCEPI for the entire series, with the overall increase 30.3 percent.

Finally, the MACPI rises much more than any of these series and finishes 61.5 percent higher over 50 years. That is over twice the increase of the PCEPI. Only from 1974 to 1976 were wages lower than in 1973. The difference between the PCEPI series and the MACPI results derive from the latter's adjustment to account for quality change, new goods, and new outlet bias, as well as its adjustment for lower-level substitution bias before 1978.

Male and Female Hourly Wages

The trend for average hourly earnings of production and nonsupervisory workers obscures the very different experiences of men and women over the past half century. Next, I use Current Population Survey microdata to show the trend in median hourly wages separately for men and women. I restrict the population to wage and salary workers between the ages of 25 and 54.[73]

Figure 2 presents trends for men. The naïve use of the CPI-U to adjust for inflation yields the conclusion that the typical male worker makes nearly 15 percent less today than his counterpart in 1973. As recently as 2014, his wages were down nearly 21 percent. The next two lines show

[73] For 1973 to 1978, I use the data from the May supplement, provided by the Unicon Corporation, a company that no longer exists. For 1979 to 1993, I use the data from the Outgoing Rotation Groups file provided by the Unicon Corporation. For 1994 to 2022, I use the Basic Monthly Survey data from IPUMS. See Sarah Flood et al., IPUMS CPS, version 11.0, University of Minnesota, Institute for Social Research and Data Innovation, October 5, 2023, https://cps.ipums.org/cps. I exclude self-employed workers who do not receive any wages or salaries as paid employees and exclude self-employment income. Hourly earnings are the reported amount for workers paid by the hour or, for other workers or if otherwise unavailable, usual weekly earnings divided by usual weekly hours.

that by either the Census Bureau's previous methods or its newly adopted inflation measure, male wages did not recover from 1973 levels until 2020. And by its old approach to measuring inflation, wages in 2023 were back below the 1973 median. Switching to chained price indexes improves things modestly, but 2023 wages are still just 7 to 9 percent higher in 2023 than a half century earlier.

The picture is again dramatically different using the MACPI. Men's wages dip below the 1973 level in 1974 and 1975 but are higher from 1976 onward. The median declines 3 percent between the 1979 and 1989 business cycle peaks but increases during every other cycle, despite a relative flattening out during the early aughts. The typical male worker in 2023 earned 35 percent more than his counterpart in 1973. That was the difference between $20.01 per hour and $27.10 (in 2023 dollars), or over $14,000 for someone working 40 hours a week, 50 weeks a year.

Women's wages have risen even more impressively (Figure 3). Even using the CPI-U, median wages rose 25 percent from 1973 to 2023. That increases steadily as one moves through the other conventional price indexes, reaching nearly 60 percent using the PCEPI. However, using the MACPI, women's wages doubled between 1973 and 2023, rising from $12.12 to $24.00 an hour.

Men's and Women's Annual Earnings, Full-Time, Full-Year Workers

Figures 4 and 5 present the corresponding trends for median annual earnings of men and women working full-time, year-round, based on published Census Bureau nominal estimates.[74] These figures include self-employment earnings. They are very consistent with the median hourly wage trends in Figures 2 and 3. In part, this is due to the restriction to full-time, full-year workers, which factors out earnings variation due to hours worked per week or weeks worked per year. The main difference is that the 1979-to-1989 period looks better when tracking annual earnings versus hourly wages.

[74] US Bureau of the Census, "Historical Income Tables: People, Table P-38. Full-Time, Year-Round All Workers by Median Earnings and Sex: 1960 to 2023," https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-income-people.html. I shift the series from 2014 to 2017 by a fixed amount and the series from 2018 to 2023 by another fixed amount to adjust for methodological breaks in the CPS data. Specifically, the adjustment from 2014 to 2017 is the amount by which the medians differ in 2013 depending on whether the old or newer methods are used, and the 2018-to-2023 shift is similarly the amount by which the 2017 medians differ depending on whether older or newer methods are used.

Rather than falling by 13 percent from 1973 to 2023 (when using the CPI-U), men's earnings rise by 38 percent using the MACPI. That is an increase from $48,400 to $66,800, or $18,400. The increase for women using the MACPI is from $27,400 to $52,600, or $25,200 (92 percent). Like the wage estimates, these figures are pre-tax and do not take any nonwage compensation into account.

Household Income

Figure 6 shows trends in the average market income of households with children in the middle fifth of the Americans as ranked by market household income. The nominal figures come from the Congressional Budget Office's "Table Builder" tool that creates a variety of income tabulations from a dataset that combines Current Population Survey and Internal Revenue Service microdata.[75] I restrict to households with children partly because including elderly households is inappropriate for understanding market income trends. Many elderly households depend heavily on social security benefits and thus have little market income, and due to the aging of the baby boomers, elderly households are a rising share of the population over time.

CBO's definition of market income is very broad and includes atypical sources of income such as the share of corporate income tax that workers and capital owners would receive in the absence of the tax, the employer's share of payroll taxes (which would be received in the absence of those taxes), and the employer's share of health insurance coverage. It also includes taxable realized capital gains. This measure does not deduct any taxes, nor does it include government transfer income. CBO's estimates only run from 1979 to 2021.

Once again, the CPI-U conveys a dour picture of how households with children are doing. The middle class was doing worse in 2013 than in 1979 by this series. By 2021, it was only 12

[75] See https://www.cbo.gov/system/files/2024-09/60341-table-builder.xlsm. I look at "market income" rather than "income before taxes and transfers," as the latter includes social insurance benefits. The Table Builder provides amounts in 2021 PCEPI-adjusted dollars. The documentation in the spreadsheet indicates that the PCEPI as of July 9, 2024 was used. I obtain the June 28, 2024 version of the PCEPI from https://apps.bea.gov/histdatacore/histChildLevels.html?HMI=7&oldDiv=National%20Accounts, National Income and Product Accounts Table 1.1.4. I deflate the dollars back to nominal amounts. When I later use the PCEPI for Figure 6, I use the version as of September 26, 2024. Note that "middle fifth" means the middle fifth of Americans (people) ranked by size-adjusted market household income. The middle fifth does not contain one-fifth of households, and it is not the middle fifth of households with children nor the middle fifth of people in households with children.

percent better off than in 1979. Using the PCEPI, the increase over time is 35 percent, or $28,300 in 2023 dollars. But using the MACPI the increase is $40,800, or 60 percent.

Figure 7 includes all households (not just nonelderly households with children) and looks at median size-adjusted post-tax and -transfer income.[76] The trends are uniformly upward, ranging from a 58 percent increase using the CPI-U to a 90 percent increase using the PCEPI to a 124 percent increase using the MACPI.

Wealth

Finally, in Figure 8, I display trends in the median family wealth of households with a head between the ages of 35 and 49, taken from supplemental data accompanying a recent CBO report. These estimates, which derive primarily from the Federal Reserve Board's Survey of Consumer Finances, run from 1989 to 2022 and are available every three years.[77] At the pre-financial-crisis peak, in 2007, median wealth was up 21 percent from 1989 according to the CPI-U, but the rise was double that according to the MACPI (42 percent, compared with just over one-third using the PCEPI). By 2010, wealth was down either 18 percent (CPI-U) or 2 percent (MACPI) from the 1989 level. However, wealth grew over the next 9 years, peaking in 2019 and falling slightly by 2022. In the latter year, the increase ranged from 41.5 percent using the CPI-U, to 65 percent using the PCEPI, to 83 percent using the MACPI. The cumulative gain was $171,700 according to the MACPI, compared with just $149,200 using the PCEPI.

6. Conclusion

Measuring price changes and the change in the cost of living is an extraordinarily complex challenge. Economists inside and outside the federal government have made great strides in developing the theory, assumptions, and models behind this measurement. Government

[76] The size-adjustment involves taking the square root of household size and then dividing household income by that term.

[77] See Congressional Budget Office, "Trends in the Distribution of Family Wealth, 1989 to 2022," October 2, 2024, https://www.cbo.gov/publication/60343. Supplemental data is available at https://www.cbo.gov/system/files/2024-10/60343-data-supplemental.xlsx. I deflate the PCEPI-adjusted dollars back to nominal amounts using the same 6/28/24 version as in the previous note. Wealth is defined as assets (home equity, other real estate, vehicles, business equity, bank deposits, financial securities, cash value of life insurance, trust funds, Social Security wealth, defined contribution and defined benefit retirement wealth) less debt (non-home real estate loans, student loans, credit card debt, vehicle loans, and other debt).

economists have improved on earlier methods, particularly since the mid-1990s. Federal agencies have, for the most part, adopted the better price indexes as they have become available. That said, some practices of the Census Bureau and statements from the Bureau of Labor Statistics have sent vague or mixed messages to researchers about what is known to be the strengths and weaknesses of different index choices.

Increasingly, researchers inside and outside government have adopted the use of chained indexes—the C-CPI-U and PCEPI—but many continue to use inferior alternatives. Even the Census Bureau presents its poverty trends using the CPI-U to update poverty thresholds over time. And while it recently began using a price index based on the C-CPI-U from 2000 forward, in earlier years the index is based on the R-CPI-U-RS, the CPI-U-X1, and (far enough back) the CPI-U.

Even the chained indexes, however, suffer from known biases—biases that, on net, overstate increases in the cost of living. Examining wage, earnings, income, and wealth trends that adjust for inflation using these indexes will understate improvement in living standards. Given what is known about the biases that afflict even the chained indexes, it makes more sense to use an index that accounts for them. The MACPI is an attempt to do just that, to better inform policymaking and the discourse around how the nation's economy is doing.

In these regards, it matters greatly whether the typical wage earner is better off by 2 percent since 1973 or better off by over 60 percent. The evidence presented here suggests that that typical wage earner has seen double the gain that even the PCEPI implies, and about three times the gain that current Census Bureau methods imply. The truth may be somewhere in between…or it may be an even larger increase than the MACPI suggests. The MACPI is not intended as an upper-bound estimate, and the evidence included in the summary above notes studies that find even larger upward biases than I assume in the MACPI.

Researchers and policymakers would surely benefit from having more precision about the magnitude of price index biases. Improved data collection methods and better-developed econometric modeling could yield more solid estimates that don't apply point-in-time bias estimates to multiple years as I have done here. The state of our knowledge would be much improved if we were to see the same productivity from researchers on these questions that occurred in the 1990s. These efforts followed Federal Reserve Board Chairman Alan

Greenspan's highlighting of the problem of CPI-U bias, which led a Senate committee to task the Boskin Commission with researching the problem. We are overdue for Boskin 2.0.

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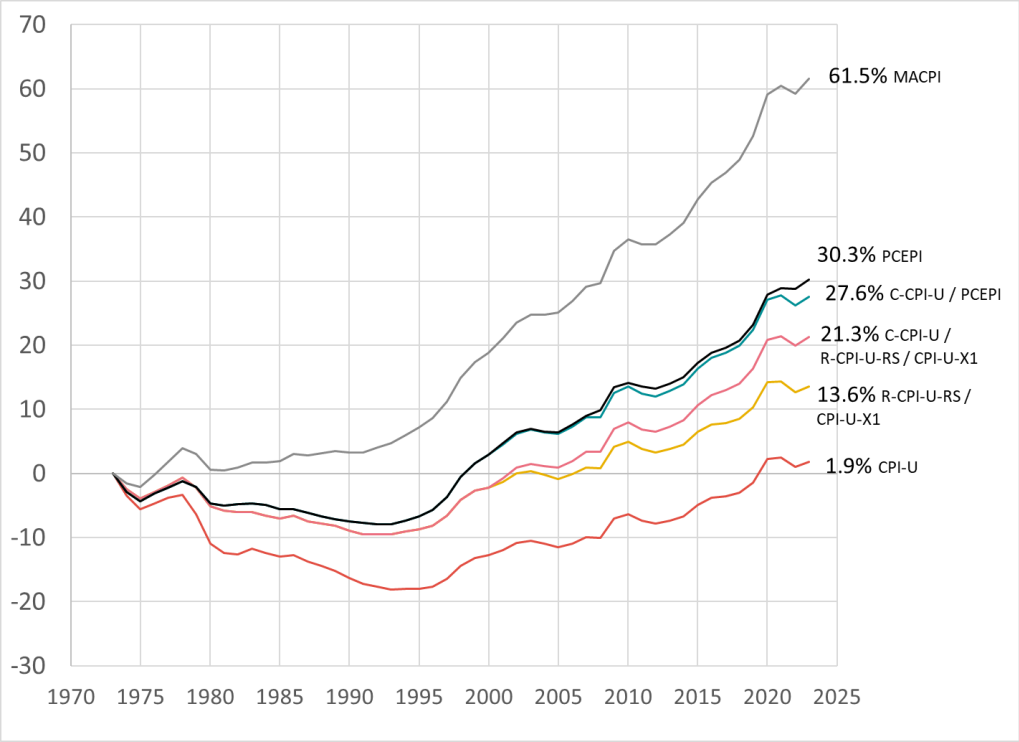
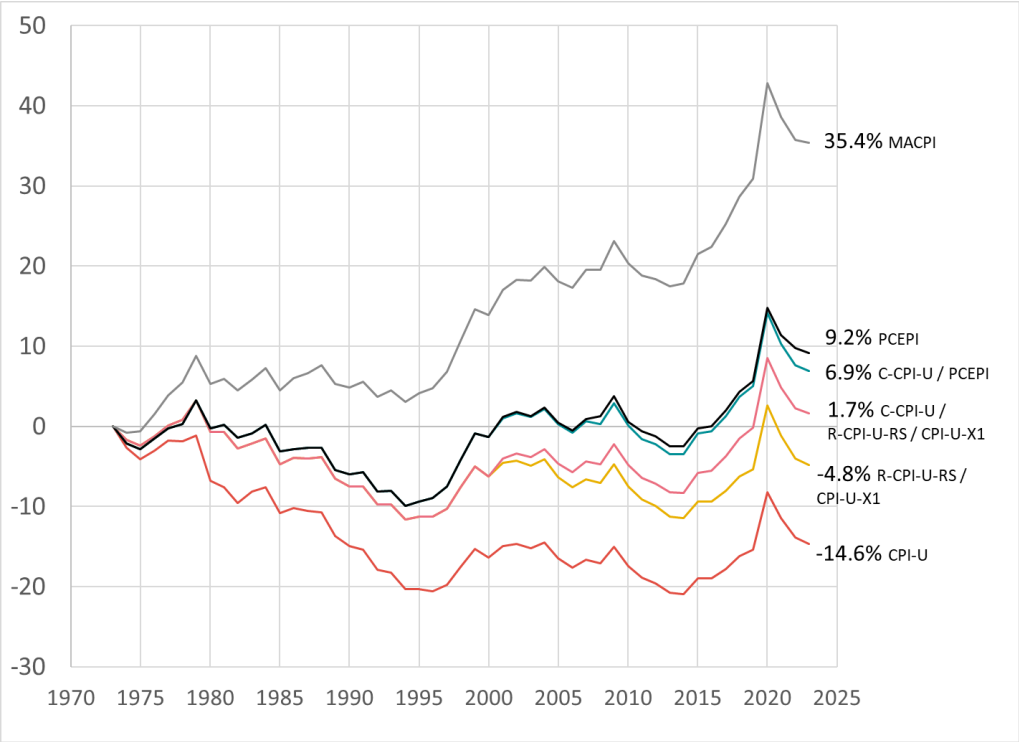
Figure 1. Cumulative Percent Change in Average Hourly Earnings of Production and Nonsupervisory Workers, 1973-2023



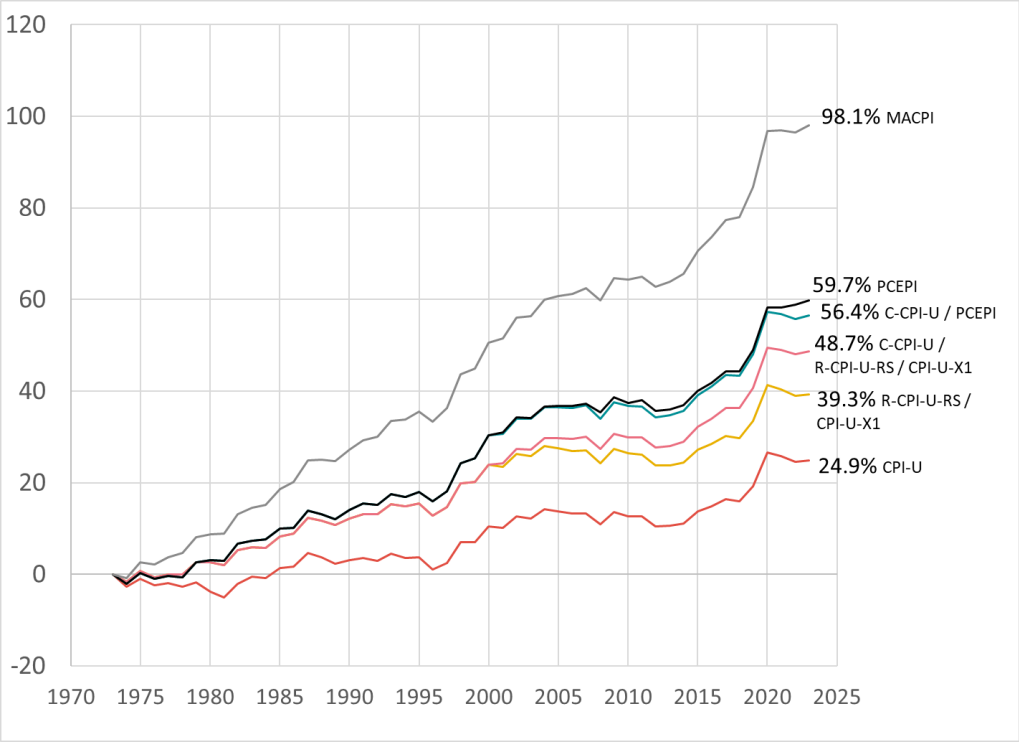
Source: Bureau of Labor Statistics, Current Employment Statistics program and price indexes as cited in the text.

Figure 2. Cumulative Percent Change in Median Hourly Wages, Men Ages 25-54, 1973-2023



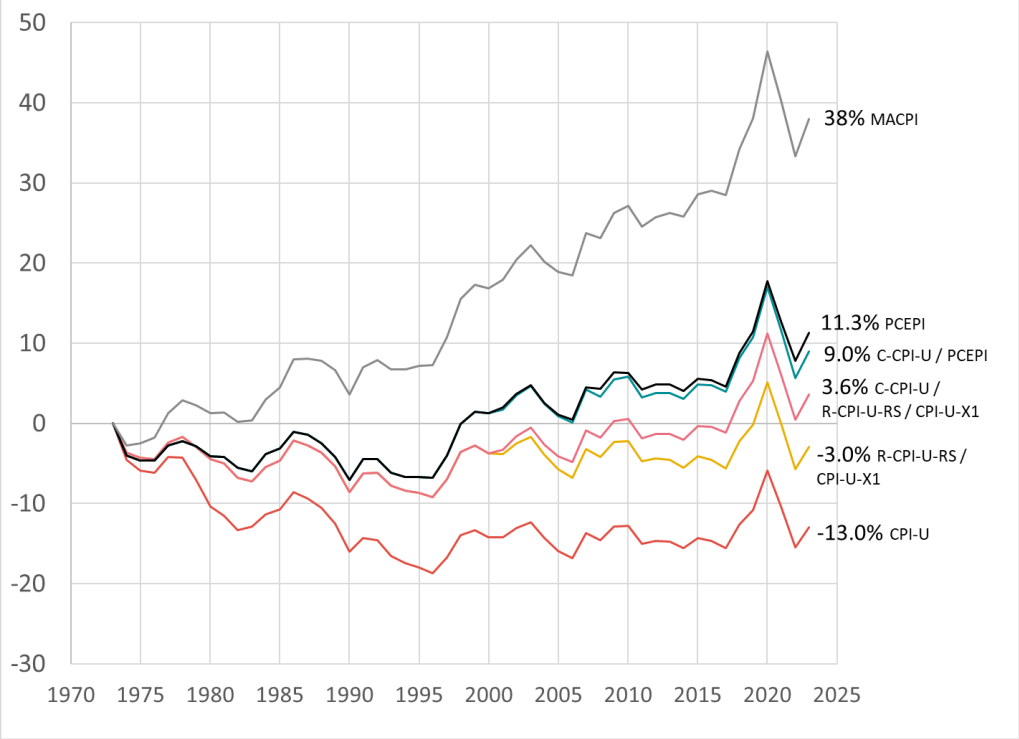
Source: Author's analyses of Current Population Survey (May supplement, outgoing rotation groups, basic monthly survey) microdata and price indexes as cited in the text.

Figure 3. Cumulative Percent Change in Median Hourly Wages, Women Ages 25-54, 1973-2023



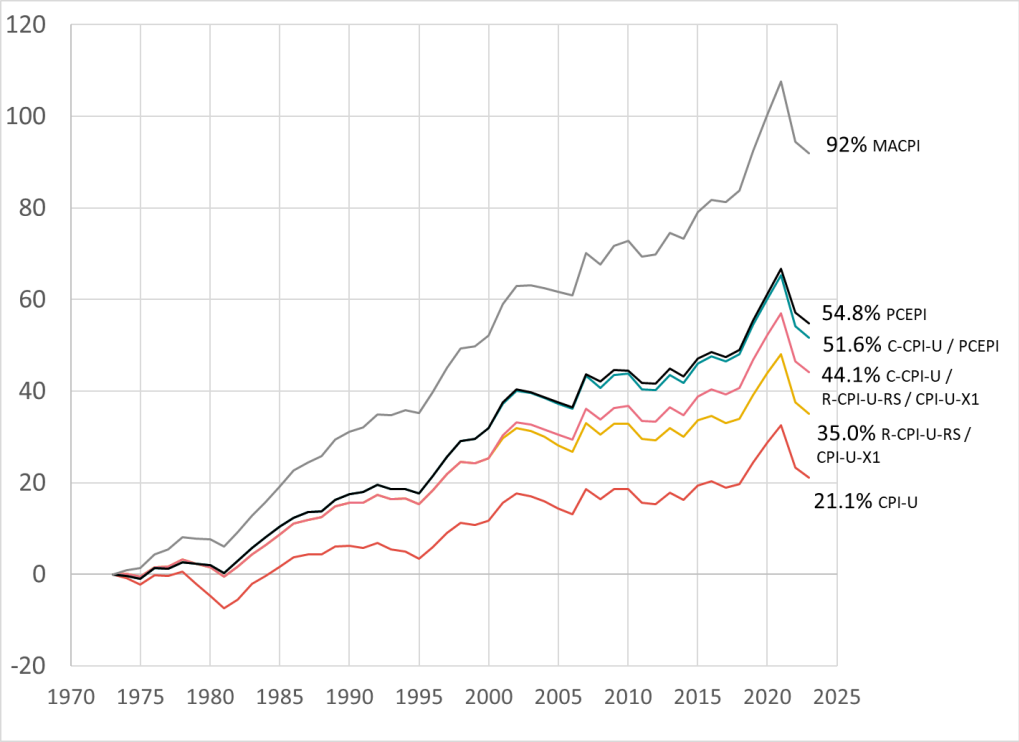
Source: Author's analyses of Current Population Survey (May supplement, outgoing rotation groups, basic monthly survey) microdata and price indexes as cited in the text.

Figure 4. Cumulative Percent Change in Median Annual Earnings, Male Full-Time, Year-Round Workers, 1973-2023



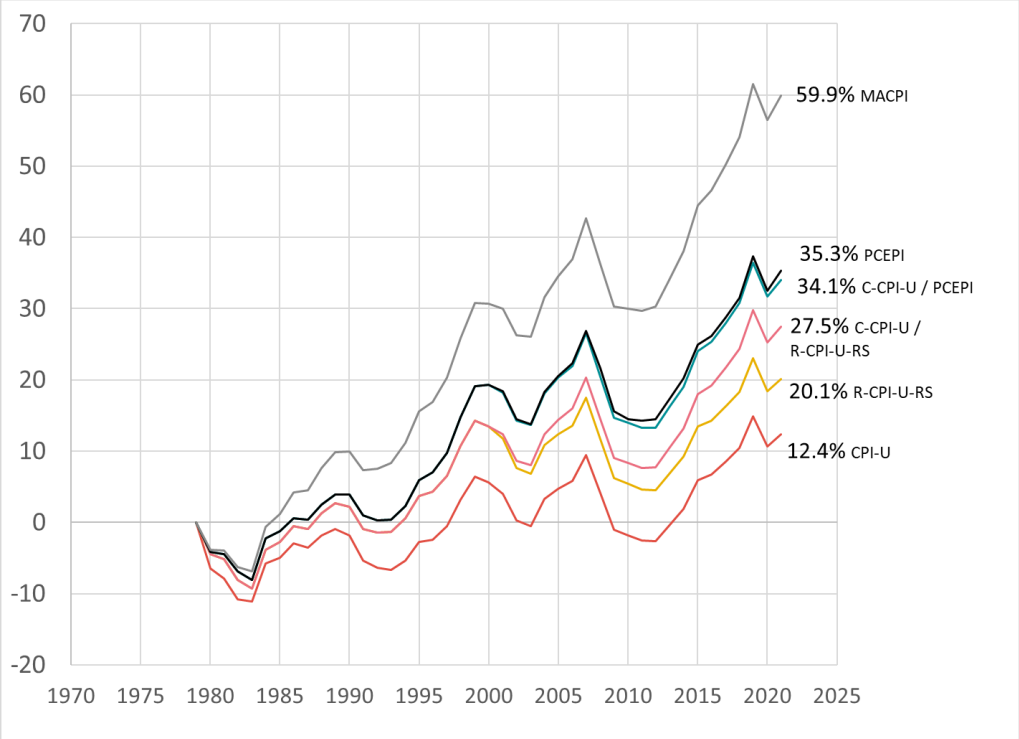
Source: Census Bureau, Historical Income Tables and price indexes as cited in the text.

Figure 5. Cumulative Percent Change in Median Annual Earnings, Female Full-Time, Year-Round Workers, 1973-2023



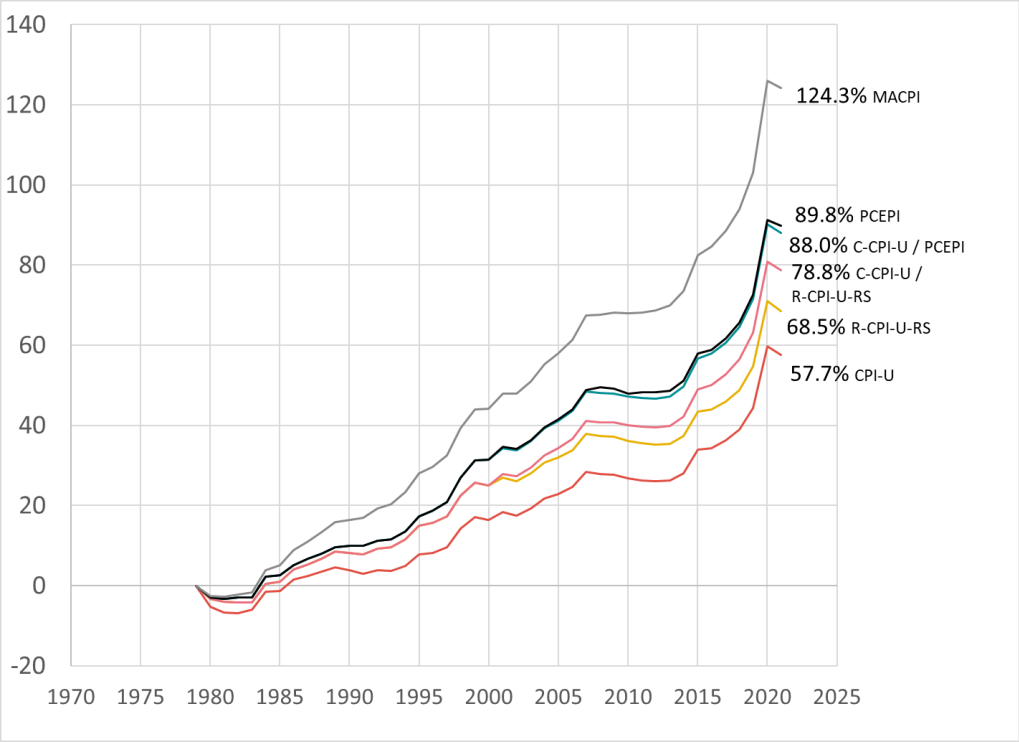
Source: Census Bureau, Historical Income Tables and price indexes as cited in the text.

Figure 6. Cumulative Percent Change in Average Annual Market Income of Households with Children in the Middle Fifth of Income, 1979-2021



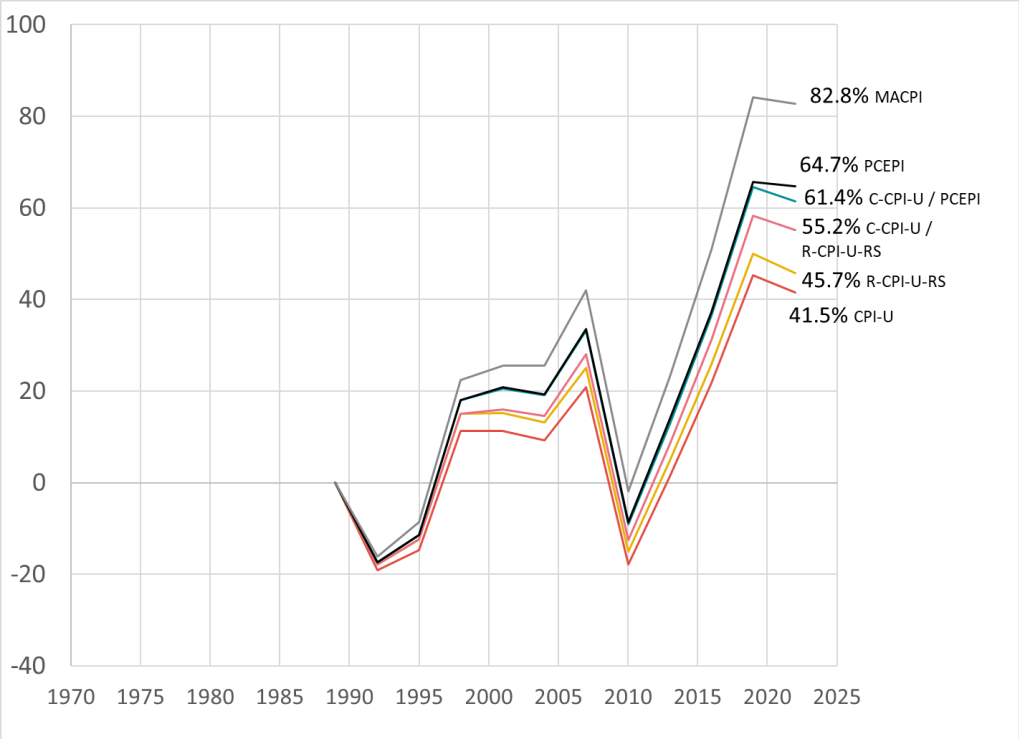
Source: Congressional Budget Office, Distribution of Household Income Table Builder and price indexes as cited in the text.

Figure 7. Cumulative Percent Change in Median Size-Adjusted Annual Post-Tax & -Transfer Income of Households, 1979-2021



Source: Congressional Budget Office, Distribution of Household Income Table Builder and price indexes as cited in the text.

Figure 8. Cumulative Percent Change in Median Wealth, Families with Head Age 35-49, 1989-2022



Source: Congressional Budget Office, Trends in the Distribution of Family Wealth (based on Federal Reserve Board's Survey of Consumer Finances) and price indexes as cited in the text.

Appendix Table 1. Price Index Values, 1973-2023

Year	CPI-U	R-CPI-U-RS / CPI-U-X1	C-CPI-U / R-CPI-U-RS / CPI-U-X1	C-CPI-U / PCEPI	PCEPI	MACPI
1973	100.00	100.00	100.00	100.00	100.00	100.00
1974	111.04	109.96	109.96	110.41	110.41	108.98
1975	121.17	119.07	119.07	119.62	119.62	116.94
1976	128.15	125.85	125.85	126.18	126.18	122.45
1977	136.49	133.90	133.90	134.38	134.38	129.08
1978	146.85	143.01	143.01	143.74	143.74	136.60
1979	163.51	156.57	156.57	156.50	156.50	148.60
1980	185.59	174.10	174.10	173.36	173.36	164.20
1981	204.73	190.54	190.54	188.89	188.89	178.55
1982	217.34	202.05	202.05	199.38	199.38	188.09
1983	224.32	210.68	210.68	207.86	207.86	194.80
1984	234.01	219.44	219.44	215.72	215.72	201.55
1985	242.34	226.84	226.84	223.24	223.24	206.93
1986	246.85	230.68	230.68	228.10	228.10	208.98
1987	255.86	238.48	238.48	235.15	235.15	214.59
1988	266.44	247.25	247.25	244.33	244.33	220.98
1989	279.28	257.94	257.94	255.00	255.00	228.98
1990	294.37	270.68	270.68	266.20	266.20	238.68
1991	306.76	280.54	280.54	275.10	275.10	245.71
1992	315.99	287.52	287.52	282.43	282.43	250.11
1993	325.45	294.78	294.78	289.47	289.47	254.67
1994	333.78	300.95	300.95	295.51	295.51	258.22
1995	343.24	308.21	308.21	301.73	301.73	262.64
1996	353.38	316.43	316.43	308.19	308.19	267.80
1997	361.49	323.28	323.28	313.55	313.55	271.73
1998	367.12	327.66	327.66	316.04	316.04	273.51
1999	375.23	334.51	334.51	320.65	320.65	277.31
2000	387.84	345.88	345.88	328.76	328.76	284.80
2001	398.87	355.74	353.68	336.17	335.35	290.05
2002	405.18	361.36	358.14	340.41	339.75	292.52
2003	414.41	369.58	365.43	347.34	346.89	297.28
2004	425.45	379.44	374.59	356.05	355.50	303.51
2005	439.86	392.31	385.56	366.47	365.74	311.15
2006	454.05	405.05	396.75	377.11	376.04	318.90
2007	466.99	416.56	406.80	386.66	385.69	325.68
2008	484.92	432.59	421.98	401.09	397.11	336.50
2009	483.19	431.08	420.01	399.21	396.00	333.54
2010	491.12	438.07	425.99	404.90	403.09	336.92
2011	506.62	452.04	439.01	417.27	413.29	345.84
2012	517.10	461.49	447.56	425.40	420.99	351.16

Appendix Table 1. Price Index Values, 1973-2023 (continued)

Year	CPI-U	R-CPI-U-RS / CPI-U-X1	C-CPI-U / R-CPI-U-RS / CPI-U-X1	C-CPI-U / PCEPI	PCEPI	MACPI
2013	524.68	468.48	453.04	430.61	426.55	354.02
2014	533.19	476.28	459.59	436.84	432.51	357.69
2015	533.82	477.11	459.05	436.32	433.31	355.80
2016	540.56	483.27	463.33	440.39	437.69	357.66
2017	552.07	493.54	471.50	448.16	445.34	362.50
2018	565.56	505.60	481.02	457.21	454.45	368.33
2019	575.80	514.78	488.01	463.85	460.96	372.17
2020	582.91	521.62	493.25	468.83	466.00	374.65
2021	610.29	546.83	515.30	489.79	485.29	389.85
2022	659.13	591.07	554.86	527.39	517.08	418.19
2023	686.27	615.46	576.41	547.87	536.59	432.71