Harmonized Population and Labor Force Statistics*

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Abstract

The official labor force statistics often exhibit discontinuities in January, when updated population estimates are incorporated into the Current Population Survey (CPS) for the current year but are not revised backwards through history. We construct harmonized population estimates spanning five decades and produce new sampling weights for the CPS microdata that are benchmarked to these estimates. Using these weights, we estimate harmonized labor force statistics that reflect the latest available information about the population and its characteristics. The harmonized labor force series are free from the discontinuities in the historical data and show a notably larger labor force shortfall in the post-pandemic period.

JEL codes: C8, E24

Keywords: Population, labor force, employment, unemployment

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1. Introduction

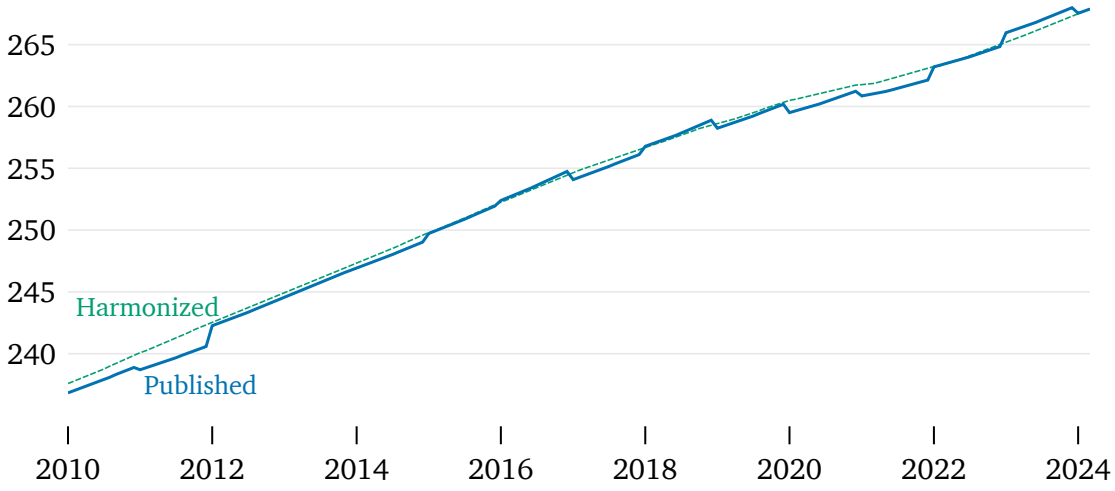
The Bureau of Labor Statistics (BLS) publishes timely statistics about the U.S. labor market that receive wide attention each month. Many of these indicators, including the unemployment rate and labor force participation rate (LFPR), are derived from a monthly survey of about 60,000 households. Statistics from this survey, the CPS, are able to capture the overall labor market because individual survey responses are weighted to be representative of the demographic and geographic composition of the U.S. population. However, since population cannot be counted perfectly in real time (except for once every ten years in the decennial census), the weights are constructed to match population *estimates*, which revise when underlying source data are updated.

Each January, the BLS incorporates updated population estimates into the CPS for the current year, but does not revise the official household survey estimates back in history. When the revisions shift the composition of the population across demographic groups whose labor market outcomes differ, this can result in large discontinuities between the updated labor market statistics for the current year and the out-of-date statistics for previous years, potentially confounding statistical analyses and assessments of the labor market. This issue affects not only the official statistics published by the BLS, but also statistics that researchers calculate from CPS microdata.

In this paper, we introduce a methodology for estimating CPS-based labor force statistics that are harmonized over five decades to consistently reflect the latest available data on the population. Our approach involves assembling harmonized population data at the demographic group level, reweighting CPS microdata to match these targets, and then computing time series estimates from the reweighted microdata. Since our method closely follows the BLS' estimation process, our harmonized labor force statistics can be interpreted as the values that the BLS would have produced if they had been able to use the latest population data when they originally published their statistics. We provide updated estimates for the unemployment rate and LFPR, along with updated microdata weights that researchers can use to reproduce any CPS statistic adjusted for population revisions.

By not revising the historical time series of labor force statistics to reflect new population data, the BLS' standard practices often introduce discontinuities in the time series between each December to January. These discontinuities are evident in the published series for the civilian noninstitutionalized population (CNP) 16 years and older, shown by the solid blue line in figure 1. For example, in January

Figure 1. Civilian noninstitutionalized population 16 years and older
Millions



Source: Bureau of Labor Statistics (BLS) and author's calculations using data from the Census Bureau and the BLS.

2012, the CPS incorporated population estimates derived from the 2010 Census, which resulted in a jump of 1.7 million from December 2011 to January 2012, even though the typical pace of change before and after was only about 200,000 per month. Population revisions can also result in downward revisions to population, such as in 2017, 2019, and 2020.

Our harmonized time series, shown by the dashed green line in figure 1, does not exhibit any such discontinuities because all years of the harmonized series reflect the latest population data. Our approach to constructing the harmonized series involves several steps.

We begin by assembling Census Bureau estimates for the population at the demographic subgroup level for the period in between each decennial census, and adjust for the "surprise" contained in the actual decennial census count. Harmonizing these detailed population estimates involves some adjustment between eras in which data was collected differently, but maintaining the fine level of demographic detail is essential for our approach.

With these estimates in hand, we replicate the BLS' weighting and estimation procedures to produce time series with similar properties as the official series. We construct new CPS microdata weights at broadly the same level of demographic detail that the BLS uses while ensuring that these weights match our harmonized population estimates — and thus reflect the latest population data. We also replicate

the method that the BLS uses for producing composite time series estimates that exploit the longitudinal structure of the CPS. Using published seasonal factors and adjusting for the CPS survey redesign, our time series estimates replicate as closely as possible what the BLS would have produced if they had our current harmonized population estimates in real time.

As described in section 4, the time series we produce are smoother than official estimates and feature some notable differences, particularly in the period around the pandemic. For instance, our estimate of the LFPR is above the published estimate in February 2020 on the eve of the pandemic, and shows a slower, but more even pace of recovery during 2021–22. Our estimates indicate that the labor force shortfall in the post-pandemic period was 1.5 million larger than published data indicated.

In addition to headline series, we can construct estimates of any CPS statistic on a harmonized population basis. Since we produce new CPS microdata weights consistent with harmonized population targets, researchers can correct the statistical series that they derive from the microdata for the effects of population revisions simply by using our weights in place of the published sampling weights.

Our analysis does not yet incorporate the large population revision the BLS introduced in early 2025. Over the last several years, immigration has contributed more to population growth than the Census Bureau's previous estimates indicated, so in their Vintage 2024 estimates (which the BLS incorporated into the January 2025 data) the population level was revised up by nearly 3 million people. In our current analysis, the latest estimates we use are the Vintage 2023 estimates, since detailed demographic estimates and projections are not yet available for the Vintage 2024 estimates. We plan to update our microdata weights and time series later this year, when the Census Bureau publishes the monthly Vintage 2024 estimates by age, sex, race and Hispanic origin that our methodology requires.

The new estimates we produce help shed light on the post-pandemic labor market recovery. Previous studies analyzing the pace of labor market recovery and the extent of recovery remaining have tended to rely on either the BLS' published series or author-constructed series based on published CPS microdata, both of which have been subject to large breaks in post-pandemic years (Cooper et al. 2021; Forsythe et al. 2022; Hobijn and Sahin 2022). Robertson and Willis (2022) and Robertson (2023) represent notable exceptions, as they adjusted published series for population revisions by assuming the revision phased in smoothly since the base period. Our approach instead allows the underlying source data to dictate

how the population revisions are distributed since the previous base period, thus accounting for potentially nonmonotonic revisions over history.

We also contribute an enhancement for researchers using CPS: microdata weights that match harmonized population controls. Prior literature has enhanced the CPS microdata by contributing longitudinal linking procedures (Madrian and Lefgren 2000; Drew, Flood, and Warren 2014), wage cleaning (Schmitt 2003), and harmonized industry and occupation codes (Flood et al. 2024), among other innovations. Our new microdata weights can be used as a drop-in replacement for the published sampling weights, making it easy for researchers to produce statistics consistent with harmonized population estimates.

The rest of the paper proceeds as follows. Section 2 provides a high-level overview of BLS' process for constructing time series estimates. Section 3 details how we construct harmonized population estimates and replicate BLS' process to produce our own time series estimates. Section 4 reports our new estimates of headline series, showing how they differ from published estimates.

2. Overview of the BLS' methodology

In this section, we provide a high-level overview of the BLS' procedure for constructing time series estimates of labor force statistics. This procedure involves four main stages to go from individual-level responses in the CPS to nationally representative aggregate time series. Our summary draws heavily on *Current Population Survey Design and Methodology Technical Paper 63RV* (2002), *Technical Paper 66* (2006), and *Technical Paper 77* (2019), which interested readers should refer to for more information.

1. **Weighting based on geography:** The first stage constructs a sampling weight for each individual based almost solely on geographic information. This weight is the product of three factors: 1) a "base weight" reflecting the probability of sample inclusion, 2) a "nonresponse adjustment factor", which redistributes weight from nonresponding units to responding units within a narrow geographic cell, and 3) a "first-stage adjustment factor", which accounts for differences in the Black population between geographic units included in that month's sample relative to state-level totals. Importantly, each of these factors are either the same for all individuals within a geographic cell (as the first and second terms are), or can be calculated in advance and do not depend on survey responses (as the first and third terms are).

2. **Reweighting based on demographics to match population controls:** This stage reweights demographic groups within the sample so that subgroup population totals match Census Bureau estimates. Sampling weights are adjusted to match detailed national race/ethnicity/sex/age totals ("national coverage step"), then to match state-level race/sex/age totals ("state coverage step"), and then finally are adjusted to jointly match three coarser sets of population controls ("second-stage weighting"). This final adjustment involves using iterative proportional fitting (or "raking") to jointly match national race/sex/age controls, national ethnicity/sex/age controls, and state/sex/age controls. We refer readers to *Technical Paper 77* (2019) for the exact definition of demographic groups used in each of these population controls.

   The demographic-group-specific population estimates used in this phase come from the Census Bureau's Population Estimates Program (PEP). Each year, this program releases updated monthly estimates of the CNP (and other population concepts) for detailed demographic groups, based on source data measuring births, deaths, immigration, and other flows. These estimates cover the period since the most recent decennial census and include a projection through the current year. The BLS aggregates the population across these detailed demographic groups into the more-aggregated demographic groupings used as population controls for each step.

3. **Calculating composite estimates:** The BLS' estimates for not seasonally adjusted quantities such as employment and unemployment each month are a composite of two separate estimates. The first estimate is the quantity total summed up using the second-stage weights constructed in the previous phase. The second estimate uses the longitudinal nature of the CPS, taking the month-over-month change in the quantity among continuing respondents and adding to the previous month's composite estimate. Huang and Ernst (1981) show that constructing a composite estimate that incorporates both stock and flow information in this way reduces the variance of time series estimates.

   For ease of reproducing these estimates, the BLS adds to the CPS a set of "composite weights", which add up to the composite estimates for a given month at the demographic group level. These composite weights are produced by raking weights within state, national race/sex/age, and national ethnicity/sex/age cells such that total employment and unemployment within the cell matches the composite estimate.

4. **Seasonal adjustment, including adjustment for known breaks:** The final stage involves adjusting the NSA series for seasonality and known discontinuities. The BLS uses X-13ARIMA-SEATS to conduct seasonal adjustment, outlier detection, and adjustment for level shifts that occur on known break dates. These known breaks include the dates when updated population controls were introduced, as well as the introduction of the CPS redesign in 1994 and several other CPS changes (see *Technical Paper 77* 2019, Chapter 2-5 for a complete list).

   To produce headline series, such as the unemployment rate or labor force participation rate, the BLS seasonally adjusts component series and then calculates the headline series from the seasonally adjusted components. For example, the seasonally adjusted 16+ labor force level is the sum of eight separately seasonally adjusted components: the levels of unemployment and employment each among four demographic groups (men/women $\times$ 16–19/20+). The seasonally adjusted unemployment rate is the ratio of 16+ total unemployment (sum of seasonally adjusted unemployment in each of the four demographic groups) to the seasonally adjusted 16+ labor force level.

Each January, the BLS incorporates a new vintage of population estimates for the current year from the Census Bureau, which it uses as the external population controls in the second stage as described above. Although these population estimates extend back to the previous decennial census, previous years' sampling weights are not revised, nor are the aggregate time series estimates based on the CPS. As a result, the time series for population and other outcomes can exhibit sharp discontinuities between December and January each year. In some years these discontinuities are small relative to the regular variation in the series, but some years show significant jumps or falls that complicate interpreting the trend in these series. Importantly, these discontinuities are not just disruptions layered on top of otherwise correct series, they reflect that previous years' data were controlled to population controls that are no longer the best estimate, having been superseded by the current year vintage.

One might wonder how the aggregate time series estimates would differ if the BLS revised previous years' data to reflect the most up-to-date population estimates. The key phase where population controls enter the process for calculating time series estimates is the second phase, in which observations are reweighted based on demographics. If the BLS had different population estimates during this phase, it would lead to different second-stage weights in the microdata, different composite estimates (and weights), and ultimately different estimates for aggregate

seasonally-adjusted time series. Importantly, different population estimates would not affect the weights created in the first phase, only the subsequent phases. This implies that one could replicate what the BLS would have produced if they had different population estimates by using the existing weights (which incorporate the first phase adjustment) and replicating the reweighting and estimation steps in phases two through four. This is the essence of our approach, which we describe in the next section.

3. Our methodology for harmonized estimates

In this section, we describe how we construct harmonized time series estimates adjusting for population control revisions. Our approach begins by constructing a new set of harmonized population controls, and then follows the BLS' current methodology to construct new CPS microdata weights that reflect these harmonized population controls. With these new weights, we replicate the BLS' composite estimation and adjustment procedures to arrive at time series consistent with the latest population data. These time series replicate to the best of our ability what the BLS would have published if they had the harmonized population series, which reflects the latest population data, at the time they were constructing their estimates.

3.1. Harmonized population controls

Our methodology for constructing harmonized population controls involves combining estimates across five decades and adjusting for differences across time. We provide a high-level overview below, with the full details provided in appendix B.

As mentioned previously, the BLS uses population estimates from the Census Bureau's PEP as external population controls in constructing the CPS weights. These monthly estimates cover the period in between decennial censuses and the estimate for a specific month starts with a population base from the previous decennial census, adds births, subtracts deaths, and adds net migration.[1] Estimates of the population flows are based on a number of different data sources, for example births and deaths are estimated from data collected by the National Center for Health Statistics (NCHS). However, many data sources are only released with a lag (e.g., NCHS data is about two years lagged), and so the population estimates for

1. U.S. Census Bureau (2023) contains a detailed description of the methodology for the Vintage 2023 estimates.

the most recent several years of a vintage are necessarily based on projections of some source data.

Each year, PEP releases a new vintage of estimates incorporating updated source data and projections. As a result of the incoming data and revised projections, the new vintage may differ from the previous vintage over all months back to the previous decennial census, although the largest revisions are typically in the most recent years. The new vintage will also extend one year further than the previous vintage. Once every ten years, the new vintage will also incorporate a new decennial census base and therefore will cover a much shorter period than the previous vintage. For example, the vintage released in 2011 was based on the 2000 Census and covered April 2000 to December 2011, while the vintage released in 2012 incorporated the 2010 Census and covered April 2010 through December 2012.

To form harmonized population series that reflects all available information, we combine two sets sets of information:

1. The decennial census counts are the most accurate information about the population and its characteristics — but they are not timely.
2. The postcensal estimates are the timeliest estimates of the monthly path of the population since the previous decennial census — but they are subject to error.

We combine these two sources, maximizing their individual strengths, resulting in harmonized population series that are free from discontinuities.

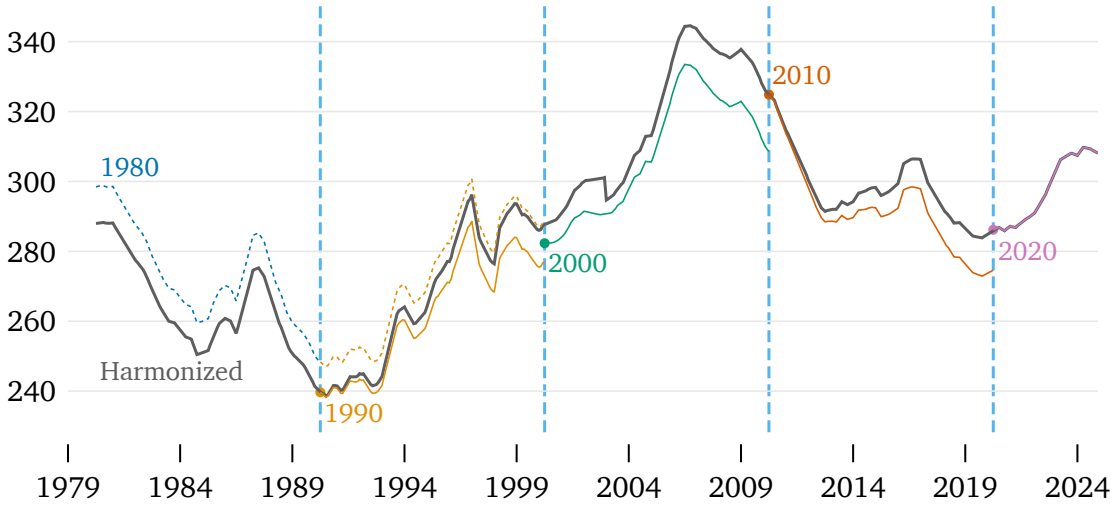
Specifically, we adjust the time series from the last postcensal estimate for a decade, which contains the best estimate of the monthly path of the population over the decade, to smooth the transition between decennial census bases, which are the most accurate counts of the population at those two points in time.[2] Errors between the postcensal estimate and what the census count ultimately showed can arise because the PEP's method for estimating population stocks by accumulating flows is imperfect and leads to some projection errors.[3] Importantly, the ultimate postcensal error could arise from a combination of errors occurring at any points between decennial censuses, so our harmonized estimate redistributes this error evenly across the decade. These harmonized population series are constructed separately for each group defined by age, sex, race, and Hispanic origin.

2. Our harmonized estimates are what the Census Bureau calls "intercensal estimates", and we use the same methodology (U.S. Census Bureau 2024). We call our estimates "harmonized" to avoid confusion with the Census Bureau's official data product.

3. These projection errors are discussed further in Serrato and Wingender (2016), who use them as a source of exogenous variation in federal spending to estimate local multipliers.

Figure 2. Population of 16-year-old non-Hispanic Black men

Thousands



Note: Dashed vertical lines denote April of each decennial census year. Solid lines show civilian noninstitutionalized population and dotted lines show civilian population (which is the only basis available for estimates before April 1990). Solid circles denote the decennial Census base.

Source: Census Bureau and author's calculations using data from the Census Bureau.

An example helps clarify these ideas. Figure 2 shows our harmonized estimate of the population for 16-year-old non-Hispanic Black men along with the relevant vintages of Census Bureau estimates. The orange line is the last postcensal estimate jumping off the census base for April 2010 (shown by the orange circle). The pink circle shows the census base for April 2020, and the gap between the last point of the orange line and the pink circle is the postcensal error. Our harmonized population estimate for this group, the gray line, smooths the postcensal error back (geometrically) to the April 2010. The pink line is the latest postcensal estimate for the current census base. Since this is the best available estimate, our harmonized series is equal to the postcensal estimate from April 2020 forward.

There are two implementation challenges with this approach worth noting, along with how we address each:

Race categories during 2000–02: The 2000 census was the first to allow respondents to check as many boxes as necessary to identify their race, whereas in previous censuses responses to the race question were limited to a single category. The CPS would eventually adopt the same survey approach, but not until January 2003. As a result, the PEP estimates for 2000–02 are not comparable to the race cate-

gories identifiable in the CPS microdata. We account for this in three steps (which are described in more detail in section B4.1 of the appendix):

1. We take the PEP estimates released in 2011 (the last to be based on the 2000 census) and adjust for the April 2010 decennial census wedge using the geometric formula given above. This delivers monthly estimates for 2000–02 on a multi-race basis.
2. We then convert these estimates from a multi-race basis to a single-race basis. We assume that respondents who identify as a particular race alone in the multi-race basis would identify as that race in the single-race basis. For respondents identifying as a combination of races, we assume that they would be equally likely to identify as any race in the combination under the single-race basis. This delivers single-race-basis estimates for 2000–02.
3. We can additionally take the single-race basis estimate for April 2000 and use it to compute the decennial census wedge for that date, comparing against the last PEP estimate for April 2000 based on the 1990 census (which used the single-race survey question). Smoothing this wedge back geometrically (following the formula above) gives single-race-basis estimates for 1990–2000.

The result of these steps are population series reflecting the latest estimates and are consistent with the CPS questionnaire over 1990–2002.

1980–1990 estimates basis: The latest vintage of PEP estimates covering 1980–90 are only available at a quarterly frequency and only cover the civilian population (CP). To get monthly estimates for the CNP, we make two adjustments. First, we interpolate the quarterly series to monthly. Second, we multiply each estimate by the ratio of CNP to CP on April 1990, separately by demographic group.

3.2. Replicating reweighting and composite estimation

With a set of consistent, harmonized population estimates in hand, we then replicate the BLS' weighting procedure using these new population controls. Since the published microdata weights already include the adjustments based on geography (described above in the first phase of the BLS weighting), we do not need to replicate this step. We take the published second-stage weights and then replicate the second phase of the BLS weighting using the new population controls.

The first step in reweighting is replicating the "national coverage step". We divide CPS respondents into demographic cells defined by the intersection of age, sex,

race, ethnicity, and month-in-sample (see Table 2-3.1 on page 72 of *Technical Paper 77* for the cell definitions). For a demographic cell d, we modify the published second-stage weights $w_{i,t}^{SS}$ of individuals in the group to match the external population control $\tilde{p}_t^{\text{Harmonized}}(d)$, giving the national-coverage-adjusted weight $w_{i,t}^{NC}$:

$$w_{i,t}^{\text{Natl. coverage}} = w_{i,t}^{\text{Second stage}} \left(\frac{\tilde{p}_t^{\text{Harmonized}}(d)}{\sum_{i \in d} w_{i,t}^{\text{Second stage}}} \right) \quad \text{for } i \in d \tag{1}$$

The next step is to replicate second-stage weighting. CPS respondents are divided into two distinct sets of groups: one defined by the intersection of race, sex, age, and month-in-sample; and one defined by the intersection of ethnicity, sex, age, and month-in-sample. For ten iterations, weights are updated to match each of these targets in turn. At each iteration, the previous weights $w'_{i,t}$ are updated into new weights $w''_{i,t}$:

$$w''_{i,t} = w'_{i,t} \left(\frac{\tilde{p}_t^{\text{Harmonized}}(d)}{\sum_{i \in d} w'_{i,t}} \right) \quad \text{for } i \in d \tag{2}$$

using each of the definitions of demographic group cells d. This iterative proportional fitting, or "raking", procedure ensures that both sets of targets are matched as well as possible (Stephan 1942).

We note that our procedure omits the state-level weighting steps in the BLS' procedure. Between the national coverage step and second-stage weighting, the BLS implements a "state coverage step" which matches state-level demographic totals. Also, during second-stage weighting, the BLS targets a third set of population controls at the state/sex/age level, in addition to the race and ethnicity targets that we use in our replication. The PEP estimates that form the external population controls do not include state-level monthly estimates of the CNP by demographic group, so we are unable to directly replicate the state weighting steps with these estimates. Incorporating state-level population controls is outside the scope of the current analysis, but this is a fruitful direction for future research.

After replicating these steps, we can produce second-stage weights consistent with our harmonized population controls. These weights are updated at the individual level in the microdata, making it possible to reproduce any analysis in the microdata in a way that is consistent with harmonized population. Researchers can benefit from these weights in that they do not require any changes to researchers' methodologies, only using a new weight variable instead of the published weights.

For calculating monthly averages (or any other moment) in the microdata, the second-stage weights are the preferred choice of weight.

To produce time series for major labor force statistics (e.g., unemployment, LFPR), we replicate the BLS' composite estimation procedure described on pages 76–78 of *Technical Paper 77*. We verified that our procedure exactly replicates the BLS' composite estimates when using the published second-stage weights, lending credence that our estimates using our new population controls are consistent with the BLS' methodology.[4]

An additional benefit of our replication is that we can construct composite estimates consistently for the entire period that CPS microdata are available. The BLS's current composite estimation procedure was introduced only in January 1998 and this is also the first time that composite weights are present in the PUMF.[5] We follow the BLS' recent approach of constructing convenience weights in the microdata that can be summed within each month to deliver the composite estimates.

3.3. Seasonal and other time-series adjustments

To maximize compatibility with published estimates, we use published seasonal factors instead of re-estimating seasonal factors. Our focus in this analysis is on the effect of adjusting for population controls, and so re-estimating seasonal factors would risk complicating the differences between our estimates and published series by introducing an additional margin along which they could differ. Nonetheless, adjusting for population controls could affect the seasonality of the series,

4. We are able to replicate the BLS' composite estimates for most months from 2003 through 2010, which is the period using the modern composite estimator and before the BLS began perturbing respondent information in the public-use microdata files (PUMF). Beginning in January 2011, the Census Bureau incorporated additional safeguards in the CPS PUMF to ensure that respondent identifying information is not disclosed. In general, respondents' ages were altered, or "perturbed," in the PUMF to further protect the confidentiality of survey respondents and the data they supply; see https://www.census.gov/programs-surveys/cps/technical-documentation/user-notes/cpsbasic_2013_01.html. Thus, although we cannot exactly match the BLS' published estimates, which are based on unperturbed data, our estimates are very close.

5. Under the old procedure, composite estimation was performed at the macro level, combining the second-stage estimate for the current month with the composite from the preceding month and an estimate of change from preceding to current month. Over time, the CPS refined the composite, updating the weights used in the weighted average as well as adding a component that captures the net difference between the incoming and continuing parts of the current month's sample. See U.S. Bureau of Labor Statistics and U.S. Census Bureau (2019) and U.S. Bureau of Labor Statistics and U.S. Census Bureau (2002).

and so re-estimating seasonal factors might deliver notably different estimates.[6] We view this step as a useful extension for future research to consider.

The CPS implemented a major redesign in January 1994, which led to changes in the measurement of many of the estimates derived from the CPS. We apply adjustment factors from Polivka and Miller (1998) to our time-series estimates from 1948–93, so that the resulting series are comparable to the post-redesign measures.

Additionally, we extend key time series back to 1948, by adjusting the published series for known breaks. CPS microdata is only available starting in 1976, so for earlier years we append the published time series, which were based on the same survey but for which microdata has not been released. We identify the dates in which updated population controls were introduced into these series using historical copies of the *Employment and Earnings* report, and collect information about the size of discontinuities introduced by each break. Similar to our approach using PEP estimates, we smooth these breaks geometrically back to the previous decennial census to get consistent population, employment, and unemployment series.

4. Results

Our time series estimates based on harmonized population controls provide new estimates of headline labor force statistics. In this section, we present several of these series and describe the important differences relative to published series. Particularly in the post-pandemic period, our series show notable differences from published LFPR and population estimates, both overall and for specific groups. However, the unemployment rate has been less affected by revisions to population estimates.

4.1. Headline series

We start by presenting updated estimates for population, LFPR, and the unemployment rate. These headline measures constructed from the CPS are among the most examined labor market indicators.

Our population estimates are notably smoother than published data. Panel (a) of figure 3 shows the CNP for men and women 16 years and older. The published versions of these series have sharp time-series breaks stemming from population

6. Additionally, if we re-estimated seasonal factors, we would be able to estimate factors for January in the same way as other months, in contrast to the official estimates which are affected by controlling for a level shift each year due to the introduction of population controls.

control revisions, which are not present in our series. As shown in panel (b), our harmonized estimates can be either above or below the published series and these differences can persist for substantial periods (e.g., our estimate for men is more than 1 million above the published series for most of 2017 to 2021). Moreover, the differences vary by characteristics, and not necessarily in offsetting ways.

As shown in figure 4, our harmonized estimate of the LFPR (the blue line) differs from the published series (the green line). Our harmonized estimate is more than 0.4 percentage point (pp) above the official estimate in 1976, mostly reflecting the adjustment for the CPS redesign, which boosts our estimate by 0.4 pp over 1976–93. (The upward shift in the published LFPR in January 1994 is visible in the upper panel). The published series jumps above our estimate in 1994, because we adjust for the CPS redesign but the published series does not, and remains about 0.2 pp above over the 2000s. The published series falls below our harmonized series in 2012, when BLS first incorporated population estimates based on the 2010 Census into the CPS, with the gap rising to about 0.4 pp at the start of 2020. The published LFPR jumped more than 0.2 pp in January 2022, when population estimates based on the 2020 Census were introduced, narrowing much of the gap to the harmonized series.

Despite the sizable differences in population and LFPR, our estimate for the unemployment rate is generally quite close to the published series. In fact, the two series in figure 5 are well within one-tenth from 1994 forward. Prior to 1994, the harmonized series is somewhat above the published series, reflecting two factors. First, adjusting for the CPS redesign added 0.1 pp to the pre-1994 series. Second, the introduction of population estimates based on the 1990 Census raised the relative population and labor force shares of younger people, who tend to have higher-than-average unemployment rates.

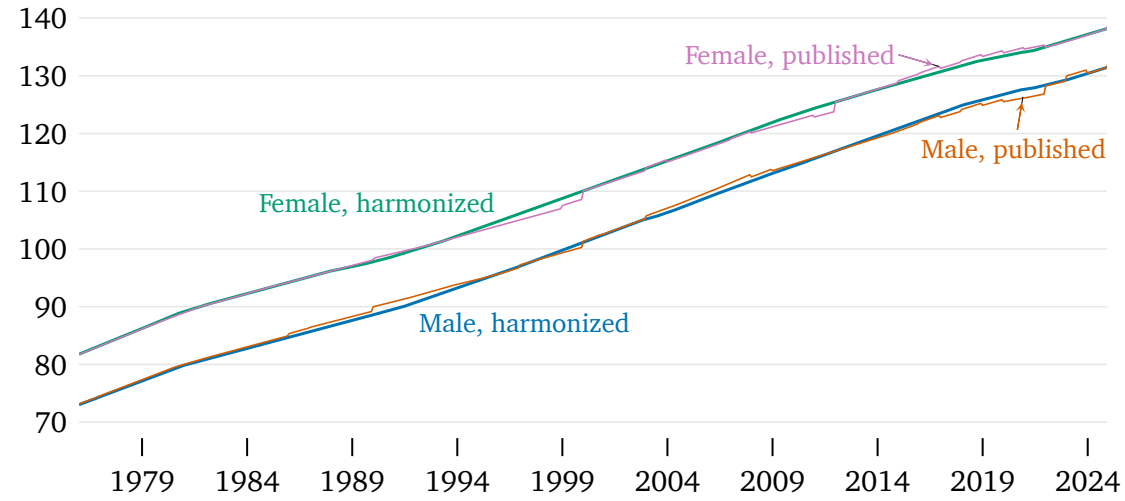
4.2. Recovery of labor force participation after the COVID-19 pandemic

Accounting for population controls has been important for understanding the recovery in LFPR following the pandemic. Updated population controls released since 2020 have seen fairly large revisions from several novel factors, including the incorporation of 2020 Census and revisions to mortality source data to reflect excess deaths during the pandemic. Each of these factors are likely to change population differentially across demographic groups, especially across the age distribution, which has important consequences for the LFPR. Our approach corrects for these factors in a consistent way across the history of the series, allowing for separate revisions to each time period depending on the underlying source data.

Figure 3. Civilian noninstitutionalized population 16 years and older

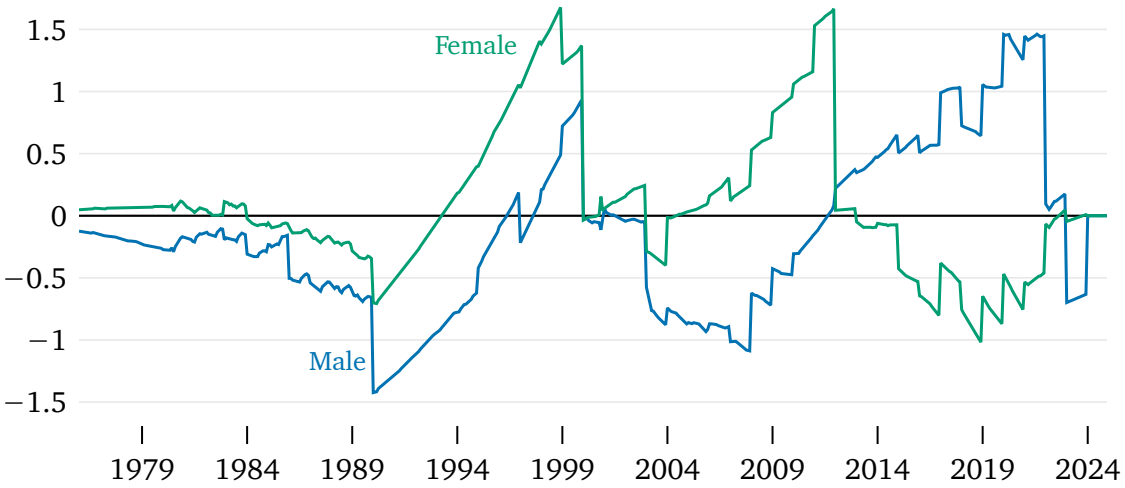
(a) Harmonized and published estimates

Millions



(b) Difference between harmonized and published estimates

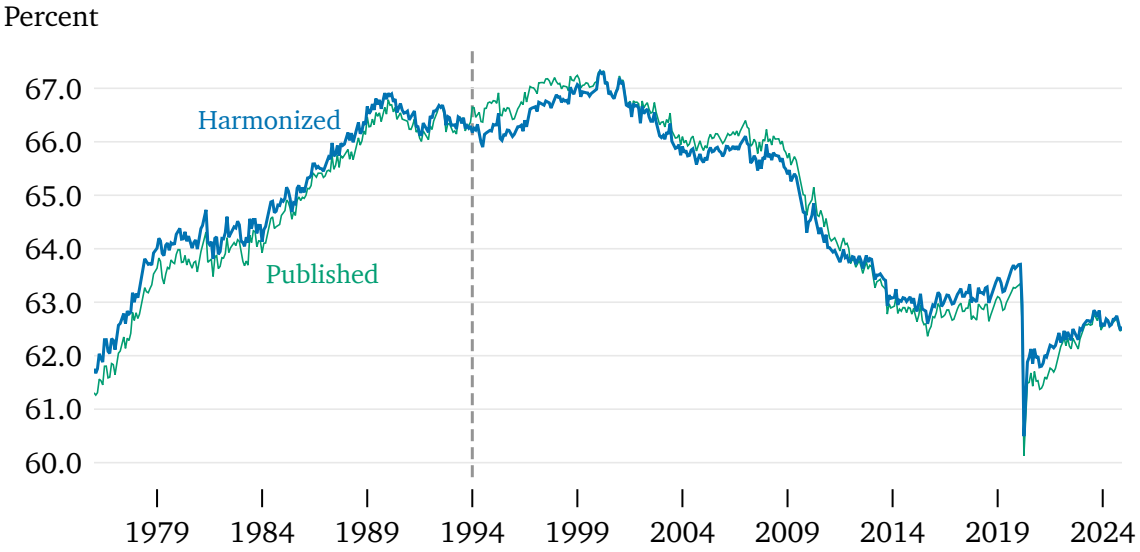
Millions



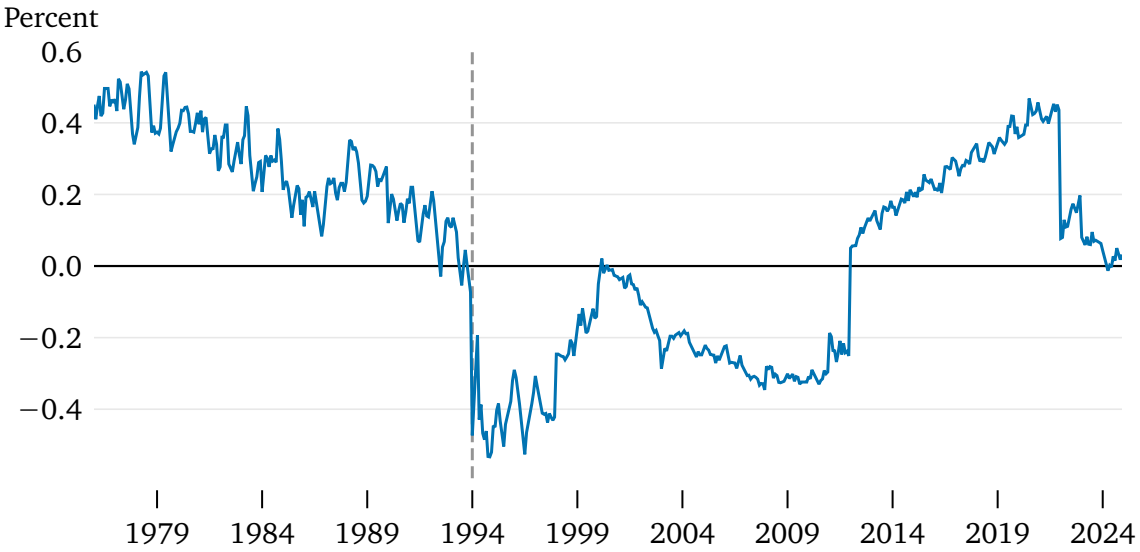
Source: Bureau of Labor Statistics (BLS) and author's calculations using data from the Census Bureau and the BLS.

Figure 4. Labor force participation rate, harmonized and published

(a) Harmonized and published estimates



(b) Difference between harmonized and published estimates



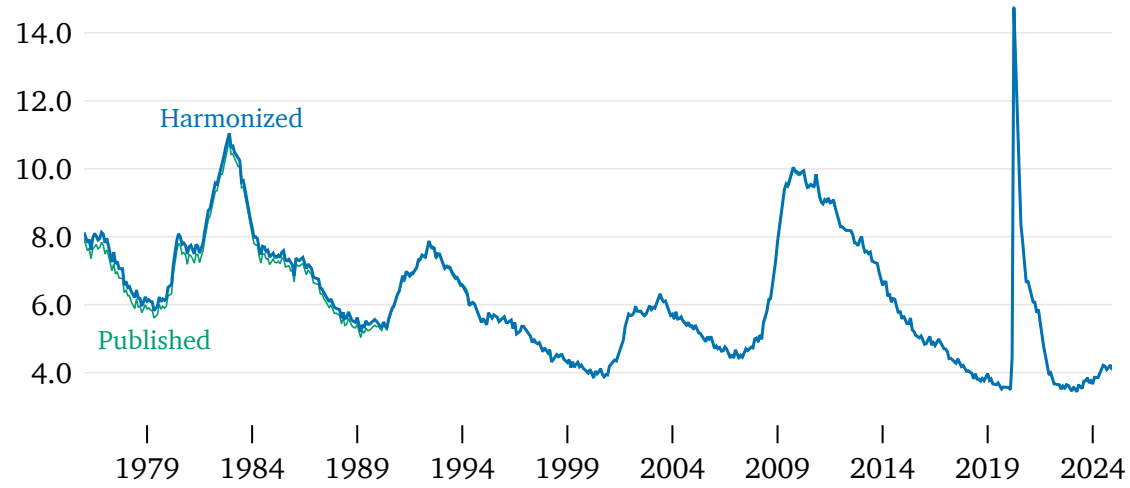
Note: Individuals 16 years and older. Vertical line denotes January 1994, when the CPS redesign was implemented.

Source: Bureau of Labor Statistics (BLS) and author's calculations using data from the Census Bureau and the BLS.

Figure 5. Unemployment rate, harmonized and published

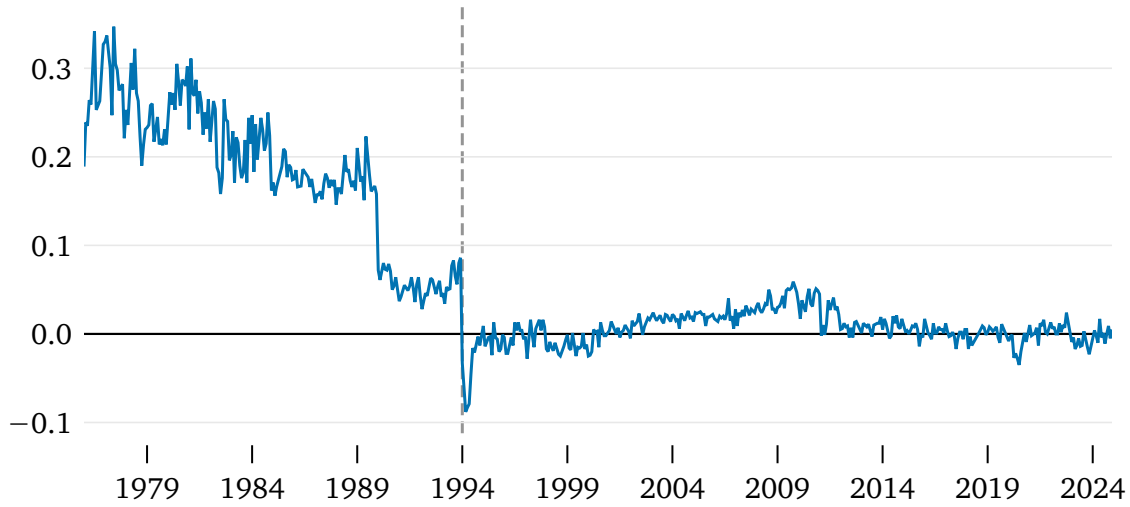
(a) Harmonized and published estimates

Percent



(b) Difference between harmonized and published estimates

Percent

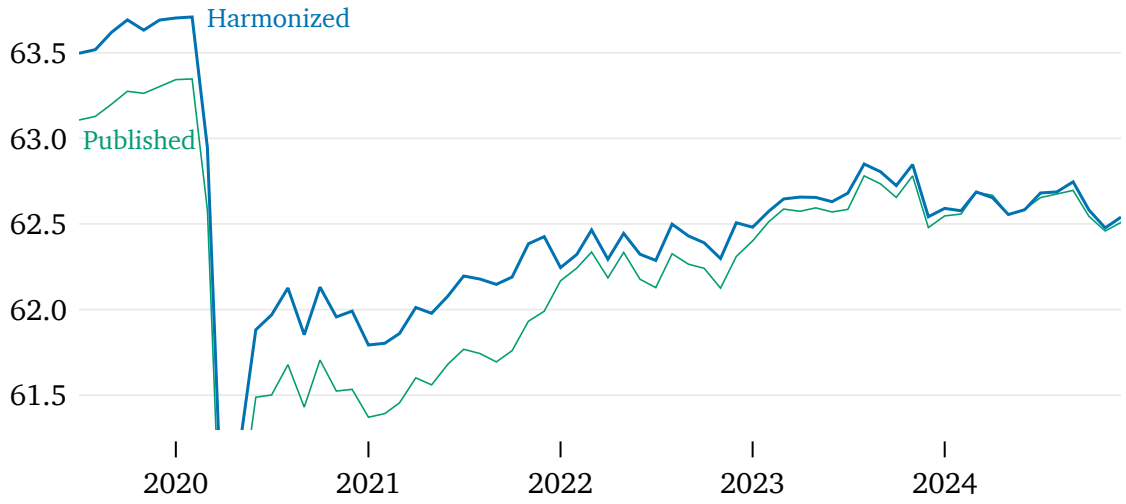


Note: Individuals 16 years and older. Vertical line denotes January 1994, when the CPS redesign was implemented.

Source: Bureau of Labor Statistics (BLS) and author's calculations using data from the Census Bureau and the BLS.

Figure 6. Labor force participation during and after the pandemic

Percent



Source: Bureau of Labor Statistics (BLS) and author's calculations using data from the Census Bureau and the BLS.

Figure 6 compares our LFPR estimate to the published series, showing several notable differences. First, our estimate is 0.4 pp higher than the published series on the eve of the pandemic in February 2020. This difference stems largely from the difference between the PEP estimates over the 2010s and the final count from the April 2020 decennial census, the latter of which saw upward revisions to population for high-LFPR age groups, particularly men 35–60 years old, and downward revisions to population for low-LFPR groups, especially men and women over 75. Incorporating this revision into the population controls, as our method does but the published data do not, results in a higher estimate for LFPR pre-pandemic.

Second, our estimate shows a more consistent pace of recovery from mid-2020 through mid-2023. Over this period, LFPR rose ¼ pp per year, with only modest fluctuations around this trend. In contrast, the published data show a notable pickup in the pace of recovery of LFPR in late 2021 into early 2022. However, this is entirely accounted for by the population control revision implemented in January 2022, which revised up the LFPR by 0.2 pp that month. Smoothing out this break, as our estimate does, reveals the steady pace of LFPR improvement in the post-pandemic period.

Third, as a result of these differences, our estimate delivers a more accurate assessment of the gap between pre- and post-pandemic LFPR. The population control revision implemented in January 2022 incorporated both the new decennial census

base for 2020 and updated estimates of mortality for 2020. Each of these factors could explain why the population of low-LFPR age groups revised down, and thus why the LFPR in early 2022 revised up, but they would have very different implications for whether the February 2020 LFPR would revise up. Our approach relies on the underlying population estimates to distinguish between these factors, so we do not need to make assumptions about how historical population revised. In this case, our estimate for February 2020 LFPR also revised up by 0.2 pp, indicating that the 2020 Census data were the dominant factor. As a result, the gap between pre- and post-pandemic LFPR in our estimates was unchanged from this revision (since both revised up 0.2 pp), while the gap for published estimates revised to be 0.2 pp narrower. In this way, the published estimates overestimated LFPR recovery relative to pre-pandemic conditions starting in 2022, while our estimates do not.

5. Conclusion

In this paper, we outline a methodology for producing harmonized population and labor force estimates. Our approach addresses the issue of yearly discontinuities in official statistics and CPS microdata, providing a set of time series consistent with the latest population estimates. These series shed new light on the post-pandemic labor market recovery, and the accompanying microdata weights offer researchers a straightforward solution to produce their own adjusted labor force statistics.

Although we focus on harmonizing official estimates of population, our approach could also be used to produce labor force statistics consistent with alternative population estimates. Recent years have seen substantially higher rates of net immigration into the United States than initially projected, but the next set of population estimates and projections by the Census Bureau accounts for this surprise and we plan to incorporate these revised estimates when the detailed demographic data are released later this year. However, if immigration was continuing to outpace projections (or fell below current projections), one would only need to add or subtract an estimate of this error to the demographic-specific population estimates and then follow our methodology to produce time series that reflect these population surprises.

We also leave to future work some additional improvements to this methodology. We have replicated the BLS' procedures for weighting to match demographic population controls, but in the future it would be helpful to additionally replicate matching the geographic targets as well. We also have not explored estimating seasonal factors for our harmonized series, which are likely similar to the seasonal factors for published series that we use, but could differ somewhat in practice.

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Appendix

A. Data sources

Our population estimates are derived primarily from data published by the U.S. Census Bureau's Population Estimates Program (PEP). For most periods, the PEP publishes estimates of the monthly national civilian noninstitutionalized population (CNP) by age, sex, race, and Hispanic origin. (We refer to age, sex, race, and Hispanic origin collectively as "characteristics".)

We use the PEP's **postcensal estimates**. "Each year, PEP utilizes current data on births, deaths, and migration to calculate population change since the date of the most recent decennial census and produce time series of estimates of population. The time series begins with the date of the most recent decennial census data and extends to the vintage year. Each vintage of estimates includes all years since the most recent decennial census, the latest vintage of data available supersedes all previously produced estimates for those dates." This contrasts with intercensal estimates, which smooths the transition from one decennial census count to the next.[7]

B. Methodology

We construct a harmonized monthly time series for the CNP by characteristics from January 1976 through December 2024. This requires merging population estimates from 6 decennial census bases:

- 1970 Census base (January 1976 to March 1980)
- 1980 Census base (April 1980–March 1990)
- 1990 Census base (April 1990–December 2002)
- 2000 Census base (January 2003–March 2010)
- 2010 Census base (April 2010–March 2020)
- 2020 Census base (April 2020–present)

B1. Calculating intercensal estimates

The Census Bureau's official intercensal estimates by characteristics are produced only for the resident population. Thus, we construct estimates for the CNP using

7. "Intercensal estimates are produced each decade by adjusting the existing time series of postcensal estimates for a decade to smooth the transition from one decennial census count to the next. They differ from the postcensal estimates that are released annually because they rely on a formula that redistributes the difference between the April 1 postcensal estimate and April 1 census count for the end of the decade (known as the error of closure) across the estimates for that decade."

the same methods as the Census Bureau.[8] Specifically, the Das Gupta method assumes that the ratio of the intercensal estimate to the postcensal estimate should follow a geometric progression over the decade

$$\frac{P_{it}}{Q_{it}} = \left(\frac{P_{iD}}{Q_{iD}}\right)^{t/D} \tag{B.1}$$

where

t = days elapsed since April 1 of previous census base
P_{it} = Population estimate for group i at day t
Q_{it} = Postcensal estimate for group i at day t
P_{iD} = April 1 population count for group i from previous census base
Q_{iD} = April 1 postcensal estimate for group i based on current census base

Equation (B.1) can be re-arranged to express P_{it} as a function of the postcensal estimate and the gap between the postcensal estimate and the new census base.

$$P_{it} = Q_{it} \times \left(\frac{P_{iD}}{Q_{iD}}\right)^{t/D}. \tag{B.2}$$

Geometric interpolation is not appropriate in some situations; in those cases we use a linear interpolation:[9]

$$P_t = P_D \times (t/D) + P_0 \times [(D-t)/D]. \tag{B.3}$$

We estimate these smoothed time series separately for each group (age, sex, race, and Hispanic origin).

B2. 1970 Census base (January 1976 to March 1980)

The Census Bureau does not have monthly estimates of CNP by characteristics before the 1980 Census base, so we used the Bureau of Labor Statistics's published estimates of the CNP by sex, age group, and race as independent targets. These characteristic groups become the starting points for calculating the population targets.

We take the monthly published population for 48 characteristic groups by sex, age (16–17, 18–19, 20–24, 25–34, 35–44, 45–54, 55–64, and 65 and older), and race (White, Black, and all other races). There are no breaks in the published levels;

8. See, for example, U.S. Census Bureau (2024).
9. [Describe where not appropriate.]

however, as they were postcensal estimates from the 1970 Census base, we need to construct an intercensal estimate so that they match the 1980 Census base. To do this, we calculate the April 1980 CNP for these groups from the 1980 Census base (described in appendix B3) and smooth the error of closure back to April 1970.

B3. 1980 Census base (April 1980 to March 1990)

There are no monthly population estimates by characteristics. We start with quarterly estimates of the civilian population (CP) by characteristics and interpolate them to monthly using the geometric method where applicable and the linear method otherwise. We then sum the interpolated monthly values to a national total and rake that to the published monthly national population total.

Next we create an estimate of the CNP. From the 1990 Census base, which reported estimates by characteristics for the CP and CNP, we calculate the ratio of the CNP to CP on April 1, 1990. We then multiply our CP estimates from the 1980 Census base by that ratio.

B4. 1990 Census base (April 1990 to December 2002)

Two major changes to the race categories took place between the 1990 and 2000 censuses:[10]

1. In previous censuses, responses to the race question were limited to a single category; in 2000, for the first time, respondents could check as many boxes as necessary to identify their race.
2. The "Asian and Pacific Islander" category was separated into "Asian" and "Native Hawaiian or Other Pacific Islander".

The new race categories were first introduced in the Current Population Survey (CPS) in January 2003. Thus, in order to calculate the error of closure for 1990 postcensal estimate, we must first estimate the 2000 Census base on a single-race basis so that it is comparable to the 1990 Census base.

Before January 2003, the CPS was controlled to 3 race categories: "White", "Black", and "all other races". (Hispanic origin is considered an ethnicity, not a race. Hispanics may be of any race.) From January 2003 forward, the CPS was controlled to 4 race categories: "White alone", "Black alone", "Asian alone", and "all other races" (alone or in combination).

10. See revision to OMB Statistical Policy Directive No. 15, *Race and Ethnic Standards for Federal Statistics and Administrative Reporting* for details.

We create population targets for 1990–2002 in three steps. The first step is to calculate the intercensal estimate for 2000–10 on a multi-race basis from the 2000 Census base. We need to do this because the postcensal estimates for 2000–02 don't incorporate revisions stemming from the 2010 Census. This ensures that the population from April 2000 to December 2002 is consistent with the *2010* Census base.

The second step is to convert the intercensal estimate from step one to a single-race basis. The total for a race on a single race basis is equal to the number reporting that race alone, plus a fraction of those reporting that race in combination. (The next section describes how that fraction is calculated.) This provides the April 2000 population level that is consistent with the 1990 race categories.

Finally, the third step is to compute the error of closure for April 2000 (on a single-race basis) and create the intercensal estimate for 1990–2000.

B4.1. Estimating single-race categories for the 2000 Census base

From 2000 forward, the postcensal estimates by characteristics published by the Census Bureau report race for 5 race categories

- White
- Black or African American
- American Indian and Alaska Native
- Asian
- Native Hawaiian and Other Pacific Islander

The data include estimates for "*R* alone" and "*R* alone or in combination", as well as a category for two or more races.

To make these categories historically comparable for the CPS population targets, we need to reclassify a fraction θ_R of individuals in the "*R* in combination" category as in the "*R* alone" category.

The total for a race on a single-race basis is equal to the number reporting that race alone, plus a fraction of those reporting that race in combination. The assumption underlying our adjustment is that those reporting a combination would have been equally likely to report any of their races under the single race concept.

The number of people reporting a combination including race *R* is equal to the number reporting *R* either alone or in combination (*rac*) minus the number reporting *r* alone (*ra*). Summing this across races will double count these individuals,

Table B1. CPS ethnicity-race categories and time periods

CPS ethnicity-race category	Single-race (1976–2002)	Multi-race (2003–24)
Not Hispanic, White/White alone	✓	✓
Not Hispanic, Black/Black alone	✓	✓
Not Hispanic, Asian alone		✓
Not Hispanic, All other races	✓	✓
Hispanic, White/White alone	✓	✓
Hispanic, Black/Black alone	✓	✓
Hispanic, Asian alone		✓
Hispanic, All other races	✓	✓

so the total should be roughly twice the number of people reporting two or more races. This ratio is θ_R.

For each category *R*, the first-stage adjustment is

$$\delta_R = \max\left(0,\ \frac{Rac}{Ra} - 1\right), \tag{B.4}$$

which is the fraction of "*R* alone or in combination" that exceeds "*R* alone". However, because individuals can select as many races as necessary, the first-stage adjustment may not sum to the "two or more" category. To account for this, define

$$\Theta = \frac{(wac - wa) + (bac - ba) + (iac - ia) + (aanac - aana)}{tom}, \tag{B.5}$$

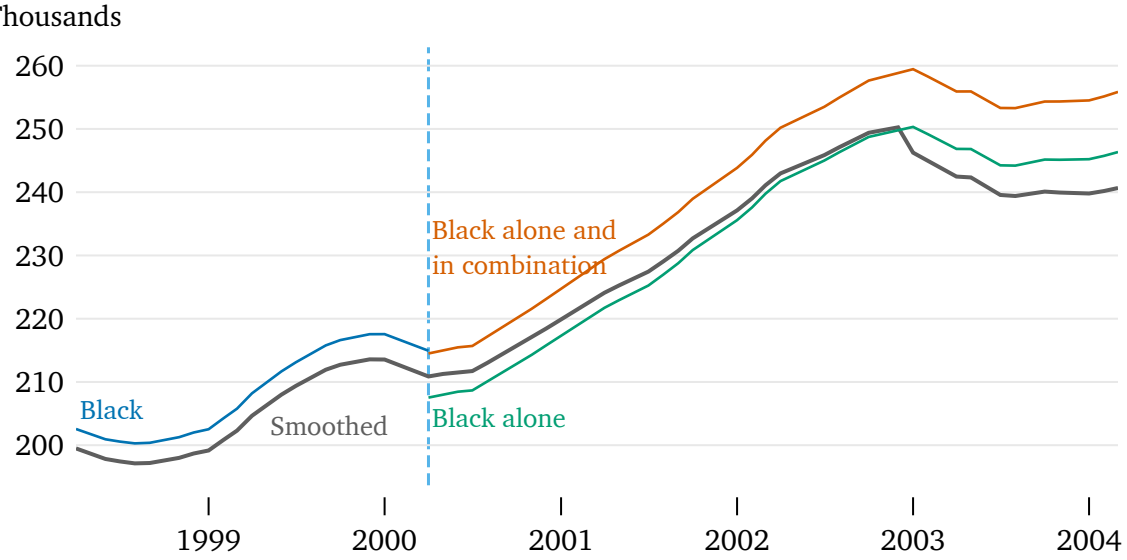
which accounts for the fact that the sum of the "in combination" races is greater than the total population. Θ is a bit bigger than 2 (since every person who selects more than one race picks at least 2).

All told, the adjustment is

$$\theta_R = 1 + \frac{\delta_R}{\Theta}. \tag{B.6}$$

The ratios are calculated from the Vintage 2009 data (intercensal estimate, to account for errors from the 2010 Census) and is done separately for each month, sex, age, and ethnicity. After the adjustment, we sum the population to race and ethnicity categories that existed in the single race concept.

Figure B1. Population of 22-year-old non-Hispanic Black men



Source: Author's calculations using data from the Census Bureau.

B5. 2000–2020 Census bases (January 2003 to December 2024)

Calculating the 2000–10 and 2010–20 intercensal estimates is straightforward, as the postcensal estimates for this period contain all the necessary information. The general procedure is to calculate the error of closure for the last postcensal vintage and smooth that to the previous census base. (See section B1 for details.) The latest available postcensal estimate of the national population by characteristics for the 2020 Census base is Vintage 2023.[11]

B6. Adjustments for the CPS redesign

As Polivka and Miller (1998) detail (p. 2), in January 1994, the CPS underwent a major redesign both in the wording of the questionnaire and the methodology used to collect the data. The objective of the redesign was to improve the quality and expand the quantity of available data. However, the redesign also caused changes in the measurement of many of the estimates derived from the CPS. Polivka and Miller estimate adjustment factors for various aggregate measures derived from the CPS in order to permit comparisons of estimates before and after the redesign.

11. See Monthly Population Estimates by Age, Sex, Race and Hispanic Origin for the United States: April 1, 2020 to July 1, 2023 (with short-term projections to December 2024).

We apply their adjustment factors to our time-series estimates from 1976–1993, so that the resulting series are comparable to the post-redesign measures. We calculate labor force statistics for 30 groups (15 age groups $\times$ 2 genders). We use the multiplicative factors for labor force participation rate and employment-to-population ratio, by demographic group, to adjust the levels of the labor force and employment. The other labor force stocks are calculated by subtraction.