Inflation Inequality Across Time and Space in the United States

Jonathan S. Hartley* Jackson Mejia†

May 8, 2024

We develop a new real-time dataset for analyzing wage and inflation inequality in the United States from 1978 onward at both monthly and annual frequencies. We give several examples of how to use our data for research at different levels of geographic aggregation. At the national level, we present three main findings. First, we find that inflation is typically slightly higher for low-income households, but that this seems to only hold in a fifteen year period between the late 1990s and 2012. Second, we investigate if increases in the aggregate inflation rate lead to more inflation inequality. The correlational evidence is weak. Third, we find mixed evidence in support of the view that inflation volatility is hump-shaped along the income distribution. Our more novel contribution is documenting extreme inflation inequality between the nine Census divisions divisions. The degree of geographic inflation inequality typically is typically twice as large as income-based national inflation inequality.

*Department of Economics, Stanford University. Email: hartleyj@stanford.edu.

†Department of Economics, Massachusetts Institute of Technology. Email: jpmejia@mit.edu. This paper consolidates two separate papers on national inflation inequality and regional inflation inequality circulated by the Foundation for Research on Equal Opportunity (FREOPP) in 2022 and 2024, respectively. The 2022 paper, "Inflation's Compounding Impact on the Poor" examines national inflation inequality, while the 2024 paper is forthcoming under the title "The Disparate Geographic Impact of Inflation." Most of the second half of the paper is identical or quite similar to the latter. Our work is graciously supported by FREOPP. We benefited from enormously useful conversations, detailed comments, and editorial assistance from Avik Roy, Mike Franc, Jonathan Blanks, and Michael Tanner. Remaining errors are our own.

1 Introduction

There is a clear and pressing demand for real-time inflation inequality estimates from policymakers. Indeed, in January 2022, Federal Reserve Chair Jay Powell observed that "we control inflation for the benefit of all Americans, but…it's particularly hard on people with fixed incomes and low incomes who spend most of their income on necessities which are experiencing high inflation now." In this paper, we quantify the phenomenon that Powell describes through the creation of an inflation inequality index over both time and space for the United States. We meticulously follow the Bureau of Labor Statistics' own methods to create a long time series on inflation inequality which offers the ability to analyze wage and inflation inequality by income and geography from 1978 onward. Our data are hosted by the Foundation for Research on Equal Opportunity and are updated monthly in an effort to provide policymakers with real-time updates.

Toward demonstrating the utility of the data, we conduct several descriptive analyses of both income and geographic inflation inequality. With respect to income-based inflation inequality, we have several findings:

- The extent of inflation inequality depends on the inflation metric. Core and supercore inflation inequality are both more volatile and are higher on average.
- A large quantity of accumulated inflation inequality comes from the Great Moderation; inflation inequality before and after appears smaller.
- The evolution of inflation inequality during the pandemic depends significantly on whether one uses core, headline, or supercore inflation inequality.
- It would be important for policymakers considering an increase in the target inflation rate if higher inflation led to more inflation inequality, but the correlational evidence for that is weak. Under some specifications, core inflation Granger causes inflation inequality to rise, but the reverse direction is not true. Most specifications fail to support this. On the other hand, correlational local projections suggest that increases in aggregate inflation rates correspond to a decline in inflation inequality up to ten years after a unit increase in the aggregate inflation rate.
- The hump-shaped profile of inflation volatility across the income distribution largely disappears when using core inflation.

Our findings on income-based inflation inequality join a host of academic and policy work exploring the distributional effects of inflation. Notably, most researchers find that there is a small inflation premium for low-income households (Hobijn and Lagakos 2005; Jaravel 2019, 2021). Our findings largely align with theirs and to some extent with Cravino, Lan, and Levchenko (2020), which was an enormous help in putting together the data.

Researchers have devoted considerably less effort to geographic inflation inequality. We find this puzzling because geographic inflation inequality dominates income-based inflation inequality by a significant magnitude. Moreover, if we think there is something structural about geographic or income-based consumption demand, then analyses should probably focus more on the former than the latter because economic mobility is considerably higher than geographic mobility. For example, about two percent of Americans move to different states every year (Palarino, Pugh, and McKenzie 2023) whereas 34 percent of Americans see their incomes go up or decline by more than 25 percent annually (Elmi, Currier, and Key 2017).

An adequate visual summary of our contribution is in Figure 1. We plot cumulative inflation inequality by income, geography, and a combination of both. We define income inflation inequality as the ratio of price levels between the bottom and top of the income distribution, geographic inflation inequality as the ratio of the Census's Pacific region to the West North Central (the upper Midwest), and combining the two is the price level ratio between the bottom decile in the Pacific and the top in the West North Central. Researchers have generally focused on income inflation inequality but not geography to the same degree. In light of Figure 1, we view it as imperative to treat geographic inflation inequality with the same significance.

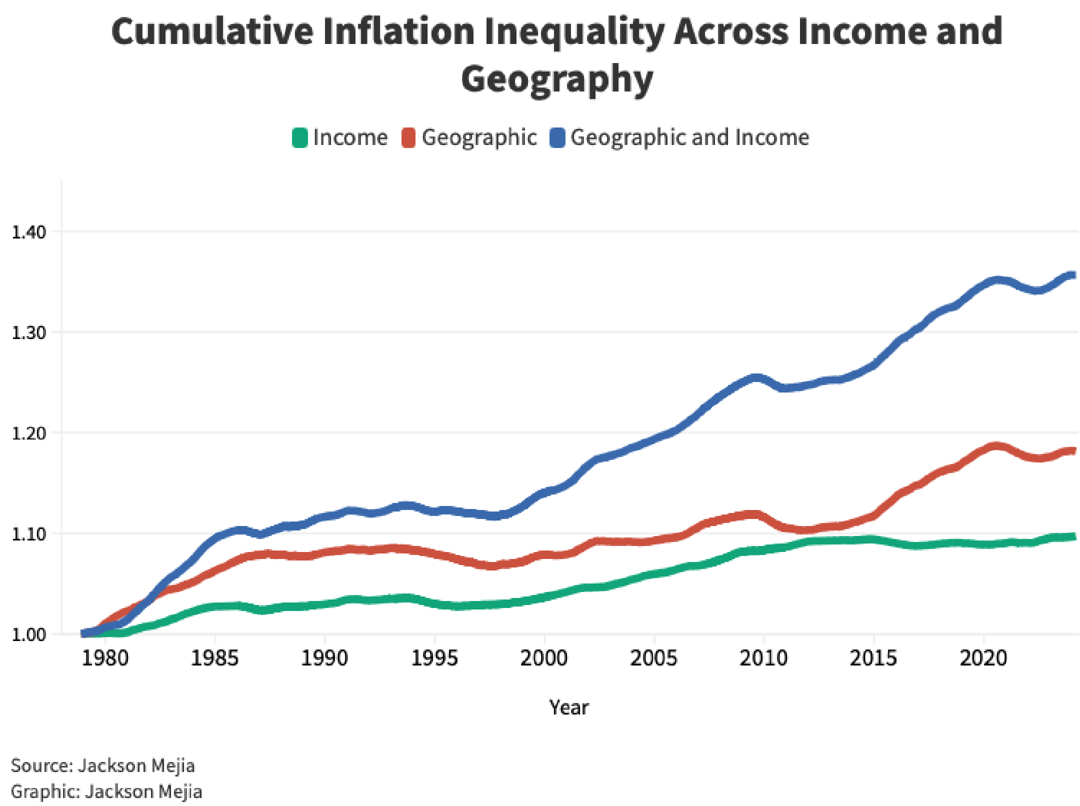


Figure 1: Cumulative inflation inequality by income is defined as the ratio of the bottom income decile to the top. Inequality by geography is the ratio of the Pacific region's price level to the West North Central region's price level. Combining both is the ratio of the bottom decile in the Pacific to the top in the West North Central.

There are several reasons to care about regional inflation inequality. First, many welfare programs adjust for inflation based on national inflation rather than regional inflation, let alone demographic-specific inflation within a region. With systematic inflation differences across regions over time, the benefits one receives may be degraded by inflation depending on where they live. Wimer, Collyer, and Caravel (2019) make a similar point about poverty thresholds at the national level. In that sense, even small inflation differences may have quite large welfare effects on the margin because they may push a household up or below poverty thresholds with resulting access to benefits. Second, a clear understanding of historical and contemporaneous regional inflation disparities is informative about the effects of monetary policy, the usefulness of targeted fiscal assistance, and political debates about the relevance of inflation. Third, precisely because inflation inequality varies substantially by region, real wages can vary even if nominal wage growth is equal across the country. Indeed, we find that the Midwest leads the country in real wage growth over the past forty years because their inflation was relatively tame.

Our results on geographic inflation inequality are striking:

- Geographic inflation inequality is significantly larger than income-based inflation inequality in the United States. Headline prices are 20% higher in the Pacific region than the Upper Midwest compared to 1979, whereas prices for the bottom income decile are only 10% higher cumulatively than the top income decile. Accounting for mobility would sharpen the difference.
- Taking account of nominal wage growth, real wage growth has been highest in the Midwest in the last forty years precisely because of inflation inequality playing such a large role. By contrast, the South has the worst performance among the bottom quartile of workers.
- There is no clear link between increases in aggregate inflation and geographic inflation inequality.
- Inflation inequality is highest where inflation has historically been least relevant (the Midwest).
- Since the beginning of the recent inflationary surge, there is significant heterogeneity in how quickly real wages have recovered by region.

We believe our work firmly meets the demand of former Obama CEA chair and current President of the Federal Reserve Bank of Chicago Austan Goolsbee's for more data on inflation inequality: "For all the talk about income inequality, we need a matching discussion about inflation inequality." We hope that researchers and policymakers agree.

Roadmap. In Section 2, we discuss data and methods, but defer a more detailed discussion to the appendix. Section 3 gives several examples for the importance of analyzing income-based inflation inequality at the national level, while Section 4 does the same at the regional level. We focus relatively more on regional inflation because researchers have studied income-based inflation inequality to a large degree already. Finally, we conclude in Section 5 with a discussion of the vital importance of deeper investigation into greater accuracy and precision of inflation at granular levels.

2 Data and Methods

In this section, we briefly summarize our data construction procedure. A detailed discussion is in the Appendix.

Our methodology largely follows Nakamura et al. (2018) and Cravino, Lan, and Levchenko (2020). For the national indices, it is almost entirely the same as the latter paper. We construct Laspeyres price indices for particular income quantiles, subnational geographic regions, and income quantiles within a subnational geographic region. These constitute our units of observation. To optimally balance geographic variation against concerns about data quality, we focus on the nine Divisions defined by the U.S. Census Bureau in Table 1. Our consumption data from the Consumer Expenditure Survey and the price data from the BLS.

Census Division	**States**
New England	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
Middle Atlantic	New Jersey, New York, Pennsylvania
East North Central	Illinois, Indiana, Michigan, Ohio, Wisconsin
West North Central	Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota
South Atlantic	Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, District of Columbia, West Virginia
East South Central	Alabama, Kentucky, Mississippi, Tennessee
West South Central	Arkansas, Louisiana, Oklahoma, Texas
Mountain	Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
Pacific	Alaska, California, Hawaii, Oregon, Washington

Table 1: Census Divisions and Corresponding States

With the Laspeyres index, it is important to define expenditure weights for each unit of observation. We use the Consumer Expenditure Survey (CEX) to do this and simply group households within the relevant unit of observation for every time period based on demographic data contained in the CEX. Note that the CEX is designed for accuracy at the national level, which means that our estimates should be used and interpreted with caution.

Price data are not at the same level of granularity as consumption data and are also less reliable, which means we need to map consumption into prices and there is some trade-off between precision and granularity. The BLS defines a hierarchy of prices for eight major groups of expenditures, around seventy expenditure classes, more than 200 item strata, and over 300 entry level items. Typically, prices are always available and reliable for major groups with decreasing availability and reliability down the hierarchy. We focus on mapping consumption into expenditure classes. This procedure is not trivial and is detailed in the Appendix. We are reasonably confident in the accuracy of our inflation series. In Figure 2, we plot the official BLS inflation rate against our construction. Our estimates suffer somewhat in the 1980s because CEX data availability forces us to use a 2004 consumption basket for all years prior to 2004. After 2004, we follow the expenditure basket dates from the BLS. This same problem plagues other researchers (Cravino, Lan, and Levchenko 2020).

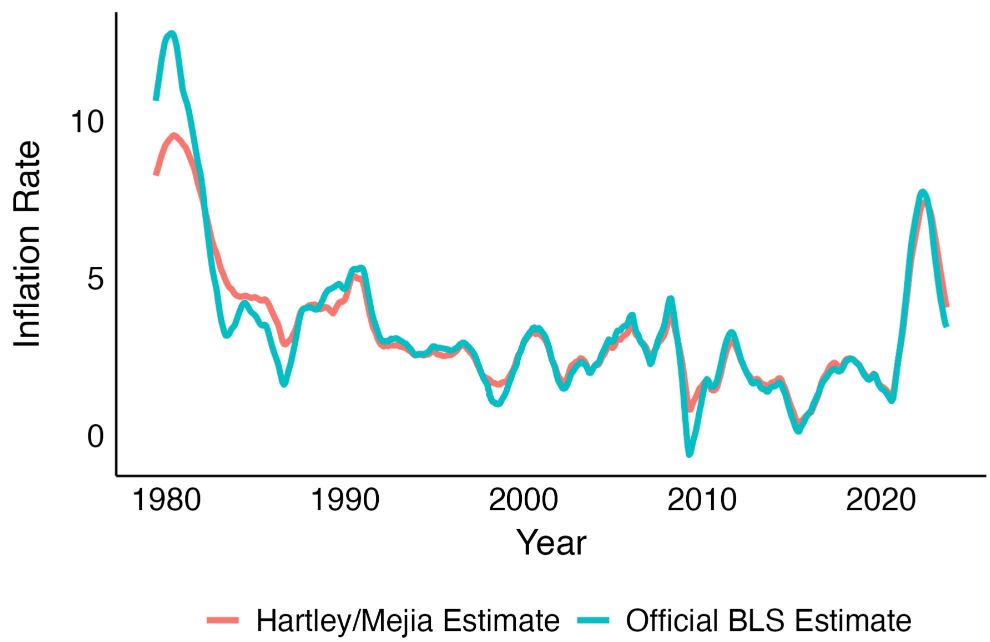


Figure 2: Official aggregate inflation plotted against our estimate based on micro consumption and price data.

Our price series for the geographic estimates are stitched together over time with increasing detail, which adds another layer of complexity to interpreting the estimates. Of the seventy expenditure classes, only around ten are surveyed at the subnational level. We apply national price series for the remainder. Until 2018, we map prices from the four Census Regions into their corresponding Census Divisions. Starting in 2018, BLS began surveying some prices at the Division level, which we use when possible. We compare our estimates to official monthly price level publications from the BLS in Figures 23, 24, 25, and 26 in the appendix. They perform quite well, albeit with some small differences.

In this paper, we refer to inflation inequality as the difference in inflation rates between groups i and j:

$$\mathcal{I}_t^{i,j} = \pi_{i,t} - \pi_{j,t}. \tag{1}$$

Alternatively, we could formulate it as a ratio:

$$\tilde{\mathcal{I}}_t^{i,j} = \frac{\pi_{i,t}}{\pi_{j,t}}.. \tag{2}$$

We prefer (1) because it is more relevant for welfare. Suppose $\pi_{i,t} > \pi_{j,t}$. If the aggregate inflation rate rises proportionally for all groups, then inequality under (2) would register no change in inequality even though it would rise under (1). However, under standard assumptions on utility, the change in welfare resulting from the rise in inflation is larger for group i than group j, so welfare inequality rises, which is precisely the reason we care about inflation in the first place.[1] Hence we use (1) as our definition of inflation inequality throughout.

We supplement our headline inflation inequality estimates with core and supercore inflation inequality. The former strips out energy and food, while the latter also strips out housing. We provide these because it is often claimed that these are potentially more relevant measures of inflation for policy. If so, then it is important to also have a notion of inequality within these measure. In Figure 3, we plot each of the three measures for the aggregate inflation rate.

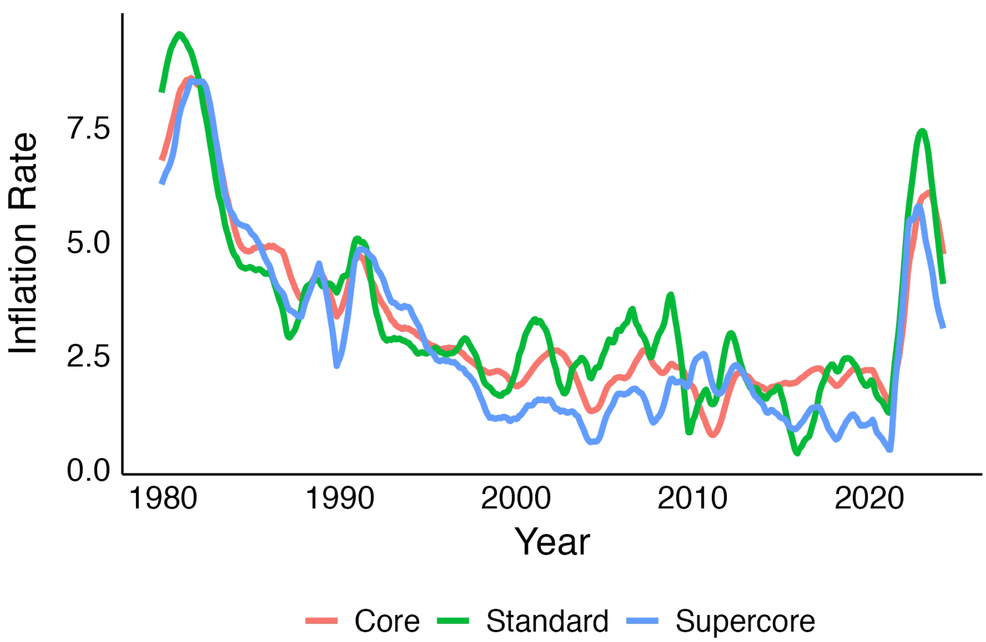


Figure 3: Headline, core, and supercore inflation for the aggregate smoothed with a twelve-month rolling average.

1. Oberfield (2023) shows that there are important theoretical exceptions to this, but which are beyond the scope of the paper for dealing with here.

Finally, we occasionally put together nominal wage growth with our inflation data by region and income group following the methodology of the Federal Reserve Bank of Atlanta's Wage Growth Tracker. We use monthly data from the Current Population Survey and cleaned by the Atlanta Fed on nominal wages from 1983 onward. Because the sample size is not very large, we use nominal wage growth for Census Regions rather than Census Divisions. To construct real wages by geography, we match Census Divisions (for inflation) with Census Regions (for wages) and subtract inflation from nominal wage growth. Note that this is intentionally casual: we do not carefully match the CEX sample to the CPS sample and so it is meant to be illustrative.[2]

3 National Inflation Inequality Indices

In this section, we present findings about inflation inequality across the income distribution. Our results largely serve to confirm an earlier literature on inflation inequality, but we augment them with additional evidence on core and supercore inflation inequality. In this section, inflation inequality always refer to the inflation rate of the bottom income decile minus the inflation rate of the top income decile.[3]

In Figure 4, we plot the evolution of inflation inequality over time between the top and bottom deciles of income for headline, core, and supercore inflation. We apply a twelve-month rolling average to inflation inequality. Inflation inequality is generally persistently positive for all three series. However, this appears to be driven almost entirely by a period from the late 1990s to the early 2010s when inflation inequality was never negative. Aside from that period, it is difficult to see any systematic inflation inequality.

2. Dube et al. (2023) and Gregory and Harding (2024) document many facts about real wage growth during the recent inflationary surge.

3. Our results are robust to using less granular measures of inequality.

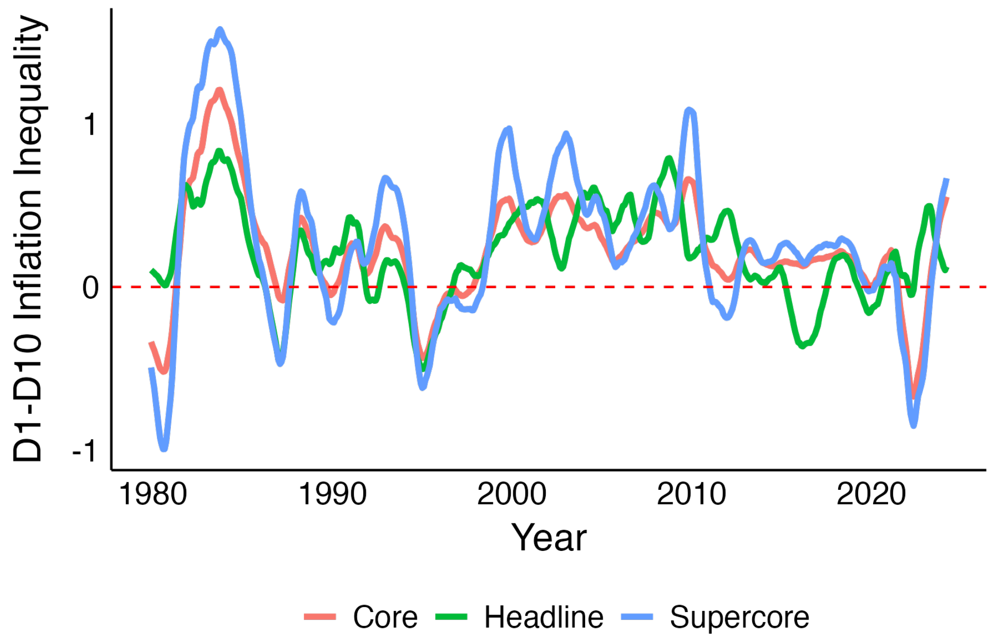


Figure 4: Evolution of inflation inequality between the top and bottom decile of income over time. Inequality is positive when the bottom decile's inflation rate is higher.

In Table 2, we document the moments of inflation inequality for each type of inflation. They are all positive on average, but core and supercore are much more volatile and exhibit more inequality on average. Partially that is because the core and supercore strip out components which tend to be a larger budget share for lower income households.

Inflation Type	25th Percentile	Mean	Median	75th Percentile	Std. Dev.
Headline	0.0525	0.205	0.183	0.412	0.283
Core	0.0770	0.225	0.200	0.381	0.320
Supercore	-0.0351	0.268	0.240	0.535	0.486

Table 2: Moments of the inflation inequality distribution for each inflation type.

In Figure 5, we plot the cumulative effects of inflation inequality. We define this as the ratio of the bottom decile's price level to the top decile's price level. Here, the importance of the inequality period is even more evident: almost all of the difference in cumulative prices between the top and bottom is driven by it. That raises the important question of how endogenous inflation inequality is to the systematic conduct of monetary policy and whether inflation inequality should enter into choice of optimal rules, something researchers should investigate in the future.

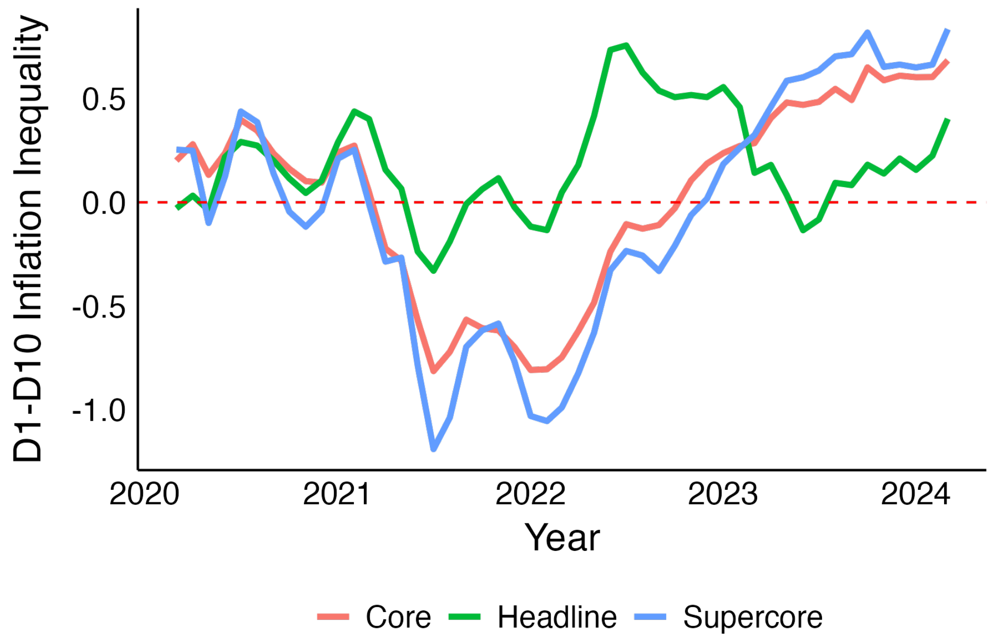


Figure 5: Cumulative inflation inequality between the top and bottom decile of income over time. Inequality is positive when the bottom decile's inflation rate is higher.

In Figure 6, we plot raw (unsmoothed) inflation inequality from the start of the pandemic through March 2024. This serves to highlight the utility of our data for real-time analysis. More importantly, it also raises the conceptual question of whether increases in inflation lead to increases in inflation inequality. At the beginning of the inflation surge, inflation inequality rose, but that reversed from mid-2021 until the beginning of the Russia-Ukraine war in February 2022. It is not obvious *ex ante* whether a higher aggregate inflation rate should lead to more inflation inequality, but it is a relevant question if the Federal Reserve targets a higher trend inflation rate.

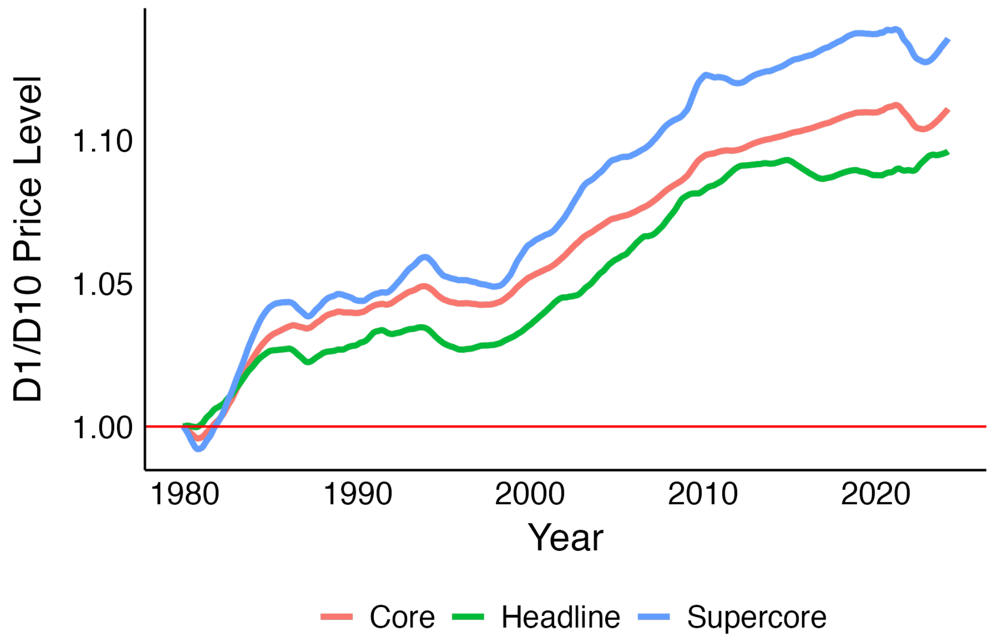


Figure 6: Inflation inequality during the 2021-2024 inflation surge.

At a first pass, the evidence is mixed for whether or not more inflation leads to more inflation inequality. In Table 3, we evaluate whether or not aggregate inflation Granger causes inflation inequality and vice versa for each inflation type. That is, we ask whether each type of aggregate inflation *temporally* causes headline inflation inequality to increase. Evidently, the answer is no. Except for a single specification, in which core inflation may Granger cause inflation inequality, and not vice versa, the evidence is generally not suggestive that inflation temporally precedes inflation inequality as defined here. The data here are not smoothed. However, the test is not particularly sophisticated and academics should do more work to figure out the causal connection in the sense of modern econometrics.

Causality	Granger P-Value (BIC)	Granger P-Value (AIC)
Headline		
Inflation Granger Causes Inflation Inequality	0.7298	0.01569
Inflation Inequality Granger Causes Inflation	0.00939	0.00939
Core		
Inflation Granger Causes Inflation Inequality	0.15223	0.00461
Inflation Inequality Granger Causes Inflation	0.74093	0.24148
Supercore		
Inflation Granger Causes Inflation Inequality	0.55758	0.55758
Inflation Inequality Granger Causes Inflation	0.34777	0.40407

Table 3: Granger causality test for inflation inequality and aggregate inflation. Inflation inequality here is between the bottom and top income deciles. Each column is the Granger statistic for the specification chosen by the BIC or AIC.

However, it may be that the groups are not granular enough to pick up the temporal connection. That is, the groups may be a large enough share of inflation in the aggregate that it is difficult to extract their movements from inflation overall. With that in mind, we now look at inflation inequality between the second and 24th quantiles of an income distribution split into 25 parts. Results for Granger causality are in Table 4. The outcome provides stronger evidence for Granger causality going either both ways or from inflation to inflation inequality but not vice versa.

Causality	Granger P-Value (BIC)	Granger P-Value (AIC)
Headline		
Inflation Granger Causes Inflation Inequality	0.08852	0.05119
Inflation Inequality Granger Causes Inflation	0.04349	0.04349
Core		
Inflation Granger Causes Inflation Inequality	2e-04	0.00604
Inflation Inequality Granger Causes Inflation	0.88982	0.05445
Supercore		
Inflation Granger Causes Inflation Inequality	0.12487	0.01591
Inflation Inequality Granger Causes Inflation	0.60051	0.29825

Table 4: Granger causality test for inflation inequality and aggregate inflation. Inflation inequality here is between the second and 24th income quantiles (out of 25). Each column is the Granger statistic for the specification chosen by the BIC or AIC.

Returning to inflation inequality defined using income deciles, we now investigate the relationship between inflation and inflation inequality dynamically. In particular, we regress headline inflation inequality on a constant and a measure of the aggregate inflation rate for up to 10 years after a unit increase in the inflation rate today:

$$\mathcal{I}_{t+h}^{D1,D10} - \mathcal{I}_{t-1}^{D1,D10} = \alpha_h + \beta_h \pi_t + \varepsilon_t. \tag{3}$$

(3) is a local projection of the response of inflation inequality from periods $t, \ldots, t+h$ over h periods compared to its initial $t-1$ value given a one percentage point increase in the aggregate inflation rate. Again, we do this for both headline and core inflation. In Figure 7, we plot the coefficient β_h for up to $h = 48$ months. Note that the data for this regression are not smoothed.

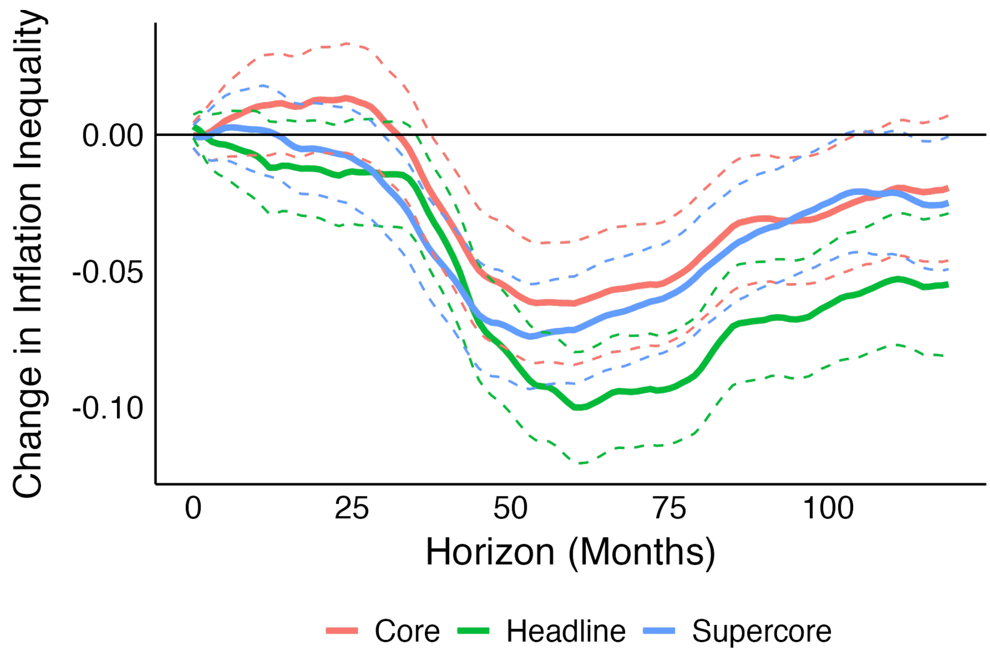


Figure 7: Local projection of the response of core, headline, and supercore inflation inequality to a unit increase in their respective aggregate inflation rates along with a 95% confidence interval. HAC standard errors.

For all three types of aggregate inflation, there is little response for the first years and then there is a persistently negative decline in inflation inequality. If truly causal, then that may likewise be interesting for policy. Lower inflation inequality may make a higher inflation target more tolerable. As a final attempt to say something about the comovement between inflation inequality and aggregate inflation, we look at the correlation between the cyclical components of both using the boosted Hodrick-Prescott filter. The correlation between cyclical inflation inequality and core inflation is -0.12 for the first and tenth deciles and -0.05 between the second and 24th quantiles in the 25 quantile distribution. Hence the is rather weak and perhaps goes in the wrong direction for thinking that inflation leads to more inflation inequality.

Next, we tentatively confirm results from Cravino, Lan, and Levchenko (2020) on inflation volatility. That paper finds a hump-shaped inflation volatility profile. Intuitively, that makes sense because necessities like energy, food, and gasoline—all of which are highly volatile—comprise a much larger fraction of consumption among low earners. In Figure 8, we plot the distribution of the standard deviation of inflation across the income distribution for core, headline, and supercore inflation. The left panel is the standard deviation of the cyclical component of inflation extracted using the boosted Hodrick-Prescott filter from Phillips and Shi (2021). The right panel is raw inflation. Both are normalized such that the standard deviation of the first income decile is one. We extract the cyclical component because there appear to be some trends in the inflation inequality time series and it is interesting to consider inflation volatility using filtered data.

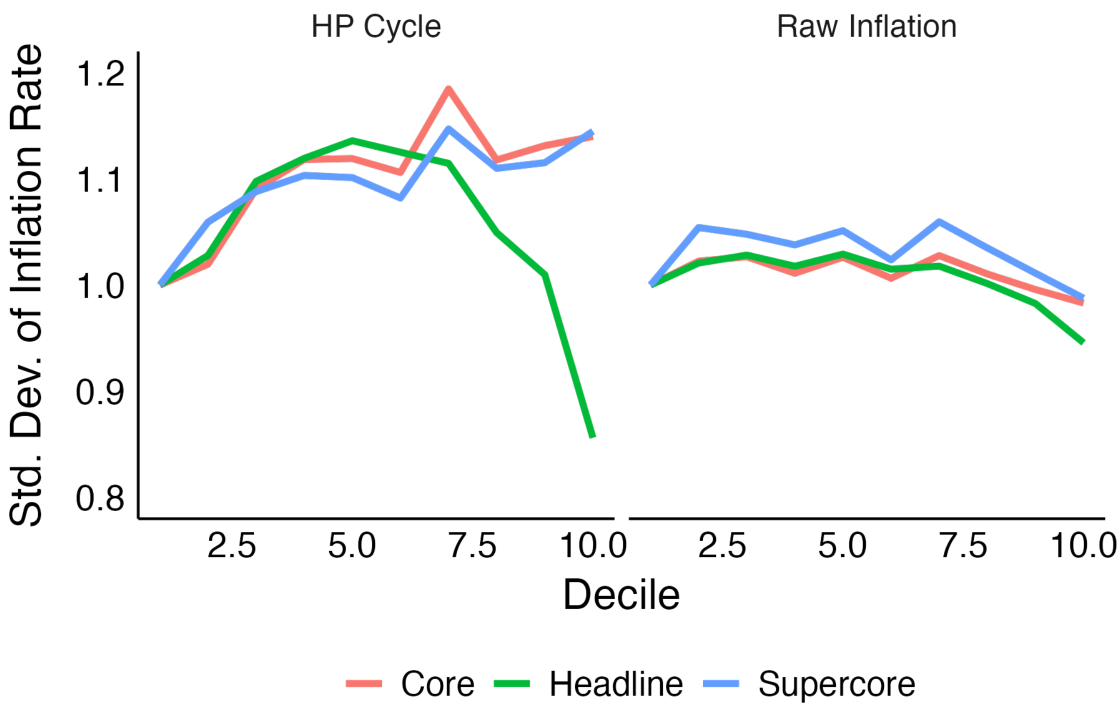


Figure 8: Distribution of the standard deviation of inflation across the income distribution for core, headline, and supercore inflation. The left panel is the standard deviation of the cyclical component of inflation extracted using the boosted Hodrick-Prescott filter from Phillips and Shi (2021). The right panel is raw inflation. Both are normalized such that the standard deviation of the first income decile is one.

Although we replicate the Cravino, Lan, and Levchenko (2020) result for headline inflation in the right panel, the hump shape is much more dramatic for the cyclical component. However, there is no apparent hump shape for either core or supercore inflation; indeed, they appear to be upward sloping for the cyclical component. The implications of this are not obvious. In Cravino, Lan, and Levchenko (2020), the results are driven by the fact we replicate here, which is that headline inflation inequality is hump-shaped. But if, for policy reasons, the Fed really only controls core inflation or supercore, that fact no longer holds, which changes the distributional consequences of monetary policy shocks.

4 Regional Inflation Inequality Indices

In this section, we demonstrate the usefulness of considering geographic inflation inequality in two steps. First, we consider long-run trends in and the effect of the pandemic inflation on regional inflation and real wages at the aggregate level. Second, we conduct the same analysis, but broken down by income quartiles so that we have the ability to analyze inflation inequality *within* regions. To our knowledge, this is the first attempt to do so.

As a preliminary exercise, we compare the magnitude of regional inflation inequality to income-based inflation inequality. In Figure 9, we plot the twelve month rolling average of the maximum inflation gap between regions in orange with the rolling average of the the maximum inflation gap between income quartiles in blue. Which region or income group has the most inflation is irrelevant for this exercise; all we want to do is show the extent of the differences. On average, regional inflation inequality is about 1.1, more than three times larger than income inflation inequality at 0.31. We obtain a similarly large gap when expanding to income deciles, although income inflation inequality rises to an average value of 0.47 in that case. Moreover, there is not a single point over the past forty years when inflation inequality for income groups exceeded geographic inflation inequality. Geographic inflation inequality is also significantly more volatile.

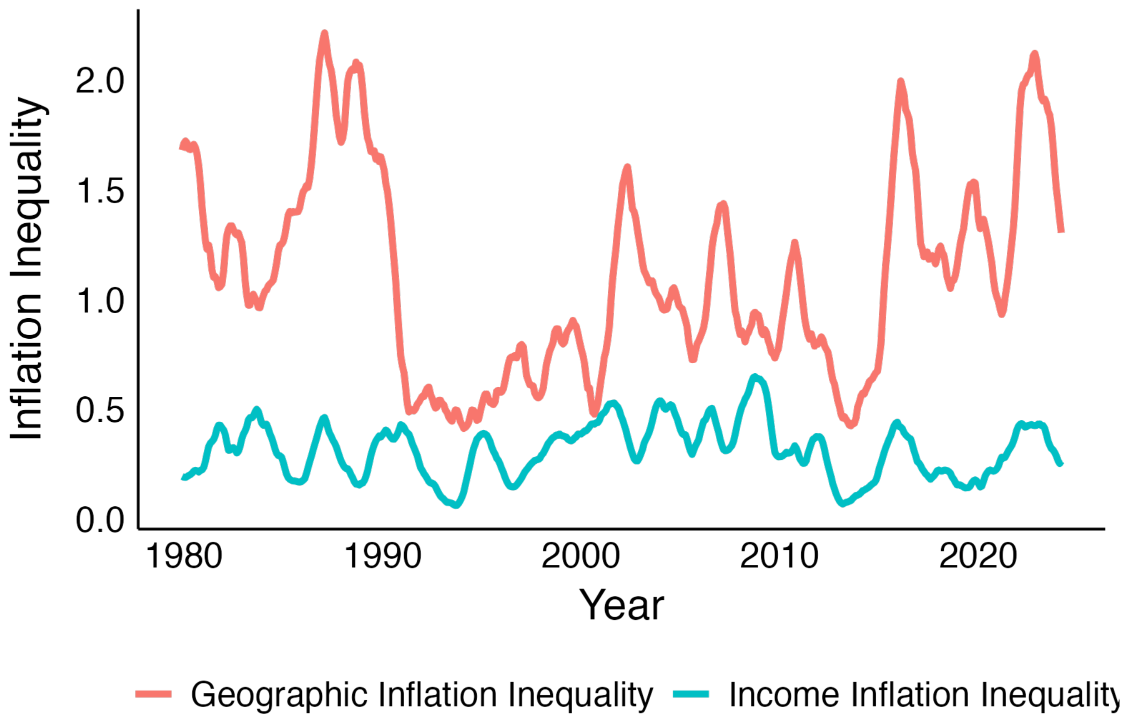


Figure 9: Inflation inequality for each type of inflation. The orange line is the twelve month rolling average of the maximum inflation inequality between regions for each month, while the blue line is the same for income deciles. That means we are not targeting inequality between any specific groups, but only the maximum value for each month.

The point of Figure 9 is is not to say that income inflation inequality is irrelevant, but that geographic inflation inequality is worth analyzing.

4.1 Inflation Inequality Between Regions

Understanding distributional inflation by region addresses a key criticism of most types of demographic-based inflation inequality. There may be nothing special or *structural* about the consumption baskets of poor people or racially based inflation. But there are strong reasons to think that structural factors play a key role in distinguishing regional inflation. In particular, transport costs and regulations likely play a large role, something future research will have to address. Additionally, with social mobility, it is questionable to apply compounding inflation rates to income groups. With strong social mobility, there is little reason to think that an inflation rate specific to an income group will apply for the duration of one's life. Consequently, compounding inflation rates may be inappropriate because people accumulate significantly more income over the lifecycle. However, when considering the distribution of regional inflation inequality, the criticism does not apply because the relevant mobility is geographic rather than economic. Precisely because geographic mobility is comparatively lower than economic mobility, it is reasonable to consider compounding inflation by region.

With that in mind, in Figure 10, we plot the cumulative price level by region since the start of the series in 1978. Darker values indicate more cumulative inflation, with a high approaching 530 in western regions and lows around 450 in the middle of the country. By comparison, the same number for the United States aggregate CPI is 490, meaning that prices are about five times higher today than in January 1978. Simply looking at aggregate inflation misses a great deal of the spread in inflation between states, in this case about eighty percentage points cumulatively. Notably, the middle of the country has been historically insulated from inflation.

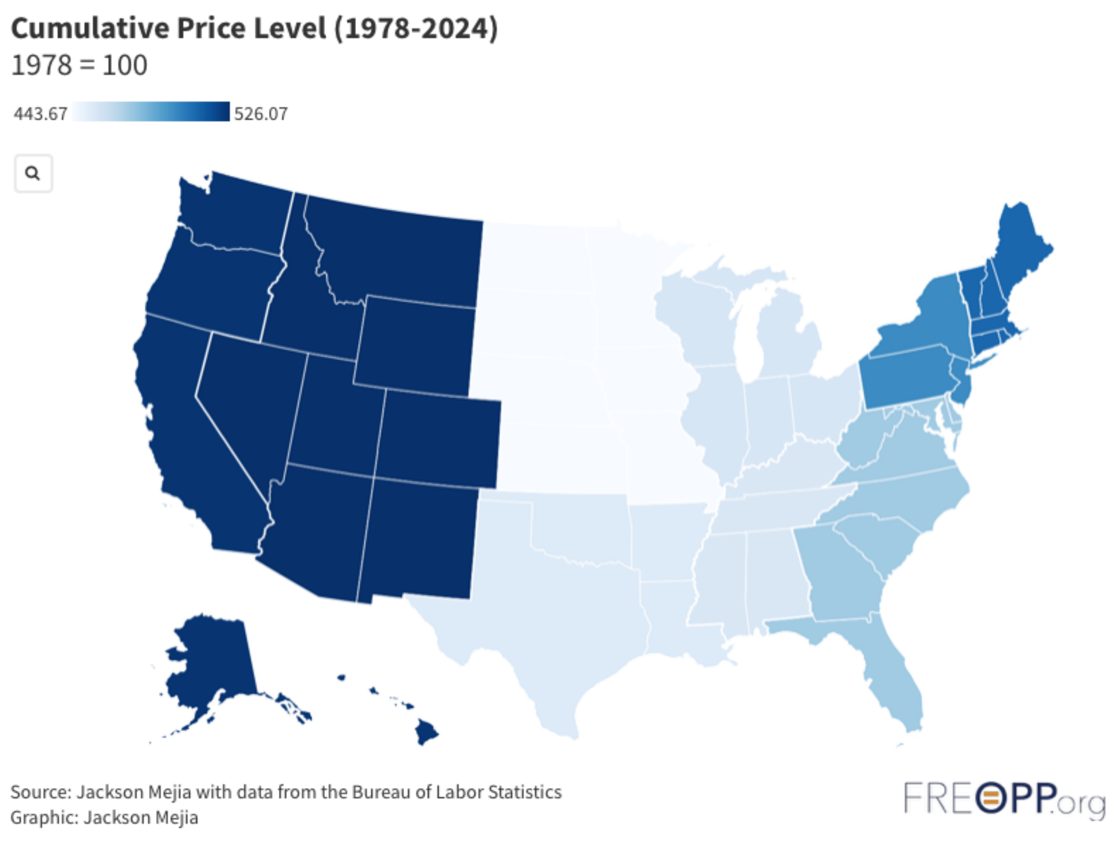


Figure 10: Cumulative price level by region since 1978.

Figure 10 suggests that even if nominal wages grow at the same rate around the country, real wages may differ substantially because of regional inflation inequality. Indeed, a potential rejoinder to Figure 10 is that nominal wage demands have been strong enough along the coasts that they make up for the inflation deficit. That does not appear to be true. In Figure 11, we plot real wages for each region normalized to relative to the lowest inflation region, the West North Central. Real wages come from applying the Current Population Survey applying the methodology of the Federal Reserve Bank of Atlanta. The East North Central and West North Central regions—both in the Midwest—have the highest real wage growth in the country. The Northeast is not far behind. On the other hand, the West Coast and the South lag behind. The latter is largely because of lower nominal wage growth, while the former struggles because of historically high inflation relative to other regions. Altogether, this indicates that it is critically important to correct for regional inflation before discussing real wages across the country.

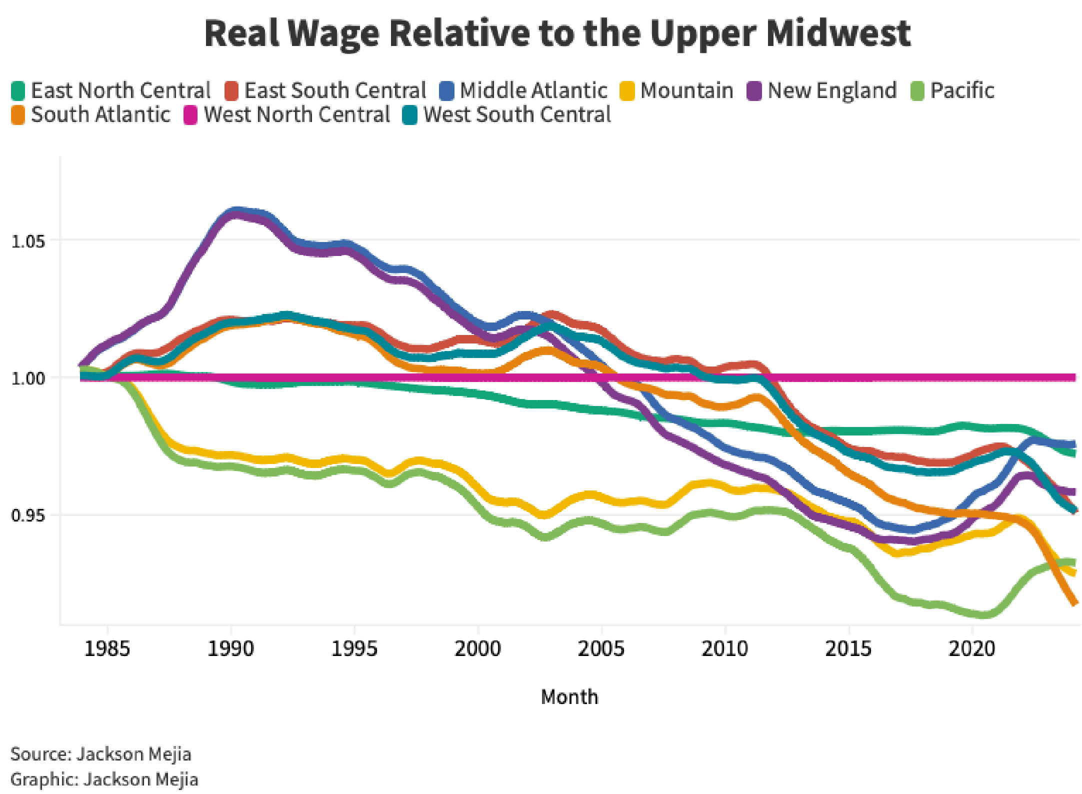


Figure 11: Real wages by region from 1983 onward computed as the difference between regional nominal wage growth and regional inflation and then converted to an index of 100 at the beginning of the sample. Regional wage data come from the Current Population Survey. Normalized relative to the West North Central region and smoothed with a twelve month rolling average.

In Figure 12, we repeat the same cumulative inflation exercise in Figure 10, but this time with a start date of February 2021. This way, we get a sense of cumulative exposure to the pandemic-era inflation which continues to this day. Here, the figure is substantially different from the long-run cumulative inflation plot in Figure 10. Today, a typical consumption basket in the Midatlantic, New England, and Pacific regions costs about 17% more than it did in February 2021, while that same figure is about 21% for the rest of the country. The geographic disparity combined with the relatively high incomes of the low inflation regions may even help explain some of the political disagreement over the relevance of inflation.

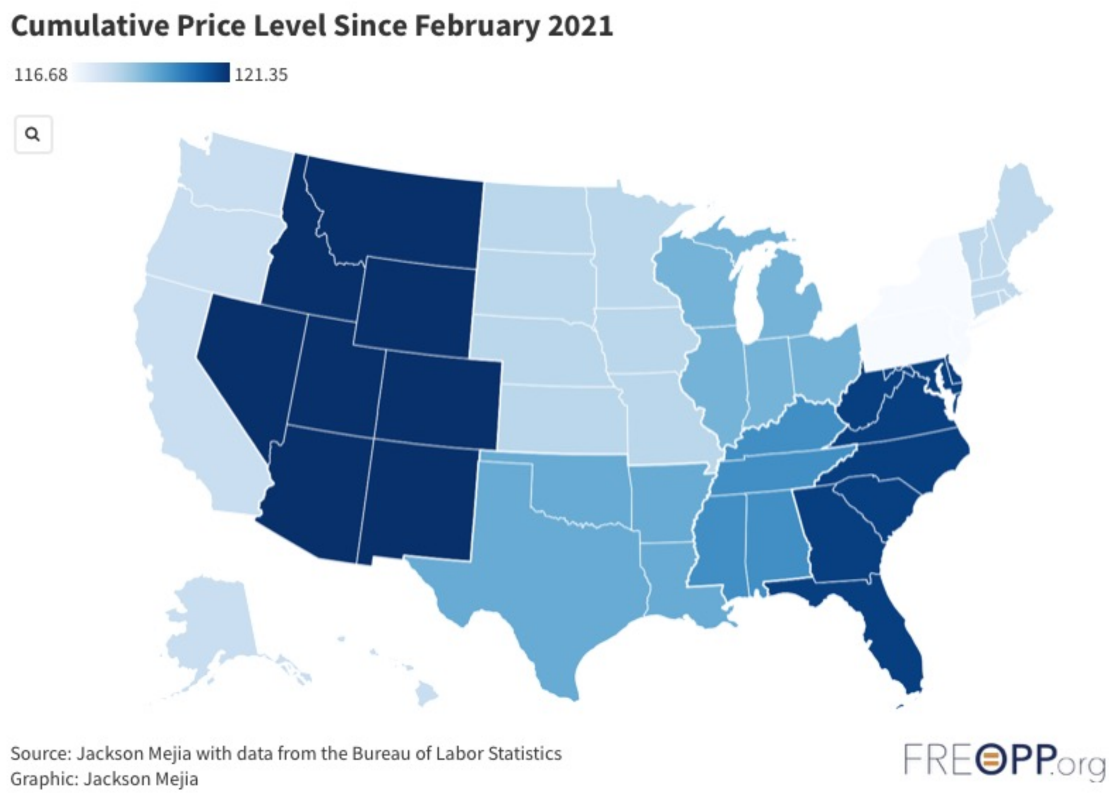


Figure 12: Cumulative price level by region since February 2021.

Geographic disparities in real wages tell an interesting story. In Figure 13, we plot the evolution of real wages by region since the start of the pandemic inflationary episode. Across the country, real wages are either typically lower than they were in 2021 or barely higher. Indeed, the Pacific and the Middle Atlantic regions—strongholds for Democrats aside from Pennsylvania in the Middle Atlantic—are the only ones with real wages exceeding 2021. Every other region has lower wages than they did over three years ago, an astounding outcome for the strongest post-pandemic economy in the world and a damning indictment of the destructive consequences of inflation.

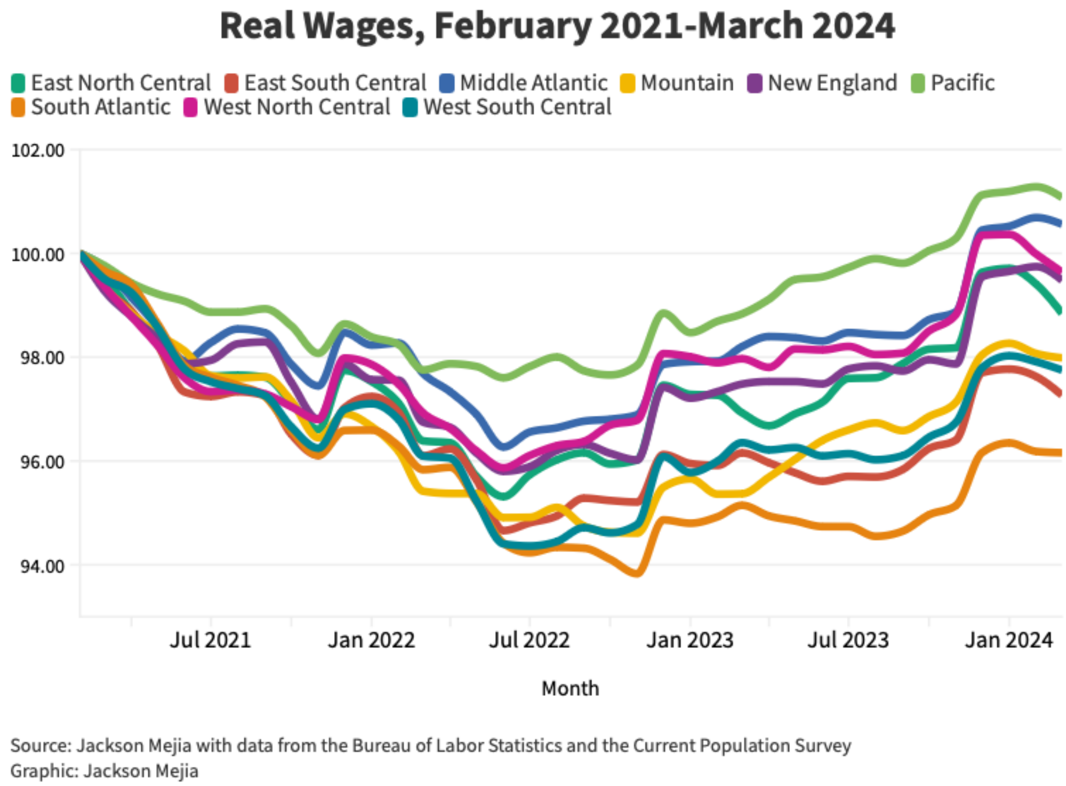


Figure 13: Real wages by region since the beginning of the inflation surge.

The heatmaps in Figures 10 and 12 indicate that measuring aggregate inflation misses underlying regional heterogeneity. In Figure 14, we chart the average contribution of each major expenditure type to inflation for each region. Loosely, a major expenditure type's contribution to inflation is its expenditure share multiplied by its own inflation as a share of total inflation within the region. Clearly, there are large differences between regions driven by housing, transportation, and to a lesser extent, food. These components are almost exactly those excluded in analyses of "supercore" inflation favored by some economists.

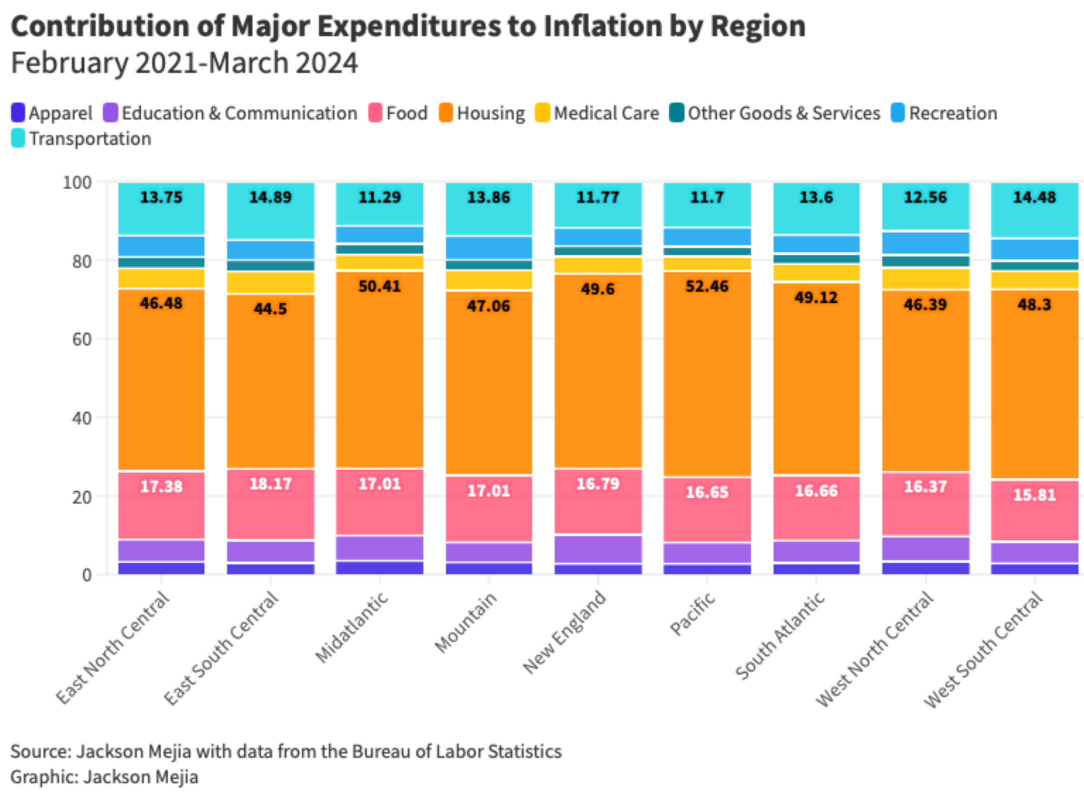


Figure 14: Average contribution of major expenditure groups to inflation within each region during the pandemic inflation episode. Loosely, the average contribution for each group is inflation for each major group multiplied by the major group's expenditure share averaged over the relevant timeframe.

Traditionally, economists prefer looking at "core" or, more recently, "supercore" inflation than headline inflation to monitor the performance of monetary policy. Such measures exclude volatile components of the consumer price index that may be largely outside the control of the Federal Reserve. It may be true that such measures are more sensible for evaluating Fed policy performance, but they fail to capture the regional heterogeneity in such distinctions. In Figure 15, we plot the difference between headline and core inflation for each region during the pandemic era inflation. A larger gap for a particular region indicates that emphasizing core inflation is less relevant for that region. As the gap grows, wonkish discussions of core inflation become more likely to fall on deaf ears. The headline-core gap is substantial between states, with a difference of nearly two percentage points in July 2022 between the West South Central region and the neighboring Mountain region. Such differences become even larger when using the supercore measure instead.

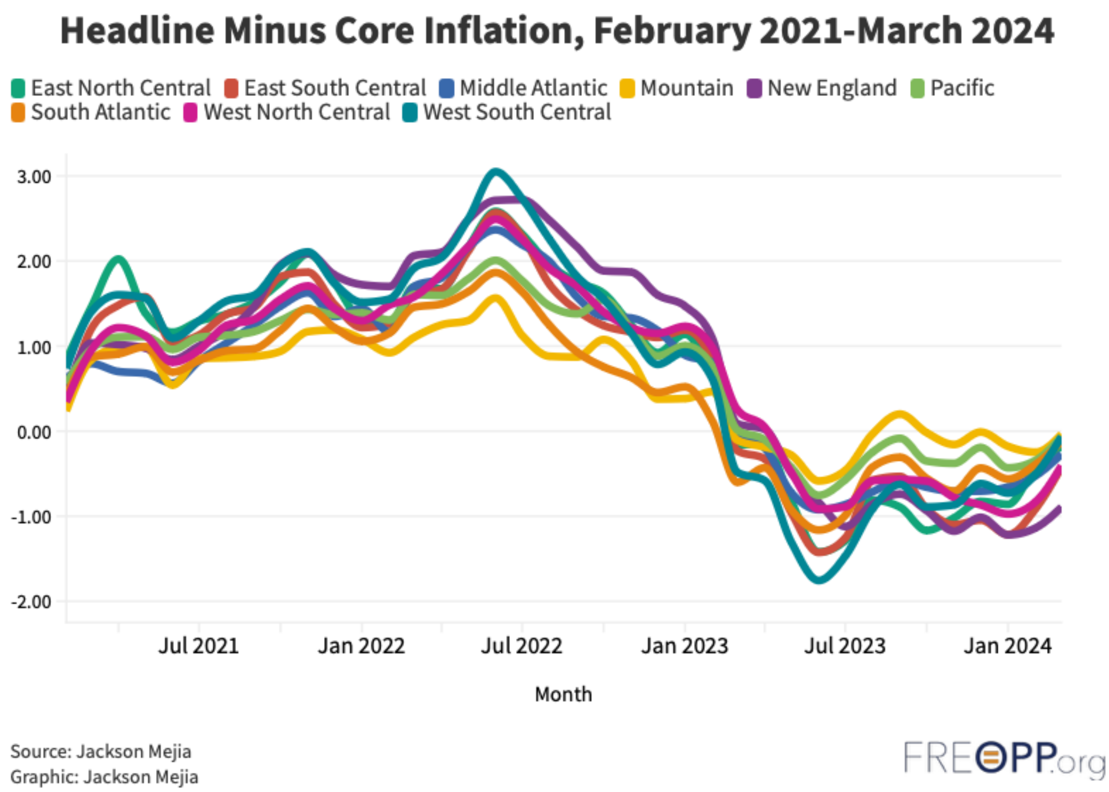


Figure 15: Difference between headline and core inflation from February 2021 to March 2024. Core inflation excludes energy and food.

Over a longer time horizon, it is clear that there are typically large differences between regions in how much core inflation deviates from headline inflation. In Figure 16, we plot the annual average difference between core and headline inflation for each region from 1978–2024. The East South Central typically has the largest gap, averaging around 0.8 percentage points, while it is smallest in the Pacific region at 0.5 points.

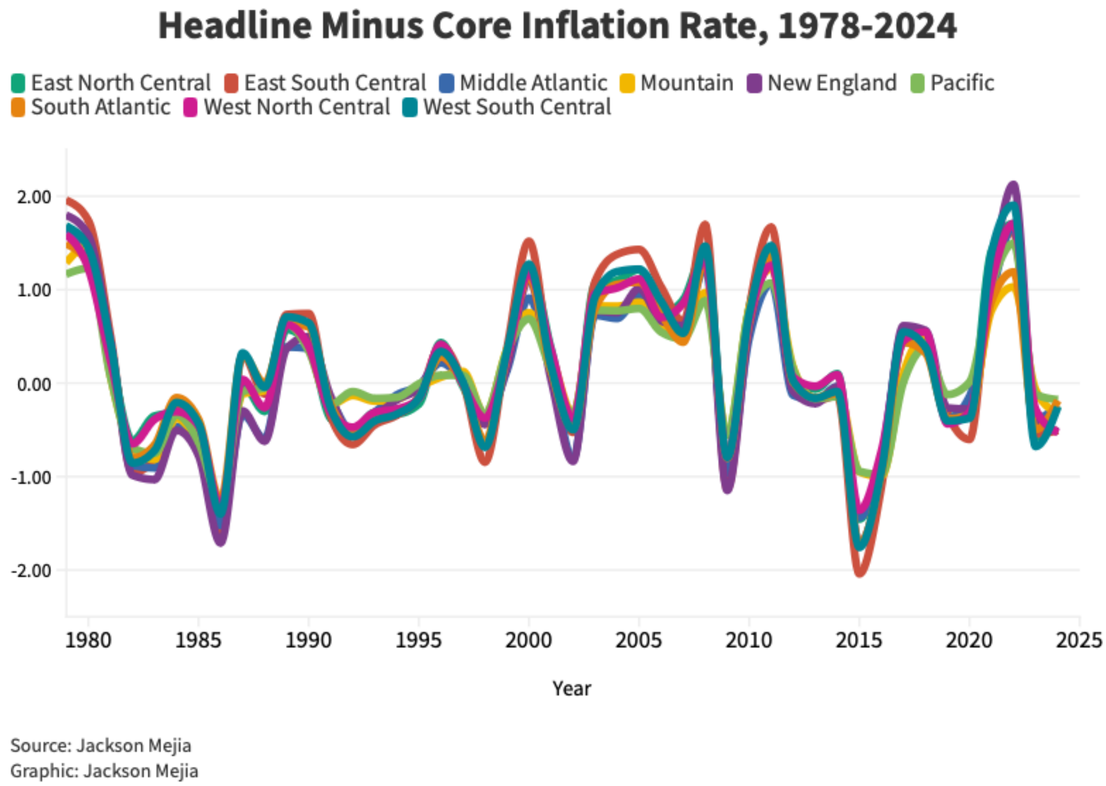


Figure 16: Difference between headline and core inflation from 1978-2024. Core inflation excludes energy and food.

Geographic inflation inequality interacts with inflation type in a significantly different way than income inflation inequality does. In Figure 17, we plot cumulative inflation inequality between the West North Central and Pacific regions for each of core, headline, and supercore inflation. Cumulative inflation inequality at the regional level is the Pacific price level divided by the West North Central price level. A value of 1.2 corresponds to cumulative inflation being 20% higher in the Pacific region. We do the same for inflation inequality between the top and bottom deciles of the national income distribution, where cumulative inflation inequality is the bottom decile divided by the top decile. There are two interesting patterns. First, the cumulative effect of inflation inequality is stable over time and across inflation types for income inflation inequality, the opposite is true for geographic inflation inequality. Second, whereas geographic cumulative inflation inequality is about twice as large as income inflation inequality for both headline and core inflation, that pattern reverses when we look at supercore inflation. Indeed, geographic inflation inequality goes the opposite direction. This underscores the dramatic importance of housing for determining geographic inflation inequality.

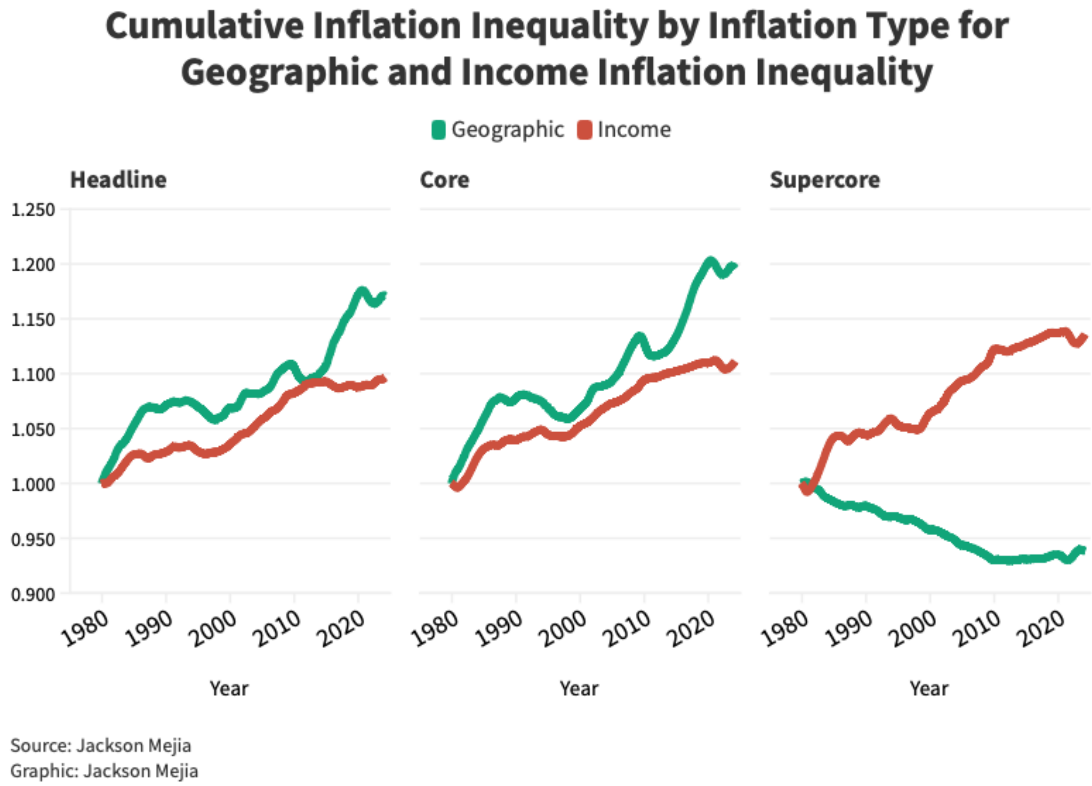


Figure 17: Cumulative inflation inequality is defined as the ratio of price indices. For geographic inflation inequality, we use the ratio of the Pacific region to the West North Central region. For income inflation inequality, we use the ratio of the bottom to top income deciles.

Observed significant regional heterogeneity in inflation is important for two reasons. The first reason is economic: higher inflation rates correspond to lower personal well-being. This means that regional inflation inequality exacerbated by monetary policy shocks leads to disparate outcomes for people in different states. Everyone loses during bouts of inflation, but some states simply lose less than others. For states and even the federal government, this may present an opportunity to target inflationary treatment and relief to a larger degree geographically than it currently does. The second reason is political and follows from the first: when there is significant regional heterogeneity in inflation rates, geographic perceptions of inflation will differ substantially. Because inflation is especially salient for many Americans, these regional variations cause varying degrees of geographically based frustration with government efforts to reduce inflation. Policymakers too often overlook these differences because they focus on traditional measures of inflation, like the national consumer price index.

Following the discussion in Section 3 about whether aggregate inflation may be a cause of geographic inflation inequality, we repeat some of the same exercises. We define geographic inflation inequality as the difference between Pacific inflation and East North Central inflation. In Table 5, we investigate Granger causality between geographic inflation and aggregate inflation for all three inflation measures. The results are, again, quite mixed. Headline and inflation inequality Granger cause each other, while that is not true for headline and core inflation. It is entirely plausible that we would get a more precise answer with more granular data. Consequently, it is difficult to draw any conclusions from Granger causality.

Causality	Granger P-Value (BIC)	Granger P-Value (AIC)
Headline		
Inflation Granger Causes Inflation Inequality	0.00439	0.00642
Inflation Inequality Granger Causes Inflation	0.00223	5e-05
Core		
Inflation Granger Causes Inflation Inequality	0.42035	0.50072
Inflation Inequality Granger Causes Inflation	0.2273	0.71897
Supercore		
Inflation Granger Causes Inflation Inequality	0.46947	0.27804
Inflation Inequality Granger Causes Inflation	0.36297	0.54475

Table 5: Granger causality test for inflation inequality and aggregate inflation. Inflation inequality here is between the West North Central and Pacific regions. Each column is the Granger statistic for the specification chosen by the BIC or AIC.

Next, we repeat the local projections exercise. That is, we repeat regression (3) for geographic inflation inequality. In Figure 18, we plot the coefficient β_h for up to $h = 48$ months. Note that the data for this regression are not smoothed.

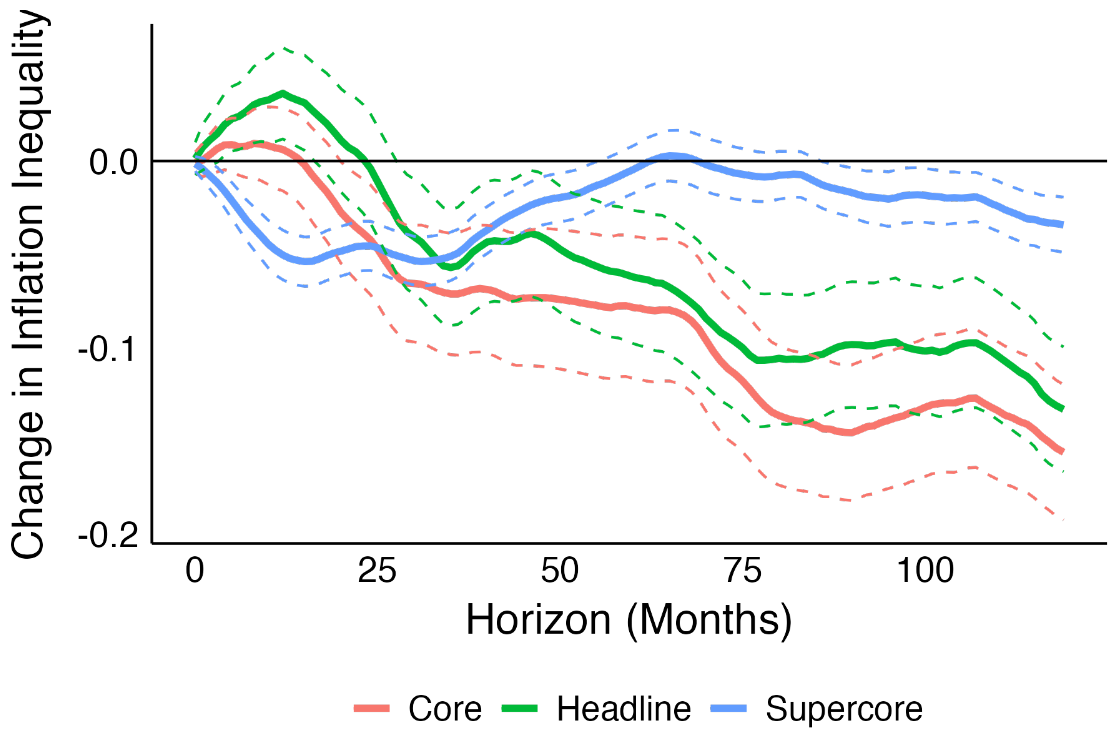


Figure 18: Local projection of the response of core, headline, and supercore inflation inequality to a unit increase in their respective aggregate inflation rates along with a 95% confidence interval. HAC standard errors.

Evidence here is substantially weaker than in Section 3 that aggregate inflation increases are associated with increases in regional inflation inequality. However, that may be because of how we define inflation inequality and further work here is necessary.

4.2 Inflation Inequality Within States

Perhaps the key feature of this dataset is the ability to examine inflation inequality within states over time. Because the inequality estimates come from the Consumer Expenditure Survey designed for analysis of national inflation, it is not possible to be quite as granular at the state level as at the national level. Consequently, we focus on income quartiles rather than income deciles for each region.

Grouping together all national data, the lowest income quartile on average faces an inflation rate 19 basis points higher than the highest income quartile, which is consistent with our earlier research on inflation inequality. Over 45 years, this annual difference compounds into a difference of about nine percentage points of cumulative inflation. For comparison, the difference between the lowest and highest inflation region in cumulative inflation is approximately 80 percentage points, nearly an order of magnitude larger. To illustrate where inflation inequality has been most prominent historically, we plot the average inflation inequality for each state in Figure 19 over the period 1979–2024. We define inflation inequality as the difference between the bottom income quartile's inflation rate and the top quartile's inflation rate, so that positive inflation inequality corresponds to higher inflation for low-income households. Each region has positive average inflation inequality over time, but there are larger spreads between regions. Interestingly, the West North Central region has the most inflation inequality despite having the least inflation. By contrast the Northeast—led by New York, Pennsylvania, and New Jersey—has almost negligible inflation inequality.

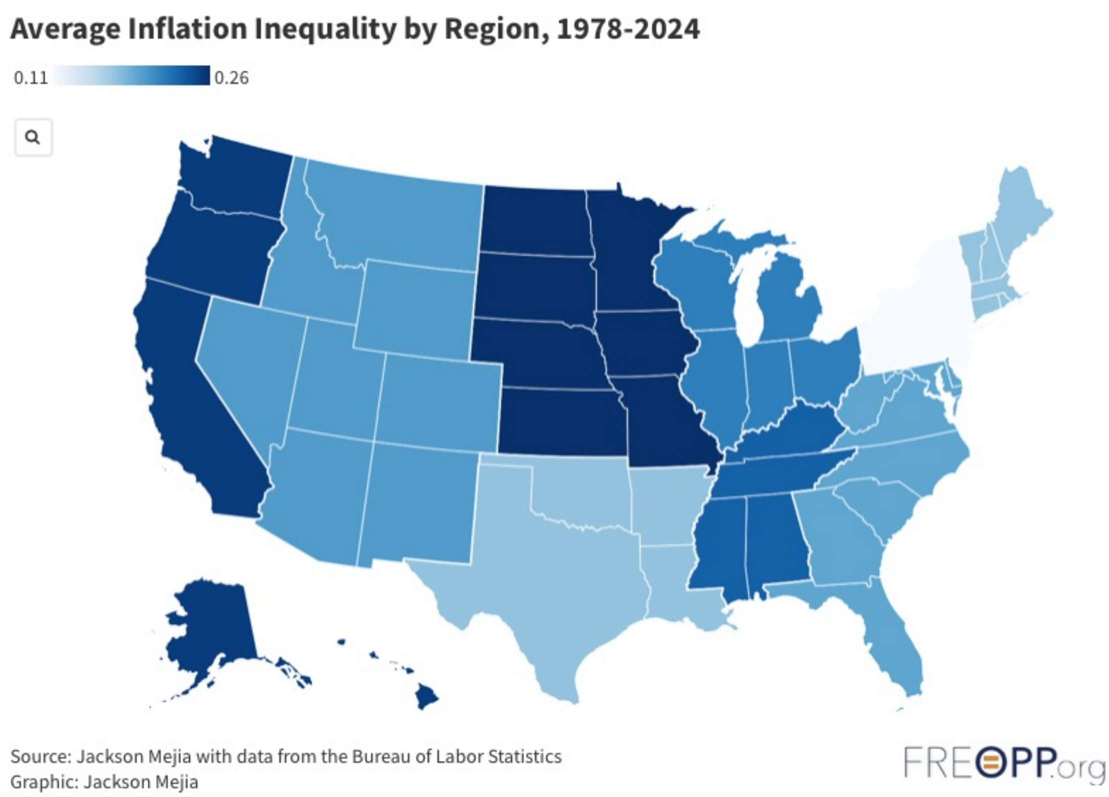


Figure 19: Average inflation inequality by region. Inflation inequality is defined as the lowest income quartile's inflation rate minus the top quartile's.

It is useful to think about how we arrived at Figure 19 over a longer time horizon. In Figure 20, we plot inflation inequality by region for each year in the sample. Interestingly, the relatively high average inflation inequality for the Pacific Region is driven by a high burst of inflation in the early 1980s. Removing this outlier results in a near total inversion of Figure 10. That is, inflation is lower on average in the middle of the country, but inflation inequality is only a significant phenomenon in the middle of the country. In the context of welfare programs, that means adjusting for regional inflation is insufficient.

Moreover, simply observing regional inflation is far from a sufficient indicator of how people in the middle of the country tend to be affected by inflation, even if it might be for more coastal areas.

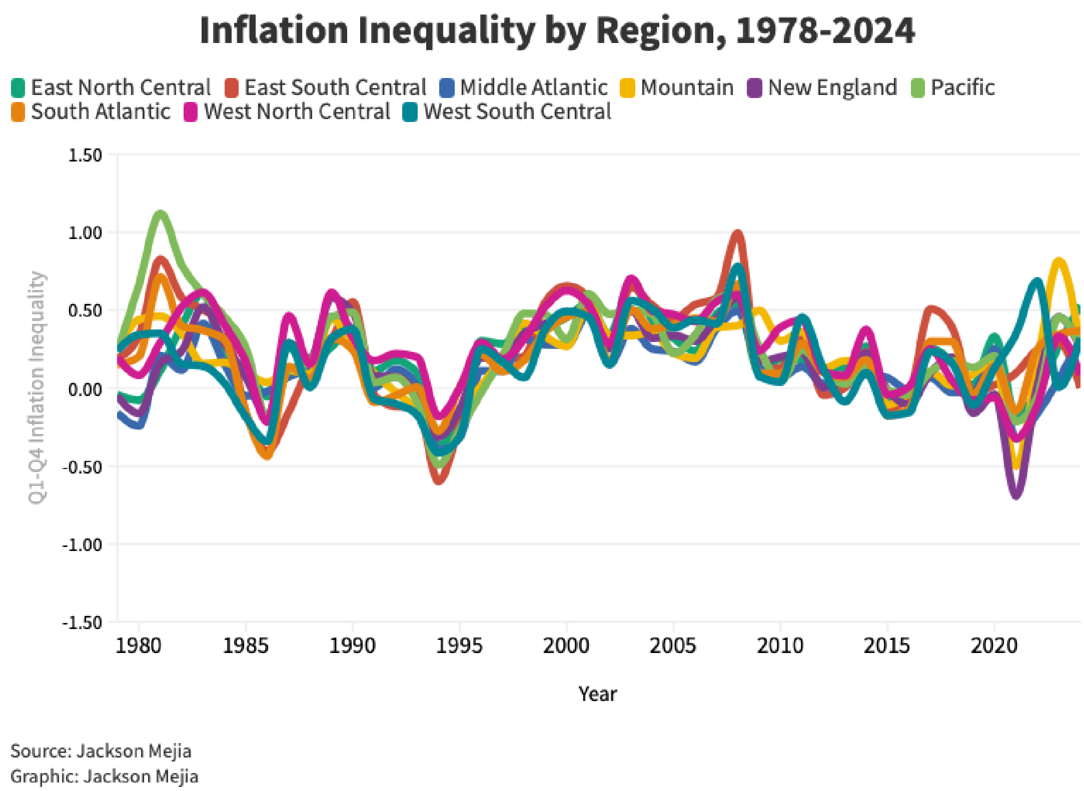


Figure 20: Inflation inequality for each region from 1978–2024. Inflation inequality is the difference in inflation rates between the bottom and top quartile of income.

Figure 20 also reveals that inflation inequality within regions tends to move in tandem, with the exception of the recent inflationary surge. In 2021 and 2022, inflation was higher for the top income quartile in all regions except the West South Central.

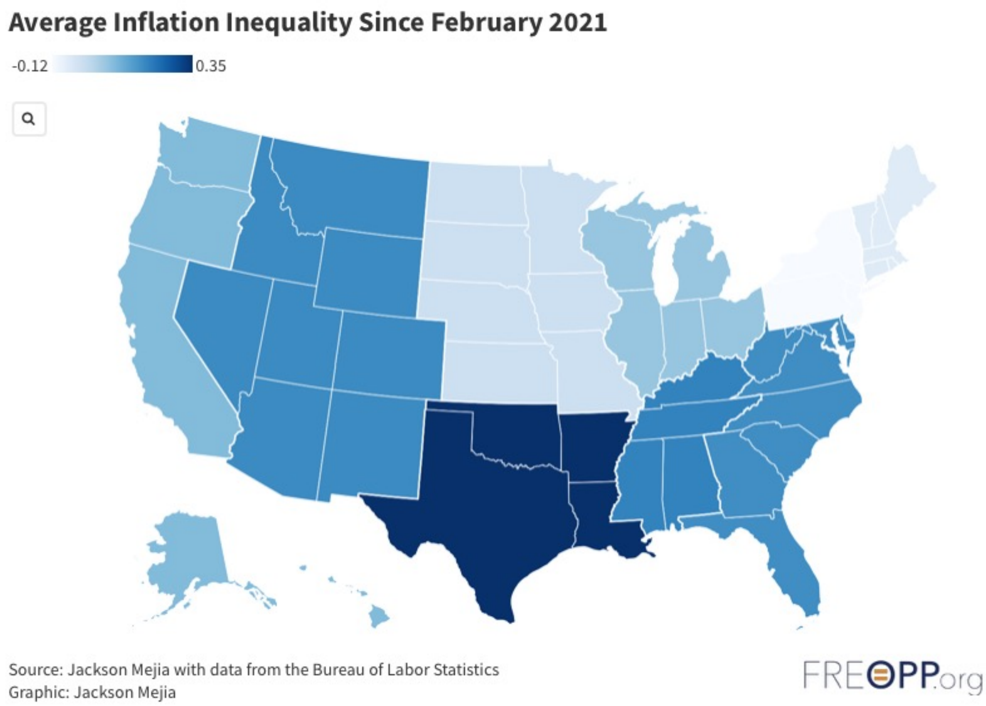


Figure 21: Average inflation inequality by region since February 2021.

Figure 21 plots average inflation equality around the United States since February 2021. Figures 20 and 21 highlight the difficulty with doing policy around inflation inequality. It is difficult to predict when inflation inequality will emerge and there are not clear systematic patterns relating to monetary policy in the same way that there is with inequality between regions.

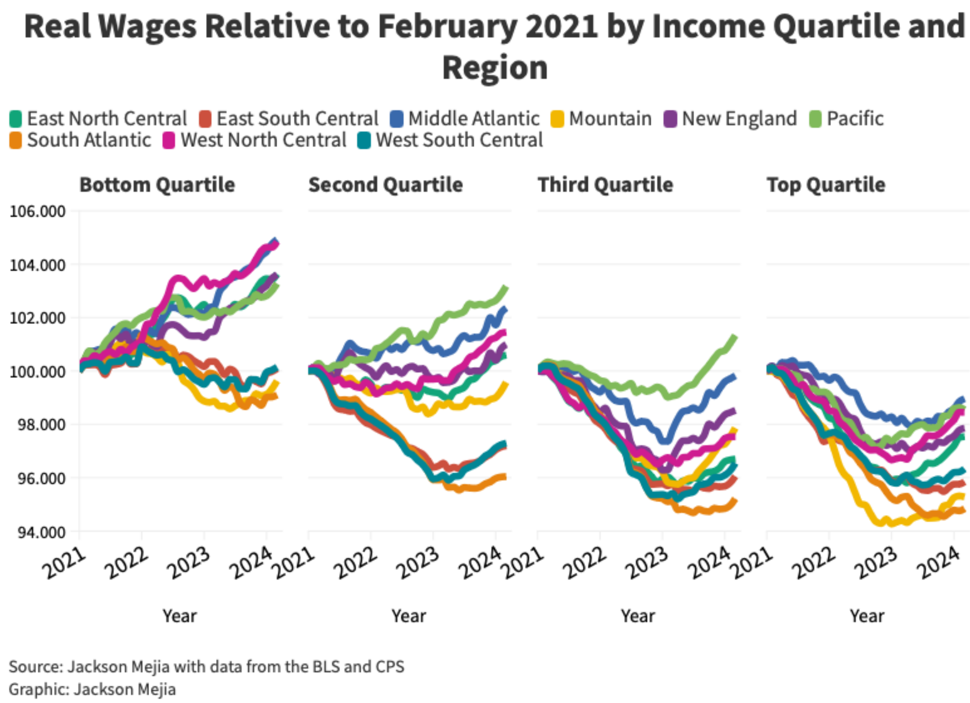


Figure 22: Real wages by income quartile and region relative to their February 2021 level.

Dube et al. (2023) and Gregory and Harding (2024) document significant wage compression since the beginning of the pandemic. In Figure 22, we complement their analyses by plotting real wages relative to February 2021 by income quartile and region. Two things stand out. First, there is significant heterogeneity in how far wages fell for each income quartile. For example, wages fell the least for the bottom quartile in the Mountain region, but the top quartile saw the sharpest drop. Second, we observe that the spread of wage drops increases by income.

Differences across regions and between income groups boil down to differences in demand for different goods. Indeed, just as the difference between headline and core inflation differs between regions, it differs between income groups as well. Since 2021, the absolute value of the difference between headline and core inflation is about 0.32 percentage points higher for the lowest income quartile than it is for the top income quartile. Consequently, abstract discussions about core inflation will tend to be less reflective of price inflation for the bottom income quartile than for the top income quartile.

5 Concluding Remarks

When inflation is low, policymakers pay less attention to it. It inflicts less pain across the board, leading politicians and media outlets to focus on other issues. While that is sensible in the moment, policymakers then lack the tools to adequately assess who inflation hurts the most when it happens. Congress should adequately fund data collection agencies to study inflation in greater detail, particularly at the regional level. Even the available indices are riddled with measurement error. There is not adequate coverage in the Consumer Expenditure Survey to estimate consumption for each state, let alone state-level consumption inequality. At the same time, the Bureau of Labor Statistics does not publish state-level price indices at a regular frequency, so that it is not even possible to estimate state-level inflation without significant measurement error. Our own regional indices are far from ideal.

Granular inflation indices are vitally important for two reasons. First, monetary policy does not affect everyone equally and often makes particular regions or income groups significantly worse off. That inequality cannot be addressed with monetary policy because national monetary policy is necessarily a blunt instrument. However, if policymakers know who monetary policy hurts the most and where the inflationary pressure is, then fiscal policy may be well-suited to help alleviate some of that pain without aggravating inflation further. That may mean targeted policy toward certain regions without having to use a blunt instrument like national monetary policy. Precisely because attention remains fixated on inflation, policymakers should act now to give us the tools to more precisely measure granular inflation going forward.

Overall, inflation varies widely geographically and the degree of inflation inequality within regions varies widely by geography. While there appears to be no systematic relationship between aggregate inflation and income inflation inequality, there is a strong relationship between national inflation and geographic inflation inequality. This revelation should prompt further study of how to use fiscal policy to precisely target those hurt the most by inflation. Such studies will require better and more extensive data in real time. For now, we hope our stitched together estimates can fill the gap.

References

Cravino, Javier, Ting Lan, and Andrei A. Levchenko. 2020. "Price stickiness along the income distribution and the effects of monetary policy." *Journal of Monetary Economics* 110, no. 1 (April): 19–32. ISSN: 03043932. https://doi.org/10.1016/j.jmoneco.2018.12.001.

Dube, Arindrajit, Daniele Girardi, Òscar Jordà, and Alan Taylor. 2023. *A Local Projections Approach to Difference-in-Differences Event Studies.* Technical report. Cambridge, MA: National Bureau of Economic Research, April. https://doi.org/10.3386/w31184.

Elmi, Sheida, Erin Currier, and Clinton Key. 2017. *How Income Volatility Interacts With American Families' Financial Security.* Technical report. Pew.

Gregory, Victoria, and Elisabeth Harding. 2024. "Real Wage Growth at the Micro Level." *Review* 106 (2). https://doi.org/10.20955/r.106.87-105.

Hobijn, Bart, and David Lagakos. 2005. "INFLATION INEQUALITY IN THE UNITED STATES." *Review of Income and Wealth* 51, no. 4 (December): 581–606. ISSN: 0034-6586. https://doi.org/10.1111/j.1475-4991.2005.00170.x.

Jaravel, Xavier. 2019. "The Unequal Gains from Product Innovations: Evidence from the U.S. Retail Sector*." *The Quarterly Journal of Economics* 134, no. 2 (May): 715–783. ISSN: 0033-5533. https://doi.org/10.1093/qje/qjy031.

———. 2021. "Inflation Inequality: Measurement, Causes, and Policy Implications." *Annual Review of Economics* 13, no. 1 (August): 599–629. ISSN: 1941-1383. https://doi.org/10.1146/annurev-economics-091520-082042.

Nakamura, Emi, Jón Steinsson, Patrick Sun, and Daniel Villar. 2018. "The Elusive Costs of Inflation: Price Dispersion during the U.S. Great Inflation." *The Quarterly Journal of Economics* 133, no. 4 (November). ISSN: 0033-5533. https://doi.org/10.1093/qje/qjy017.

Oberfield, Ezra. 2023. *Inequality and Measured Growth.* Technical report. Cambridge, MA: National Bureau of Economic Research, March. https://doi.org/10.3386/w31096.

Palarino, Justin, James K. Pugh, and Brian McKenzie. 2023. *Share of Americans Who Said They Moved Declined Between 2019 and 2021.* Technical report. Census Bureau.

Phillips, Peter C. B., and Zhentao Shi. 2021. "BOOSTING: WHY YOU CAN USE THE HP FILTER." *International Economic Review* 62, no. 2 (May): 521–570. ISSN: 0020-6598. https://doi.org/10.1111/iere.12495.

Wimer, Christopher, Sophie Collyer, and Xavier Caravel. 2019. *THE COSTS OF BEING POOR: INFLATION INEQUALITY LEADS TO THREE MILLION MORE PEOPLE IN POVERTY.* Technical report. Center on Poverty & Social Policy. https://www.americanprogress..

Contents

A Introduction

A number of papers have already published estimates of inflation inequality. Our methodology largely follows the careful approach of Cravino, Lan, and Levchenko (2020); hence our appendix will look quite similar to theirs. We still provide an appendix for a couple of reasons. First, we hope to provide a more granular level of detail, primarily because we hope that future researchers will choose to use our data and code rather than trudge through messy CEX and CPI data to recreate our result. Second, our methodology does differ in important respects. For example, our expenditure categories are somewhat more aggregated, which leads to critical differences in the concordance between the pre-1998 and post-1998 CPI data.

B Source Data and Background

In order to construct measures of inflation for different income groups, we require expenditure and price data. Every year, the Bureau of Labor Statistics (BLS) conducts the Consumer Expenditure Survey (CEX) as a means of tracking changes in spending patterns among the general population and subgroups within the American populace, as well as providing data on income and other demographic characteristics at the individual level. Note that the CEX is the primary source data for expenditure weights used for the U.S. Consumer Price Index. The CEX collects data through two surveys: the Interview Survey and the Diary Survey. The former consists of a quarterly questionnaire conducted across five quarters and accounts for approximately 95% of total expenditures, while the latter records weekly spending and is intended to track smaller expenditures on, for example, groceries. In both surveys, expenditures are put into approximately 600 different expenditure categories called Universal Classification Codes (UCCs).

To accommodate technological and personal preference shifts, the CEX has been altered and improved many times since its inception (original source data are available starting in 1980). For example, it is possible to integrate both surveys for years going back to 1996 and roughly replicate expenditure shares published by BLS. The Interview Survey has about 350 UCCs, while the Diary Survey contains approximately 250. Additionally, starting in 2004, BLS began to impute pretax and after-tax income at the individual level rather than rely on complete reporting, which significantly distorts data prior to 2004.[4]. Hence it is possible to extract reliable annual expenditure and income estimates at the individual level from CEX starting in 2004. Unfortunately, the households in the Diary Survey are not the same as those in the Interview Survey and they are not the same over time either, so it is necessary to use a household matching procedure to put the surveys together.

Along with published estimates of aggregate price inflation, the BLS releases monthly, semiannual, and annual estimates of price level changes at different levels of aggregation. Since 1998, BLS has formally embedded each series within a hierarchy, from lowest to highest, of Entry Level Items (ELIs), Item Strata, Expenditure Classes, and Major Groups. There are 303 ELIs, 211 item strata, 70 expenditure classes, and eight major groups. For example, the entry level item 450110 - New Cars falls under the item strata TA01 - New Vehicles, which in turn falls under the expenditure class TA - New and Used Motor Vehicles, which falls under the major group Transportation.[5] However, the BLS does not publish price level estimates for entry level items; the lowest level of aggregation is the item stratum. Prior to 1998, the CPI was not as hierarchical and the relationship between the CPI before and after 1998 is neither injective nor surjective. We detail how we deal with this below.

The BLS constructs the aggregate CPI by linking expenditure shares from the CEX

4. See the BLS document "Description of Income Imputation Beginning With 2004 Data" for details on the imputation procedure

5. See the BLS Document "CPI Requirements for CE" for a complete listing of the hierarchy circa 2010. For a more complete description of the changes implemented in the 1998 revision of the CPI, see the BLS document "Changing the item structure of the Consumer Price Index ."

with price level data. There are several concordances published by the BLS between UCCs in the CEX and ELIs in the CPI.[6] We document below how exactly we use these and the changes we made to account for idiosyncratic categories like healthcare, which rely on private data we do not have access to.

Outline of Steps

Broadly, what we do is:

1. Get average expenditures on each UCC for each quantile.
2. Link UCC expenditures to ELIs and thence item strata and/or expenditure classes.
    - Because certain item strata and expenditure classes sometimes do not exist but the UCCs do, we manually decide whether to reallocate expenditures to a different item strata or expenditure class or omit entirely.
3. Sum expenditures by item strata and/or expenditure class per quantile per year.
4. Following the BLS expenditure share guide, we compute expenditure shares by combining two years of data and then computing shares for each expenditure class and/or item stratum per quantile.
5. Link expenditure shares to CPI item categories.
6. Compute inflation

C Expenditure Shares

C.1 Procedure

We utilize three microdata file types per year of expenditures. For the Interview survey, we take the FMLI files, which contain detailed annual information about consumer unit characteristics, the MTBI files, which contain each expenditure reported by a consumer unit, and the ITBI file, which gives imputed income information for each consumer unit. Each consumer unit receives a unique identifying variable called NEWID. The corresponding files for the Diary survey are the FMLD, EXPD, and DTBD. Each year contains five files of each type for the Interview survey, each corresponding to a quarter. CEX gives five rather than four files because surveys are staggered such that a consumer may report for the previous three months going into a different year. Our procedure for handling this is detailed below. However, there are only four files per year for the Diary survey. Finally, we take advantage of the Integrated Hierarchy file published by CEX annually, which details which UCCs should be pulled from each survey to produce an aggregate measure (this matters because there is overlap between surveys).

6. See the CPI Methods Overview Page, in particular the documents "CPI Requirements for CE" and Appendix 5: UCC to ELI concordance.

Income Quantile Determination

The general procedure for aggregating expenditures for each year is as follows. First, we select the income variable we are interested in grouping by. Typically, this is pretax income because it tends to be the most complete, though other types of income are also feasible to use. We use imputed income measures (in most cases, pretax income), which is only available since 2004. Prior to that, BLS relied on complete income reporters. We are confident that, following Cravino, Lan, and Levchenko (2020), computing disaggregated inflation prior to 2004 would result in unusably biased results, so we only compute expenditure shares going back to 2004. Following the CEX handbook of methods, income for a consumer unit is defined as the mean of the five income imputations that CEX conducts. Our quantile thresholds are based on the empirical CDF of the CEX. Quantile choice is dependent on the granularity of income distribution we are interested in; this ranges anywhere from 100 percentiles to a completely aggregated measure.Following this, we filter all UCCs in the interview expenditure file which meet the following conditions:

- Correspond to the interview survey in the hierarchical grouping file;
- Categorized as "FOOD" or "EXPEND" in the hierarchical grouping file;
- Are in the UCC-ELI-Item Strata-Expenditure Class hierarchy in either the document "CPI Requirements for CE" or Appendix 5: UCC to ELI concordance.

We are primarily interested in constructing weighted calendar year estimates. Consequently we construct a new variable called POPWT which, following the BLS Manual of Methods, is a variable that adjusts expenditures made by each consumer unit based on their population weight and when the expenditures took place. There are three critical values for making this adjustment: QINTRVMO, which gives the month the expenditure took place, QINTRVYR, which gives the year the expenditure occurred, and FINLWT21, the weight variable for each consumer unit. The following is the formula for the variable POPWT for each consumer unit i:

$$POPWT_i = MOSCOPE_{i,t} \times \frac{FINLWT21_i}{4}, \tag{4}$$

where MOSCOPE, according the BLS Handbook of Methods, is defined as

$$MOSCOPE_{i,t} = \begin{cases} \frac{QINTRVMO-1}{3} \text{ if } QINTRVMO < 4 \text{ and } Quarter \in \{1,2,3,4\} \\ 3 \text{ if } QINTRVMO \geq 4 \text{ and } QINTRVMO \leq 12 \\ \frac{4-QINTRVMO}{3} \text{ if } Quarter = 5 \end{cases}$$

If QINTVRVYR equals the survey year, then Quarter will take a value in $\{1,2,3,4\}$. If QINTVRYR is one greater than the survey year, then it means that some of the expenditures are taking place in the following year, so it must come from the fifth quarter of the expenditure file.

After we calculate the POPWT variable, we are then able to calculate aggregate expenditures by UCC and household income percentile. We do the following:

- First, we add up all expenditures for each consumer unit on particular expenditure categories (UCCs). Call this variable COST.
- Recall that households have been sorted into quantiles. Consequently, we are able to summarize average expenditures on each UCC by each quantile. Then for all households (NEWID) i in quantile q, we find average expenditures on each UCC j by obtaining weighted expenditures on a particular UCC j for each household, summing over all households in the quantile, then dividing by the sum of the weight of all households in the quantile:

$$X_{q,j} = \frac{\sum_{NEWID \in q} COST_{i,j} \times FINLWT21_i}{\sum_{NEWID \in q} POPWT_i}$$

This process is repeated for the Diary survey with three key exceptions. First, because observations are weekly rather than quarterly, we multiply each expenditure by 13. Second, each Diary survey year has only four files, so there is no need to be concerned about collecting expenditures out of scope. Finally, we take the empirical CDF defined for CPS household incomes and use those quantiles to categorize household income in the Diary Survey. That is, if the cutoff is \$10,000 in annual income for the first decile in the CPS, we also use that cutoff for the first decile for the Diary survey. After that, we append the Diary survey quantile expenditure summaries to the Interview results. To do the regional analysis, we group income groups by region according to the state they live in.

Adjustments

Our procedure for most types of expenditures is quite simple, but it is necessary to make adjustments for certain categories. All adjustments proceed prior to computing average expenditures by UCC and quantile. All adjustments come from "CPI Requirements for CE" and Appendix 5: UCC to ELI concordance. Broadly, there are two types of adjustments. The first occurs when there are multiple UCCs allocated to different ELIs. In these cases, we follow the instructions of the BLS in the document "CPI Requirements for CE". If instructions do not exist, then we allocate equally across different ELIs. For example, the UCC 360350 - "Mens Swimsuits/Warm-Up/Ski Suits" is allocated to four different ELIs (AA013, AA022, AA033, and AA041). In this case, we give each ELI 25% of the expenditure to avoid double-counting. The second type of adjustment involves scaling down an expenditure's cost, usually because it involves an investment component.

Housing

We make two adjustments to housing. The first, following the BLS document "How the CPI measures price change of Owners' equivalent rent of primary residence (OER) and Rent of primary residence (Rent)", is an estimate of owner-equivalent rent (OER), which typically makes up approximately 23% of total expenditures. The UCC categories under housing tend to lump together a number of ongoing costs, such as property taxes and mortgage interest payments, which the CPI does not consider to be consumer goods.

According to BLS, a house is properly considered a capital good but some portion of housing (rent and its equivalent) is considered a consumer good. Hence, following "CPI Requirements for CE," we instead consult the FMLI file, which asks the following question: "If someone were to rent your home today, how much do you think it would rent for monthly, unfurnished and without utilities?" We take the answer from the FMLI file using the variable RENTEQVX, multiply it by three to get a quarterly value (rather than monthly), and create an artificial UCC that we put into the UCC-ELI hierarchy under HC011.

Second, the BLS makes an adjustment for expenditures on household maintenance, insurance, and major appliances to separate out the consumption component from the investment component. BLS assumes that, on average, 43% of these expenditures are consumption. According to Cravino, Lan, and Levchenko (2020), this is based on the likelihood that a renter in the same situation would make those expenditures. The relevant UCCs are listed in the document "CPI Requirements for CE". Each expenditure corresponding to one of those UCCs is multiplied by 0.43.

Medical Care

In the UCC-ELI concordance, expenditures on insurance are counted multiple times under different categories because insurance is fungible across categories (for example, Medicare expenditures can be used on many different types of medical goods). It is therefore required to allocate these expenditures to different categories such that the total cost is only counted once. BLS accomplishes this by redistributing weights from private health insurance and Medicare premia using the National Health Expenditure tables, which are calculated according to a formula which we do not have access to. Following Cravino, Lan, and Levchenko (2020), we approximate the BLS factors using *Table 20 Private Health Insurance Benefits and Net Cost; Levels, Annual Percent Change and Percent Distribution, Selected Calendar Years 1960-2015*.

We use factors from the table referenced above to redistribute insurance expenditures to different medical categories. Expenditures are mapped to existing UCCs or to a new artificial UCC that underlies an existing item stratum. The exact mapping for doing this is available in the file CEX_CPI_CONCORDANCE.XLSX and in the functions code file cexis_functions.R under the function average_ann_expenditures.

Transportation

Two adjustments are made to UCCs in the transportation category. First, although CPI has different ELIs for regular (*TB011*), midgrade (*TB012*), and premium gas (*TB013*), we are unable to distinguish these at the UCC level. BLS overcomes this issue by distributing expenditures according to factors which we do not have access to. Hence, following Cravino, Lan, and Levchenko (2020), we simply assume that expenditures on each category are equivalent. This is likely a poor assumption but it ultimately matters very little because the item strata for all three is simply *TB01* anyway. Second, following Cravino, Lan, and Levchenko (2020), we adjust expenditures on used cars and trucks (UCCs 450116, 450216, 460110, 460901, 860100, and 860200) such that they only reflect dealer value-added. This amounts to multiplying expenditures on each of these UCCs by 0.5.

C.2 Other Adjustments

Several UCCs are adjusted because they appear multiple times in other categories. For these expenditures, we do not have a good rationale for distributing factors in any way other than equally. The UCCs 340906 and 550310 are repeated twice, so we divide each by 2. Similarly, the UCCs 360350, 370904, 380340, and 390230 are repeated four times, so we divide expenditures on each UCC by 4.

C.3 Household Aggregation

The next two steps are interrelated: aggregate UCCs into item strata or expenditure classes and then calculate expenditure shares. The task is not straightforward for three reasons. First, the CPI underwent a major revision in 1998, introducing the ELI-item strata-expenditure class hierarchy. Consequently, it is necessary to construct a concordance between pre-1998 CPI series and the post-1998 revision such that there is some continuity. We do this in two ways. First, we rely on the BLS document "1998 Item Concordance". However, this concordance is incomplete, so when we are unable to match a series, we rely on the concordance created by Nakamura et al. (2018). The latter concordance matches at the ELI level rather than item strata or expenditure classes, which the former relies on. It is frequently the case that either multiple ELIs get matched to the same series or multiple series get matched to the same ELI. The first case is not a problem. To address the second case, we allocate expenditures to each series according to expenditure weights from Nakamura et al. (2018).

Second, certain series are not introduced until the middle of the period. We deal with this in three different ways. If a related item strata or expenditure class has an available CPI item series, then we reallocate expenditures to that or multiple item strata according to what the particulars of the situation call for. Second, if no related series is available, then we exclude the expenditures entirely. An important example of this is expenditure class *EE* (information technology hardware, and services), which does not have a CPI series until December 1988. But because in our judgment, expenditures from 2004 on something like information technology would overstate their importance prior to the introduction of this series, we omit those expenditures entirely. A related issue comes up for health insurance in the post-1998 revision. Finally, some ELIs are matched to multiple series, some of which do not begin until the middle of the period so that, for example, an ELI might be matched to a series that is present for the duration of the period and to another that does not begin until 1988. In such cases, we use coefficients based on the Nakamura et al. (2018) concordance expenditure weights. These coefficients are stored in the sheet "pre98_concordance" under the names "factor", "factor_split", and "factor_split_2". The relevance of each is determined by how often new series are introduced for particular ELIs. See the sheets "Pre-98 Plan" and "pre98_concordance" in the document "CEX_CPI_CONCORDANCE.xlsx" for details.

Finally, the task is made difficult by the fact that CEX does not report imputed income measures until 2004 and income estimates prior to then are hopelessly biased. Note that to construct a Laspeyres inflation index (which is what the CPI is; see equation 5), it is necessary to have fixed expenditure weights coming from some *reference period*. That is, Laspeyres indices measure changes in the aggregate price level by keeping expenditures fixed and evaluating the change in price for the same basket. The BLS measures price changes for different categories of goods, then constructs an aggregate price level by multiplying changes in the prices of those goods by their relative importance, or expenditure share. The expenditure shares in the past, i.e., in the reference period, form the consumption basket for the consumer in question in the future when price changes are measured. Consequently, following Cravino, Lan, and Levchenko (2020), we use expenditures from 2004-05 for all years until 2008, then follow the BLS schedule after that.[7] See Table 6 for details. Note that this implies that we use a Paasche index for years prior to 2006 and a Laspeyres index thereafter.

$$CPI = \frac{\sum_i P_{i,t} Q_{i,0}}{\sum_i P_{i,0} Q_{i,0}} \tag{5}$$

Years	Expenditure Reference Period
1977-2008	2004-05
2009-2010	2006-07
2011-2012	2008-09
2013-2014	2010-11
2015-2016	2012-13
2017-2018	2014-15
2019-2020	2016-17
2021	2018-19
2022	2019-20
2023	2020-21
2024	2021-22

Table 6: Matching expenditure shares with years 1977-2024. Note that the left column means that prices from those years use expenditures from the years in right column to form the aggregate CPI.

After compiling average expenditures per UCC by quantile per year, we proceed to construct expenditure shares. The procedure is substantially different for different years.

7. See "Chapter 17. The BLS Handbook of Methods". According to Cravino, Lan, and Levchenko (2020), the aggregate series constructed using BLS aggregate expenditure shares and the aggregate series constructed using this methodology are quite similar.

This is because even though UCCs are basically constant over time, item strata and even expenditure classes are not. Hence there is a constant need to manually reallocate expenditures to different item strata and expenditure classes. Suppose we have already constructed a concordance between UCCs and item strata (this is not straightforward and will be discussed in some detail below). We will proceed as if expenditure shares are developed at the slightly less aggregated item strata level rather than expenditure class. Then the basic procedure is

1. match UCCs with item strata using the BLS concordance (see the spreadsheet "CEX_CPI_CONCORDANCE.xlsx" for details).

2. Sum all expenditures made by a quantile within the reference period. Call this object $COST_q$.

3. Sum all expenditures by quantile and item strata within the reference period. Call this object $COST_q, i$ for quantile q and item strata i.

4. Obtain expenditure shares by item strata and quantile by taking $COST_{q,i}/COST_q$ for every quantile q and item strata i. Within each quantile, these should sum to one.

1977-1982

We use expenditures from 2004-05, with the following adjustments. Expenditures falling under item strata *HL02*, *RD02*, *HB02*, *RF03*, and *RF01* are redistributed to all remaining item strata under the same expenditure class according to the proportion of expenditures the other item strata take up within the expenditure class. For example, suppose expenditure class *HL* contains four item strata: *HL01*, *HL02*, *HL03*, and *HL04*. The CPI item-level series that best matches with *HL02* does not exist prior to 1983, so we would take all expenditures from *HL02* and redistribute them to each remaining item strata with the following weights: $HL01/(HL01 + HL03 + HL04)$, and $HL03/(HL01 + HL03 + HL04)$, $HL04/(HL01 + HL03 + HL04)$. In this appendix, the word *redistribute* always refers to this procedure. Next, we remove all expenditures made in the expenditure classes, *EE* (information technology hardware, and services) and *AG* (jewelry and watches). It is not so much that we do not believe people made expenditures on either of these categories; rather, there is not a feasible match for either in this period. Finally, BLS did not collect data on owner-equivalent rent prior to 1983. However, because it is such a large proportion of total expenditures (20-25%) and is closely related to the rent category, we think we are justified in redistributing those expenditures to the item stratum *HA01* (rent of primary residence). All remaining item strata are matched with a CPI series and multiplied by a variable called "factor" as defined in the sheet pre98_concordance in the spreadsheet "CEX_CPI_CONCORDANCE.xlsx". Health insurance expenditures are completely reallocated to all other medical care categories and the expenditure class *MG* expenditures are reallocated to the item strata *MF01* and *MF02* expenditures are redistributed.

1982-1983

Adjustments are the same as 1977-1982, except owner-equivalent rent is no longer allocated to *HA01*, *HB02* is not redistributed among *HB* item strata. Health insurance expenditures are completely reallocated to all other medical care categories and the expenditure class *MG* expenditures are reallocated to the item strata *MF01* and *MF02* expenditures are redistributed.

1984-1986

Adjustments are the same as 1982-1983, except for series multiplication by factor. For this period the item strata *RE01*, *RA03*, *RA04*, *HM01*, *GE*, *HP02*, *HP03*, *HK01*, *RE02*, *TA01*, and *TD02* are multiplied by the variable "factor" while all other item strata are multiplied by "factor_split". Health insurance expenditures are completely reallocated to all other medical care categories and the expenditure class *MG* expenditures are reallocated to the item strata *MF01* and *MF02* expenditures are redistributed.

1987-1988

Adjustments are the same as 1984-1986 except only *HL02* is redistributed. Additionally, the item strata *RE01*, *RA03*, and *RA04* are multiplied by the variable "factor", while all other item strata are multiplied by the variable "factor_split_2". Finally, item strata in the expenditure class *AA* can be matched with a CPI series, so those expenditures are counted in total expenditure and hence begin to have an expenditure weight. Health insurance expenditures are completely reallocated to all other medical care categories and the expenditure class *MG* expenditures are reallocated to the item strata *MF01* and *MF02* expenditures are redistributed.

1989-1990

The only adjustments made in this period are that *HL02* is redistributed. All series are multiplied by the variable "factor_split_2" and *EE* expenditures begin to count in total expenditures. Health insurance expenditures are completely reallocated to all other medical care categories and the expenditure class *MG* expenditures are reallocated to the item strata *MF01* and *MF02* expenditures are redistributed.

1991-1997

No adjustments are made except that health insurance expenditures are completely reallocated to all other medical care categories and the expenditure class *MG* expenditures are reallocated to the item strata *MF01* and *MF02* expenditures are redistributed.

1998-2001

Since it is the post-1998 period, UCCs are concorded according to the ELI-Item Strata-Expenditure Class hierarchy using a different concordance (see above for details). Health insurance expenditures are completely reallocated to all other medical care categories and the expenditure class *MG* expenditures are reallocated to the item strata *MF01* and *MF02* expenditures are redistributed. *ED04* expenditures are reallocated to *ED03*, *MD03* expenditures are reallocated to *MD02*, and *TA03* expenditures are redistributed.

2002-2005

Same as 1998-2001 except *TA03* is not redistributed.

2006-2008

Same as 2002-2005 except *ME* expenditures are not completely reallocated; a CPI series exists for health insurance starting December 2005.

2009

Exactly the same adjustments as 2006-2008 except this is now done using 2006-07 expenditures instead of 2004-05.

2010-January 2021

No adjustments.

January 2021-April 2021

The series corresponding to *HP04* is no longer available so we redistribute these expenditures.

April 2021-Present

The series corresponding to *TA03* is no longer available so we redistribute *TA03* to expenditure class *TA*. Additionally, the series corresponding to *HP04* is no longer available so we redistribute these expenditures. From January 2022 onward, the expenditure class *HP* is no longer available, but the unadjusted item strata CUUR0000SEHP01 and CUUR0000SEHP03 remain available. As a result, we treat *HP01* and *HP03* as separate expenditure classes and assign all extra expenditures from *HP02, HP04, HP09* to *HP01*. The problem in this case is that *HP* is initially at a different price level than *HP01* and *HP03*. To correct for this, we set the price level for *HP01* and *HP03* to the price level for *HP* in November 2021 and then use inflation rates for *HP01* and *HP03* to get the corresponding price levels for each series associated with shifting the price level.

D Household-specific CPIs

In this section, we describe our procedure for selecting specific item-level CPI series. BLS releases consumer price indices each month for series starting at the item strata level all the way up to the aggregate CPI-U. Price index identifiers follow a common naming convention. The first two letters determine whether the series is from the current survey or a prior revision (CU for the former, MU for the later). The next two letter indicates whether the series is seasonally adjusted (U for unadjusted, S for adjusted). The fourth letter gives the periodicity (R indicates monthly, S semiannual). The next four numbers determine which area is being sampled. We exclusively use national price indices. All characters after those numbers indicate the item code. Thus, for example, CUSR0000SEAA is the series ID for a seasonally adjusted, national price index from the current survey for men's apparel.

Across all periods, we only use national price indices at a monthly frequency (sampling all urban consumers). The post-1998 revision is the current survey, while all pre-1998 series are the prior revision, so they begin with "MU". When available, we use seasonally adjusted series. Frequently, these are not available for the duration of the sample, so we create "hybrid" series that typically begin with an unadjusted series and become an adjusted series when available. These series are indicated in our code and data with the letter "H" in place of "S" or "U" as the third letter in the series ID.

Occasionally, a more complicated issue arises when expenditures are reallocated from one series to another, a phenomenon described in detail in the previous section. Take owner-equivalent rent as an example. From 1977-1982, it was allocated to the price index associated with rent. But when the owner-equivalent rent price index begins to be published in 1983, it starts at a price level of 100, while the rental series is at a number well above that (around 146). The practical consequence of this is that, because OER is such a large share of total expenditures, it looks like a massive deflation has taken place when really it is simply expenditures going to a new series. To deal with this, we take two steps. First, we compute the percentage monthly percentage change in the new series, $\pi_{i,t}$. Then we take the last monthly price index value of the series to which expenditures were previously allocated and set that as the base for the new series so that instead of OER starting at 100, it would start at 146. We then iteratively compute what the price level is in the following months using the monthly inflation rates for the new series. For example, suppose the OER series begins in December 1982 at 100 and the rent series in November 1982 is 146. Using the OER series, we compute a new inflation variable and set the December 1982 price index for OER at 146. To determine what the price level is for the OER series in January 1983, we multiply 146 by one plus the inflation rate for the original OER series between December 1982 and January 1983, and so on. We follow this procedure every time expenditures are reallocated.

We then match expenditure shares with these series as described in the previous section and are therefore ready to compute aggregate inflation.

D.1 Aggregation Formula

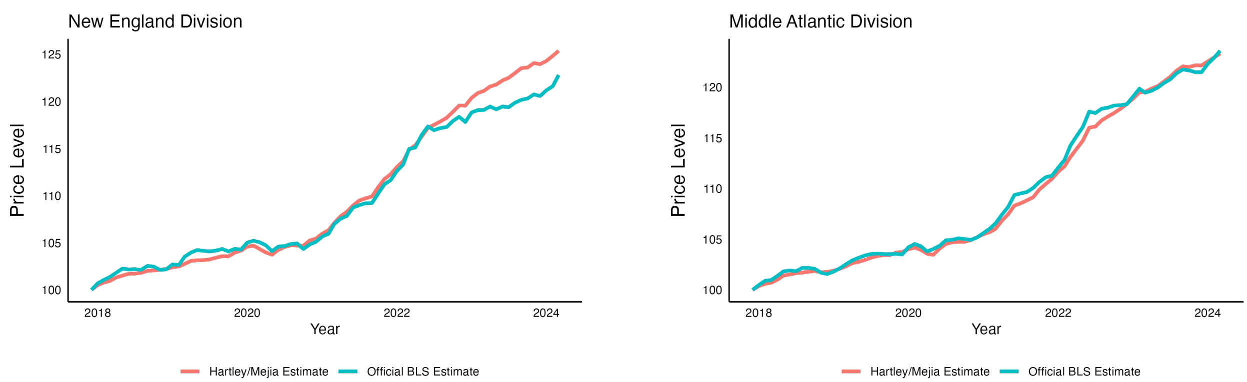
"Chapter 17. The BLS Handbook of Methods" provides an aggregation formula for the CPI. Following this and the lead of Cravino, Lan, and Levchenko (2020), we construct the income quantile CPI as follows:

$$PIX_t^h = PIX_v^h \cdot \sum_{j \in J} \left(\omega_{j,\beta}^h \times \frac{P_{j,t}}{P_{j,v}} \right)$$

where

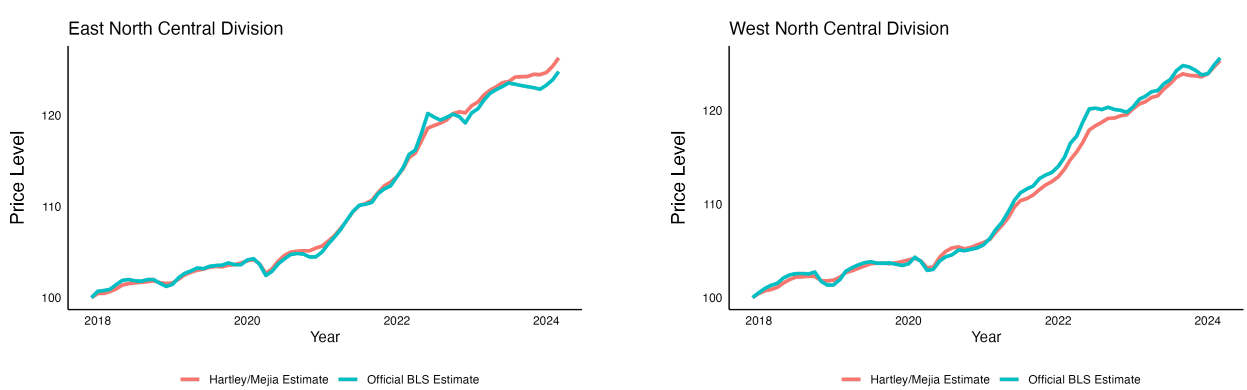
- PIX_t^h is the consumer price index for household at quantile h at time t
- v is the pivot year and month prior to the month when expenditure wights from reference period β are first used in the CPI. Note that the way we construct the weights means that these will not always start at 100, in contrast to some methodologies.
- β is the predetermined expenditure reference period
- $P_{j,t}$ price of item j at time t
- $\omega_{j,\beta}^h$ is the expenditure weight of household at quantile h on time j during the predetermined expenditure reference period β

As a robustness check, we plot the aggregate annual inflation rates from 1979-2023 using our measure versus the official statistic published by the BLS in Figure 2. As a second robustness check, we plot the official monthly price level for each region against our own measure in Figures 23, 24, 25, and 26. The official measure only begins in 2018.



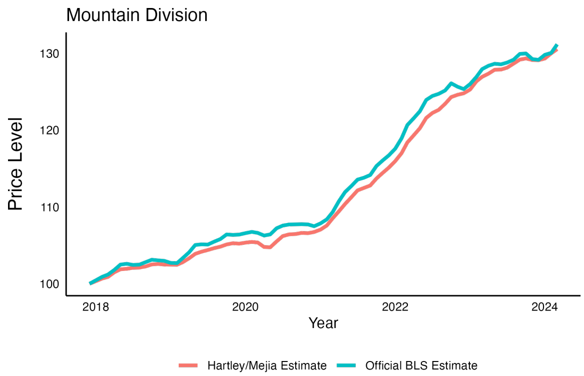
(a) New England **(b)** Middle Atlantic

Figure 23: Northeast

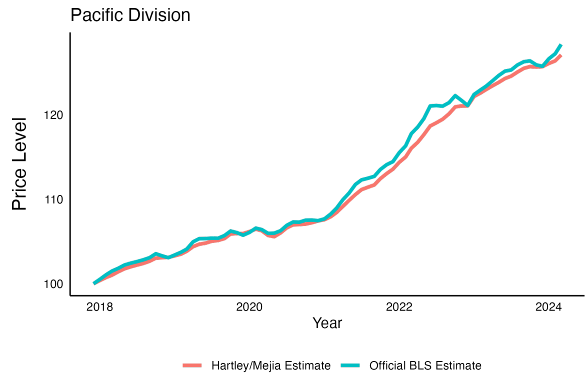


(a) East North Central **(b)** West North Central

Figure 24: Midwest

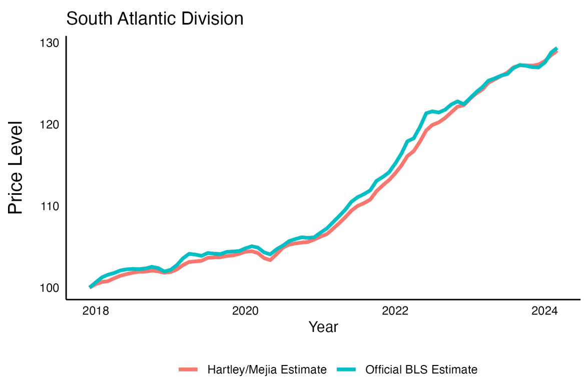


(a) Mountain

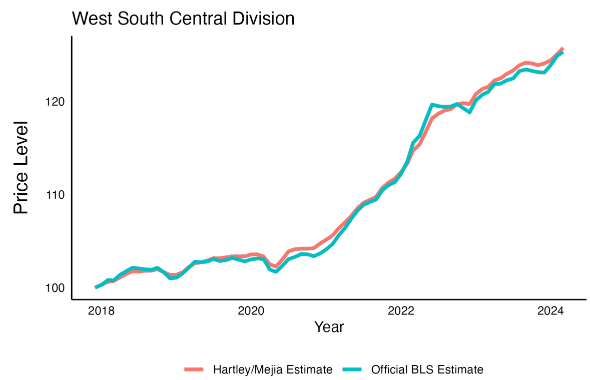


(b) Pacific

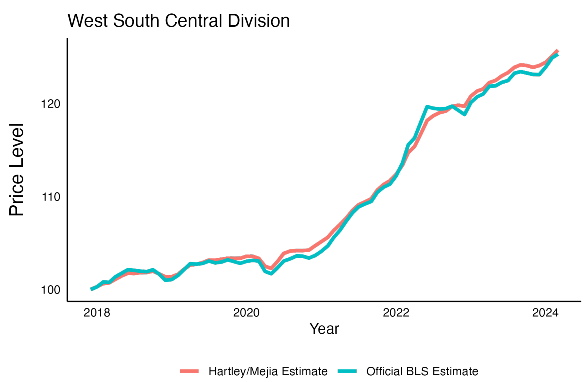
Figure 25: West



(a) South Atlantic



(b) East South Central



(c) West South Central

Figure 26: South

D.2 Core and Supercore Inflation

To form the core inflation measure, we exclude the following expenditure classes and reweight accordingly: TB, HE, HE, and every category in the Food major group. To form the supercore metric class, we drop all expenditure classes in the food and housing major groups as well as motor fuels.