# Getting Real About Wages: A Nonhomothetic Wage Deflator*

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**Abstract**

Conventional real wages—nominal wages divided by a consumption deflator—are biased from a welfare perspective when households value leisure and exhibit nonhomothetic consumption behavior. We derive a true wage deflator, shown to be a multiplicative adjustment to the consumption deflator, that can be estimated nonparametrically using cross-sectional data. Applying our framework to US data from 1984 to 2019, we find that standard measures understate real wage growth by 8–36 percent and welfare growth by 5–17 percent across the income distribution. Our deflator does not alter the compression of the wage distribution during the recent high-inflation period, however.

**Keywords:** Inflation, real wages, inequality, welfare, nonhomothetic preferences.

**JEL Codes:** C43, E24, E31, I31, J31.

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## 1 Introduction

Ashenfelter (2012, p. 617) states that the "connection between wage rates, well-being, and productivity is at the heart of the modern economic analysis of labor markets." Taking these words seriously, a natural question arises: how should we measure real wages from a welfare point of view? The conventional approach simply adjusts nominal wages using a price deflator such as the Consumer Price Index (CPI) designed to capture changes in the cost of consumption. Such real wage estimates arguably fall short as true measures of well-being, since the corresponding deflators ignore a key element of both wage income and welfare: hours worked and leisure time. Yet, despite a long line of research on inflation measurement, little is still known about the potential bias that this shortcoming generates.

In this paper, we bridge this gap through two contributions. First, we develop a theoretical framework for constructing true wage deflators when households have nonhomothetic preferences defined over both consumption and leisure, rather than just consumption. The resulting wage deflators are simple multiplicative adjustments of their corresponding consumption deflators, and the wedge between them can be directly inferred from the cross-sectional variation in nominal and real consumption expenditures, building on recent advances in the price index literature. Moreover, no parametric restrictions are imposed on preferences besides additivity between consumption and leisure—a common assumption. Bringing our framework to combined Consumer Expenditure Survey (CEX) and Current Population Survey (CPS) data, we then measure real wages and welfare trends in the United States since the 1980s—including the recent high-inflation period—and find that real wage growth is substantially higher under our new measure.

Our idea is to extend the standard concept of real consumption to a comparable definition of real wages. In the typical setting without leisure, real consumption is the expenditure needed to maintain current utility at constant base-period consumer prices. With valued leisure, we similarly think of the real wage as the wage rate that, together with consumption, preserves overall utility. Specifically, we define real consumption and wages jointly by asking: "given current nominal expenditure and number of hours worked, what consumption level and wage rate are needed to maintain current utility at base-period prices?" With additive preferences and a given number of hours worked, this setting preserves the original notion of real consumption, with reference utility now equal to total utility net of leisure. We can therefore construct real consumption independently of the wage rate using standard methods, and then back out real wages and their deflators from households' optimality conditions between consumption and leisure.

We then show that the adjustment factor between the wage and consumption deflators is determined by the elasticity between nominal and real consumption expenditures. The difference from the consumption deflator arises because, with nonhomothetic preferences, the marginal value of time varies with income. Intuitively, more leisure implies lower labor income, causing substitution away from luxuries and toward necessities. The welfare cost of this substitution depends on the composition of the consumption basket, which itself varies with income. Consistent with this intuition, we show that the wedge disappears if and only if preferences are homothetic in consumption, at which point the standard practice of deflating nominal wages by a consumption deflator is valid regardless of the valuation of leisure.

Our definition of real wages differs from the surprisingly thin and seemingly dormant price index literature on the development and estimation of wage deflators. Earlier work by Pencavel (1977, 1979a, 1979b), Lloyd (1979), Cleeton (1982), Coles and Harte-Chen (1985), Kokoski (1987), and Riddell (1990) inverts the indirect utility function to obtain constant-utility real wages as functions of consumer prices and unearned income. Our novelty is to effectively define constant-utility real wages as functions of prices and consumption expenditure via households' optimality conditions. As explained by Preston and Walker (1999), both approaches generate valid welfare metrics when leisure enters the utility function.[1] The practical advantage of our formulation is that expenditures are easily observable, whereas unearned income often is not, and this allows us to exploit state-of-the-art price index methods for consumption directly when constructing wage deflators.

To be specific, since the wage deflator is a product of the consumption deflator and a simple nominal-to-real expenditure elasticity, the empirical implementation becomes a straightforward task: compute real consumption across heterogeneous households using household-specific consumption deflators, estimate nonparametrically the cross-sectional relationship between nominal and real consumption, and evaluate the elasticity at the expenditure levels corresponding to the wage rates of interest. This mirrors the methodology proposed by Jaravel and Lashkari (2024), who develop algorithms based on the same elasticity to estimate real consumption growth under arbitrary preferences. We leverage this close connection by adopting their approach off the shelf in our empirical implementation, thereby allowing us to estimate both consumption and wage deflators in one go. The only additional requirement for our analysis is wage data, which we obtain by matching CEX and CPS data across the income distribution.

Empirically, the wage deflator generates substantially higher long-run real wage growth compared to a benchmark based on the Jaravel-Lashkari consumption deflator. Between 1984 and 2019, annual real wage growth measured in 2019 prices rises from 0.79 to 1.06 percent at the bottom income decile and from 2.09 to 2.09 percent at the top. Overall, real wage growth increases by 0.19 to 0.27 percentage points per year across the income distribution. This wage bias naturally carries over to a qualitatively similar bias in overall welfare. Considering the money metric defined as the sum of real consumption and leisure expenditure, we find that welfare growth using the corrected wages increases by 0.10 to 0.18 percentage points relative to the benchmark. Taken together, our findings suggest that the consumption deflator underestimates real wage growth by 8 to 36 percent and welfare growth by 5 to 17 percent relative to the corrected wage deflator.

The wage deflator also sheds new light on the compression of the wage distribution that followed the Covid-19 pandemic and the recent high-inflation episode, as documented by Autor, Dube and McGrew (2023) and Jaravel (2024). We extend their findings—which are obtained using homothetic and income-specific CPIs, respectively—by showing that the real wage convergence between 2019 and 2023 persists under our wage deflator and remains close to that implied by the standard CPI. While the real wage growth biases resemble those in the 1984–2019 setting above, the 2019–2023 time span is too short for cumulative growth differences to translate into sizable level effects. Instead, the large heterogeneity in nominal wage growth during this period dominates the comparatively modest differences obtained by changing deflators. Thus, while the choice of deflator matters in general, it played only a limited role in shaping the recent US wage dynamics.

Overall, our results contribute to a large body of research on inflation inequality and consumer welfare measurement. Earlier work in this literature typically constructs standard homothetic price indices for different consumer groups; see Jaravel (2021) for a survey.[2] More recent contributions such as Baqaee

[1] Preston and Walker (1999, section 2.1) define six equally valid welfare metrics for consumption-leisure models. Our real consumption and real wage correspond exactly to their metrics (c) and (d)—the consumption and wage metrics defined for a reference level of hours worked—while the earlier literature corresponds to their metric (e).

[2] Examples include Hobijn and Lagakos (2005), McGranahan and Paulson (2005), Kaplan and Schulhofer-Wohl (2017), Jaravel (2019), Argente and Lee (2021), and Klick and Stockburger (2021).

and Burstein (2023), Atkin *et al.* (2024), Baqaee, Burstein and Koike-Mori (2024), Hochmuth, Pettersson and Weissert (2024a, 2024b), and Jaravel and Lashkari (2024) highlight that such price index methods are biased in the presence of nonhomothetic behavior. Yet, a common feature across this entire literature is its exclusive focus on consumption. By showing both theoretically and empirically that a similar bias arises for real wages constructed with consumption deflators, we take a first step toward extending this literature into the wage dimension.

## 2 Framework for Deflating Wages

We depart from a setting in which households consume a set of goods and services with a price vector $\boldsymbol{p}$ and choose hours worked $h$. Our only restriction on preferences is that they are additively separable between consumption and leisure; the utility function is

$$U = v(e, \boldsymbol{p}) - u(h), \tag{1}$$

where $e$ denotes nominal consumption expenditure, $v(e, \boldsymbol{p})$ is a well-behaved indirect utility function for consumption, and $u(h)$ is the disutility from working. We denote the expenditure function corresponding to $v(e, \boldsymbol{p})$ by $e(u_c, \boldsymbol{p})$, where $u_c = v(e, \boldsymbol{p})$ is the utility obtained from consumption, and assume that households maximize utility subject to the budget constraint

$$e = wh + y, \tag{2}$$

where $w$ is the nominal wage rate and $y$ is unearned income.

### 2.1 The Wage Deflator

Our goal is to derive deflators that convert nominal expenditures and wages in current period $t$ into real variables expressed in base-period prices $\boldsymbol{p}_b$, where $b$ denotes some arbitrary base period. In the typical case without leisure, this is straightforward: real consumption $c_t(\boldsymbol{p}_b)$ is then defined as the expenditure needed to obtain current utility $u_{ct} = v(e_t, \boldsymbol{p}_t)$ at base-period prices. That is,

$$c_t(\boldsymbol{p}_b) \equiv e(u_{ct}, \boldsymbol{p}_b) = \frac{e_t}{P^c(u_{ct}, \boldsymbol{p}_b, \boldsymbol{p}_t)}, \tag{3}$$

where the consumption deflator

$$P^c(u_{ct}, \boldsymbol{p}_b, \boldsymbol{p}_t) \equiv \frac{e(u_{ct}, \boldsymbol{p}_t)}{e(u_{ct}, \boldsymbol{p}_b)} \tag{4}$$

is the Konüs (1939) cost-of-living index taking period-$t$ utility as the reference standard of living. (From now on, we leave arguments implicit and denote real consumption and its deflator simply by $c_t$ and $P^c_t$.) In this case, the real wage is just the nominal wage deflated by the consumption deflator (4), reflecting the purchasing power of wages in terms of goods and services.

When households value leisure, however, wages play a direct role for utility as the price of leisure. Analogously to real consumption, one option in this case is to define real leisure expenditure as the amount required under base-period prices to keep current hours worked—and thus current utility from leisure—fixed. Since leisure expenditure depends only on the wage rate when hours are fixed, the real wage can then be defined similarly. This setup preserves—and naturally extends—the real consumption definition above:

with additively separable preferences and fixed hours, maintaining overall utility reduces to holding the utility from consumption constant. The quantity that achieves this is the real consumption in Equation (3), which is constructed independently of the wage.

To be specific, for expenditure $e_t$ and hours $h_t$ generating total utility $U_t$, real consumption is given by Equation (3) with reference utility $u_{ct} = U_t + u(h_t)$. Meanwhile, under maximizing behavior, an interior solution for hours worked necessarily satisfies the first-order condition

$$u'(h_t) = w_t \cdot \frac{\partial v(e_t, \boldsymbol{p}_t)}{\partial e_t}, \tag{5}$$

where $u'(h_t)$ is the marginal disutility of work. To optimally choose $h_t$ under base-period prices $\boldsymbol{p}_b$, the real wage must preserve this condition at the corresponding level of real consumption. This motivates the following definition.

**Definition 1** (Real wage)**.** Consider an optimizing household with preferences (1) facing the budget constraint (2) that works $h_t$ hours in period $t$. The real wage, expressed in base-period prices, is the wage $w_t^*$ at which the household optimally chooses $h_t$ hours under prices $\boldsymbol{p}_b$ and real consumption $c_t$:

$$u'(h_t) = w_t^* \cdot \frac{\partial v(c_t, \boldsymbol{p}_b)}{\partial c_t}. \tag{6}$$

The corresponding wage deflator is implicitly defined by $P_t^w \equiv w_t / w_t^*$. ◁

Definition 1, together with real consumption, answers the question: "given a reference number of hours worked, what consumption level and wage rate maintain current utility at base-period prices?" As discussed by Preston and Walker (1999), this is a valid welfare metric when leisure affects utility, though alternatives exist. The conventional price index approach, for instance, inverts the overall indirect utility function to define real wages as functions of reference unearned income rather than hours. However, such inversion is mainly a theoretical device that rarely generates practical index formulae, and unearned income is often unobserved empirically (Ashenfelter, 2012). Applications by Pencavel (1977, 1979a, 1979b), Coles and Harte-Chen (1985), Kokoski (1987), and Riddell (1990) instead rely on bounding approximations or estimate parametric utility functions. By preserving the standard definition of real consumption and expressing real wages as functions of expenditures, we circumvent these limitations and can apply standard price index theory directly to construct wage deflators:

**Proposition 1** (Wage deflator)**.** *Consider an optimizing household with additive preferences (1) facing the budget constraint (2). For a real wage satisfying Definition 1, the wage deflator that converts the nominal wage in period t into base-period prices is given by*

$$P_t^w = P_t^c \cdot \frac{\partial \ln e_t}{\partial \ln c_t}. \tag{7}$$

*Outside the base period, this wage deflator equals the consumption deflator if and only if preferences are homothetic in consumption.*

*Proof.* Equation (7) follows directly from Equations (3) to (6) together with the fact that $\frac{\partial v(e,\boldsymbol{p})}{\partial e} = \frac{1}{\frac{\partial e(u,\boldsymbol{p})}{\partial u}}$:

$$P_t^w \equiv \frac{w_t}{w_t^*} = \frac{u'(h_t)}{u'(h_t)} \cdot \frac{\frac{\partial v(c_t,\boldsymbol{p}_b)}{\partial c_t}}{\frac{\partial v(e_t,\boldsymbol{p}_t)}{\partial e_t}} = \frac{e_t}{c_t} \cdot \frac{\frac{u_{ct}}{e(u_{ct},\boldsymbol{p}_t)} \cdot \frac{\partial e(u_{ct},\boldsymbol{p}_t)}{\partial u_{ct}}}{\frac{u_{ct}}{e(u_{ct},\boldsymbol{p}_b)} \cdot \frac{\partial e(u_{ct},\boldsymbol{p}_b)}{\partial u_{ct}}} = P_t^c \cdot \frac{\partial \ln e_t}{\partial \ln c_t}.$$

To prove the if-and-only-if statement, suppose first that preferences are homothetic. By definition, then, the expenditure function can be written $e(u_c, \boldsymbol{p}) = f(u_c)g(\boldsymbol{p})$ for some functions $f$ and $g$, which implies that

$$\frac{\partial \ln e_t}{\partial \ln c_t} = \frac{\frac{\partial \ln e(u_{ct},\boldsymbol{p}_t)}{\partial \ln u_{ct}}}{\frac{\partial \ln e(u_{ct},\boldsymbol{p}_b)}{\partial \ln u_{ct}}} = \frac{u_{ct} f'(u_{ct})/f(u_{ct})}{u_{ct} f'(u_{ct})/f(u_{ct})} = 1.$$

Hence, $P_t^w = P_t^c$. Suppose conversely that $P_t^w = P_t^c$. Then $\frac{\partial \ln e_t}{\partial \ln c_t} = 1$ by (7), which only holds for a given $u_{ct}$ if the elasticity of expenditures with respect to utility is independent of prices. That is, for all price vectors $\boldsymbol{p}$,

$$\left.\frac{\partial \ln e(u,\boldsymbol{p})}{\partial \ln u}\right|_{u=u_{ct}} = C \qquad \text{for some constant } C.$$

Solving the differential equation yields $\ln e(u_{ct}, \boldsymbol{p}) = C \ln u_{ct} + B(\boldsymbol{p})$ for some function $B(\boldsymbol{p})$, which is equivalent to $e(u_{ct}, \boldsymbol{p}) = f(u_{ct})g(\boldsymbol{p})$ with $f(u_{ct}) = u_{ct}^C$ and $g(\boldsymbol{p}) = e^{B(\boldsymbol{p})}$. It follows that $e(u_{ct}, \boldsymbol{p})$ is a homothetic expenditure function. □

Proposition 1 applies to any worker within a household, regardless of their nominal wage or hours choice, as long as the marginal utility of consumption remains independent of hours and there are no interactions between labor earnings on the income side. The elasticity $\frac{\partial \ln e_t}{\partial \ln c_t}$ can be interpreted as an adjustment to the relative price of leisure arising from nonhomothetic preferences. To see this, divide both sides of the budget constraint with the consumption deflator (4) and use Proposition 1 to form the real budget constraint (in terms of consumption)

$$c_t = \frac{\partial \ln e_t}{\partial \ln c_t} w_t^* h_t + \frac{y_t}{P_t^c}.$$

Intuitively, the unit value of leisure is the opportunity cost to get it, which is usually just the wage rate itself. With nonhomothetic preferences, there is an additional opportunity cost due to changes in the composition of the consumption basket: more leisure lowers your income, which shifts consumption away from luxuries and towards necessities. So, the marginal value of a unit of time depends on the composition of the consumption basket, which varies with expenditures. Under homothetic preferences, the composition of consumption is independent of expenditures, so this adjustment naturally disappears, and we obtain a standard real budget constraint.

Two key insights emerge from Proposition 1 and its preceding discussion. The first is that it only makes sense to deflate wages with a consumption deflator if people do not value leisure or if preferences are homothetic in consumption. Unfortunately, these knife-edge cases rarely hold in the data, so a separate wage deflator is generally required. The second insight is that this is readily achieved by adjusting the consumption deflator with a single multiplicative factor. Being an elasticity between nominal and real expenditures, this multiplier and the corresponding wage deflator are easy to estimate nonparametrically in cross-sectional data: deflate nominal expenditures using any consumption deflator, then estimate by regression the cross-sectional relationship between nominal and real log expenditures, evaluate the derivative at the relevant expenditure points, and finally apply Equation (7).

This last point highlights a close connection between Equation (7) and the recent contribution by Jaravel and Lashkari (2024), who develop a nonparametric algorithm for estimating real consumption growth under arbitrary preferences. Their approach corrects for the potential bias induced by deflating nominal growth $e_{t+1}/e_t$ with homothetic inflation rates $\pi_t$ by estimating "nonhomotheticity correction factors" $1+\Lambda_t$ such that real growth satisfies $\ln \frac{c_{t+1}}{c_t} = (1+\Lambda_t)^{-1}\big(\ln \frac{e_{t+1}}{e_t} - \pi_t\big)$. By Jaravel and Lashkari's Proposition 1, the factor $1+\Lambda_t$ turns out to be exactly the expenditure elasticity $\frac{\partial \ln e_t}{\partial \ln c_t}$ from Equation (7). This suggests that their algorithm kills two birds with one stone: not only does it generate wage deflators under arbitrary preferences, but it also obtains both necessary components—the consumption deflator and the expenditure elasticity—in one go.

## 2.2 An Illustrative Example

To build further intuition, it is useful to analyze a parametric form of the utility function. To that end, consider the intertemporally aggregable preferences of Alder, Boppart and Müller (2022), which are prevalently used in the structural transformation literature to model long-run changes in the sectoral composition of output. The indirect utility function for consumption is then

$$v(e,\boldsymbol{p}) = \frac{1}{\varepsilon}\left[\left(\frac{e-A(\boldsymbol{p})}{B(\boldsymbol{p})}\right)^{\varepsilon} - 1\right] - \frac{\nu}{\varepsilon}\left[\left(\frac{D(\boldsymbol{p})}{B(\boldsymbol{p})}\right)^{\varepsilon} - 1\right], \tag{8}$$

where $\varepsilon \in (0,1)$, $\nu \geq 0$, and $A(\boldsymbol{p})$, $B(\boldsymbol{p})$, $D(\boldsymbol{p})$ are linearly homogenous price functions. These preferences are nonhomothetic and flexible in the sense that they permit nonmonotonic (hump-shaped) budget shares. Equation (8) also nests commonly used preferences as special cases: we obtain quasi-homothetic preferences if $D(\boldsymbol{p}) = B(\boldsymbol{p})$, Muellbauer's (1975, 1976) price-independent generalized linearity (PIGL) preferences if $A(\boldsymbol{p}) = 0$, and homothetic preferences when both conditions hold.

While $A(\boldsymbol{p})$, $B(\boldsymbol{p})$, and $D(\boldsymbol{p})$ are generally functions of all individual goods and services, it helps to interpret these as representing distinct, homothetic sub-baskets with associated price indices $P_{Ct} \equiv C(\boldsymbol{p}_t)/C(\boldsymbol{p}_b)$, $C \in \{A, B, D\}$. Roy's identity then implies expenditure shares of the forms

$$s_A = \frac{A(\boldsymbol{p})}{e}, \tag{9a}$$

$$s_B = \left(1 - \frac{A(\boldsymbol{p})}{e}\right)\left[1 - \nu\left(\frac{D(\boldsymbol{p})}{e-A(\boldsymbol{p})}\right)^{\varepsilon}\right], \tag{9b}$$

$$s_D = \left(1 - \frac{A(\boldsymbol{p})}{e}\right)\nu\left(\frac{D(\boldsymbol{p})}{e-A(\boldsymbol{p})}\right)^{\varepsilon}. \tag{9c}$$

Here, $s_A$ decreases and $s_B$ increases with expenditures, while $s_D$ is hump-shaped if $A(\boldsymbol{p}) \neq 0$ and decreasing otherwise. $A(\boldsymbol{p})$ therefore represents necessities and $B(\boldsymbol{p})$ luxuries. $D(\boldsymbol{p})$ is an intermediate case in general and a necessity bundle under PIGL preferences.

Following Hochmuth, Pettersson and Weissert (2024a, 2024b), the consumption deflator and the expenditure elasticity under these preferences satisfy

$$P_t^c = \left[(1 - s_{At})\,\widetilde{P}_t^{-1} + s_{At}P_{At}^{-1}\right]^{-1} \qquad \text{and} \qquad \frac{\partial \ln e_t}{\partial \ln c_t} = \left(\frac{P_{Bt}}{P_t^c}\right)^{\varepsilon}\left(\frac{\widetilde{P}_t}{P_t^c}\right)^{1-\varepsilon}, \tag{10a}$$

where

$$\widetilde{P}_t \equiv \left[\frac{s_{Bt}}{1 - s_{At}}P_{Bt}^{-\varepsilon} + \frac{s_{Dt}}{1 - s_{At}}P_{Dt}^{-\varepsilon}\right]^{-\frac{1}{\varepsilon}}. \tag{10b}$$

The PIGL case arises when $s_{At} = 0$, implying $P_t^c = \widetilde{P}_t$ and $\frac{\partial \ln e_t}{\partial \ln c_t} = \left(\frac{P_{Bt}}{P_t^c}\right)^{\varepsilon}$, while the quasi-homothetic case occurs when $P_{Dt} = P_{Bt}$, such that $P_t^c = \left[(1 - s_{At})P_{Bt}^{-1} + s_{At}P_{At}^{-1}\right]^{-1}$ and $\frac{\partial \ln e_t}{\partial \ln c_t} = \frac{P_{Bt}}{P_t^c}$. Under homothetic preferences, Equation (10) collapses to $P_t^c = P_{Bt}$ and $\frac{\partial \ln e_t}{\partial \ln c_t} = 1$, consistent with Proposition 1.

To further illustrate the expenditure elasticity in action, consider a simple structural transformation example with separable categories, where $A(\boldsymbol{p})$ consists of agricultural products, $D(\boldsymbol{p})$ of manufacturing products, and $B(\boldsymbol{p})$ of services. We take expenditures and prices from the US National Income and Product Accounts (NIPA). Food and beverages purchased for off-premises consumption is used as proxy for agriculture, and manufacturing is defined as total goods net of agriculture; the two are merged in the PIGL and quasi-homothetic cases. Setting $\varepsilon = 0.37$ based on Alder, Boppart and Müller's (2022) estimate for the United States, we then predict budget shares at hypothetical expenditure levels using the NIPA data and Equation (9), from which we calculate the elasticities in Equation (10).

Figure 1 shows the results for 1929 and 2023. Notably, the real wage bias always disappears asymptotically: since $s_B \longrightarrow 1$ as $e \longrightarrow \infty$, it follows that $P_t^c \longrightarrow P_{Bt}$ and $\frac{\partial \ln e_t}{\partial \ln c_t} \longrightarrow 1$. In the PIGL and quasi-homothetic cases, this convergence is monotonic, thereby making the bias larger in magnitude at lower expenditure levels. The direction of the bias ultimately depends on the relative price of luxuries, however. For instance, if the price of luxuries relative to necessities is less than one, we have $P_{Bt}/P_t^c < 1$. It then follows that the consumption deflator overestimates the wage deflator and subsequently underestimates the real wage. This condition holds in 1929 but not in 2023, resulting in correction factors below one in 1929 and above one in 2023.

The economics behind these predictions amounts to nothing more than a Hicksian substitution effect. If luxuries are cheap and the wage rate equals $\frac{w_t}{P_t^c}$, households can maintain the utility of consumption with fewer working hours and consequently wish to substitute to more leisure. This is the same as saying that they demand higher wages than $\frac{w_t}{P_t^c}$ to keep leisure constant, explaining the higher real wage and the lower deflator than we obtain with the usual consumption deflator.

These insights largely extend to the broader intertemporally aggregable case. However, monotonicity now requires an alignment between basket prices and income elasticities ($P_{At} \leq P_{Dt} \leq P_{Bt}$, or vice versa); otherwise, the correction can become nonmonotonic and even change sign across the expenditure distribution. This is precisely what happens in Figure 1, where both years exhibit hump-shaped patterns, and 2023 also showing a reversed direction at low expenditure levels.

Finally, Figure 1 reveals smaller corrections in 2023 than in 1929. Echoing Jaravel and Lashkari's (2024) discussion about the choice of price base, this reflects their proximity to the NIPA base year (currently

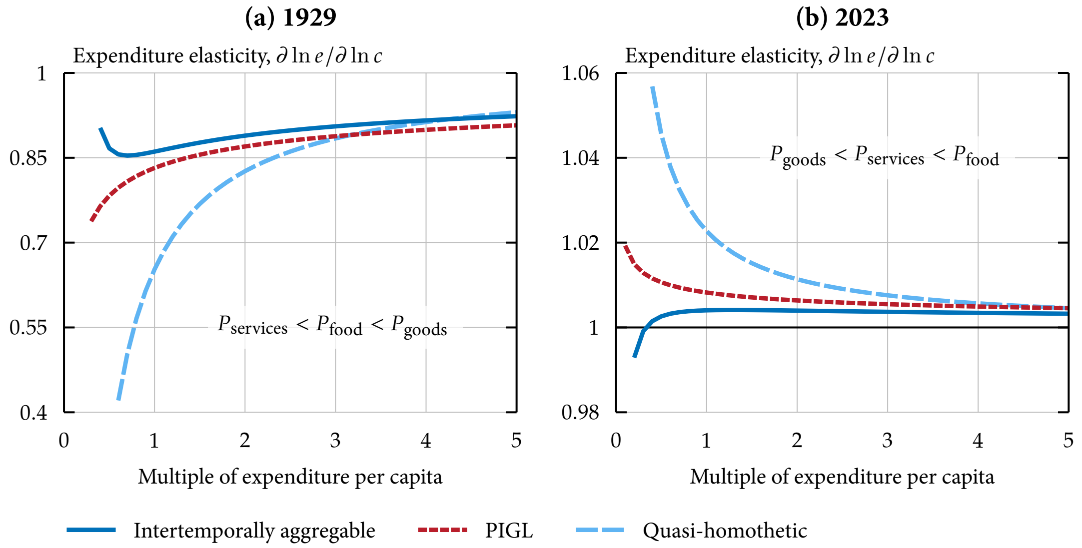


**Figure 1.** Illustrative example of wage deflator corrections.

*Notes.* The figures compute the expenditure elasticity in Equation (10) at hypothetical expenditure levels for different cases of the intertemporally aggregable preferences using US NIPA spending data on agriculture, manufacturing, and services in 1929 and 2023.

2017). By construction, nominal and real variables are similar close to the base year—and identical in the base year itself—so biases are similarly small. As we move further away from the base period, the differences accumulate, thereby increasing any bias in the deflators.

In sum, we therefore reiterate Jaravel and Lashkari (2024, p. 493): the real wage bias is "likely to be sizable when preferences are nonhomothetic, price inflation is large and correlated with income elasticities across goods, and real consumption is expressed in terms of a base period that is distant from the current period." Adding to their discussion, we further expect the real wage bias to diminish at higher expenditures and that the consumption deflators overestimate the true wage deflators whenever necessity prices exceed those of luxuries (and vice versa).

## 3 Real Wages and Welfare: Long-Run Estimates for the United States

While the theory above identifies a clear wedge between wage and consumption deflators under nonhomothetic preferences, its magnitude ultimately remains an empirical issue. To assess the significance of Proposition 1, we now put our approach to work by constructing estimates of real wages and welfare for the United States using both the consumption deflator and our corrected wage deflator. These estimates are based on consumption and wage data going back 40 years, and comparing them allows us to quantify the potential bias introduced by relying solely on conventional consumption deflators.

To fully demonstrate the advantage of our framework, we follow the suggestion in Section 2.1 and proceed with Jaravel and Lashkari's (2024) algorithm for real consumption growth, which directly produces the income-specific consumption deflators and expenditure elasticities required to apply Proposition 1. To make things even simpler, we take these components off the shelf from their replication package, which is based on CEX and CPI data spanning 596 expenditure categories and 159 distinct price series from 1984 to 2019, with 2019 as the base year.[3] We construct hourly wages from the March CPS supplement—provided

[3] Figure B.1 in Online Appendix B shows the same analysis as here using 1984 as base year. The results are similar.

by Flood *et al.* (2024)—by dividing wage and salary income by total hours worked last year (usual hours worked per week times weeks worked), restricting the sample to workers aged 18–64 with reported family income and winsorizing wages at the 1st and 99th percentiles.[4] Each observation is then assigned a deflator based on its corresponding family income. Further details are given in Online Appendix A.

The results, summarized in Figure 2, confirm the empirical relevance of our theory: the wage deflator yields substantially faster real wage growth than the pure consumption deflator. For instance, in the fifth income decile—shown in Figure 2a—real wages increase by 1.16 percent per year under the wage deflator, compared to just 0.92 percent under the consumption deflator. At a qualitative level, this finding is unsurprising. As shown by Jaravel and Lashkari (2024), the consumption deflators we use exhibit systematically higher inflation rates for lower-income households, which implies that the relative price of luxuries falls over time. Consistent with the predictions in Section 2.2, we therefore observe slower growth in the wage deflator—and faster growth in real wages—relative to the consumption deflator.

While the qualitative pattern is expected, the magnitudes we find are striking. The 0.24 percentage point gap in the fifth income decile implies that the consumption deflator generates a bias in measured wage growth equal to 20.7 percent of the corrected growth rate. In comparison, Jaravel and Lashkari (2024) estimate a "nonhomotheticity bias" in real consumption growth between 1984 and 2019 that never exceeds 7.5 percent of their uncorrected growth rates. Likewise, the substitution bias in the US CPI—roughly measured as the inflation rate difference between the BLS's chained and non-chained CPIs for all urban consumers—amounts to about 12 percent per year relative to the average chained-CPI inflation rate between December 1999 and December 2024. These reference points underline the quantitative importance of our wage deflator.

This bias is also not limited to the fifth decile but arises systematically throughout the income distribution. As shown in Figure 2c, the annual growth rate gap between the two deflators ranges from 0.19 to 0.27 percentage points across all income deciles. The gap declines monotonically with income, which again aligns with Section 2.2: since the numerator—the nominal wage—remains fixed across the wage measures, the growth differences directly reflect the wedge in Proposition 1, making the narrowing gap consistent with the prediction of asymptotic homotheticity. These differences imply a bias from the consumption deflator that ranges from 8.3 to 36.3 percent of the corrected wage growth rates, thereby highlighting that the fifth decile is representative rather than exceptional.

How does the real wage bias translate into broader measures of household well-being? While our real wage definition is explicitly designed to permit welfare statements about households that value both consumption and leisure, comparisons of wage rates alone may be seriously misleading if unearned income—implicitly captured by consumption expenditures—varies substantially across individuals. A more comprehensive and natural way to express current total utility in base-period prices in this setting is through the money metric given by the sum of real consumption and real leisure expenditures: $\mathcal{W}_t = c_t + w_t^* \ell_t$, where $\ell_t$ denotes leisure time. Following Becker's (1965) terminology, $\mathcal{W}_t$ represents the household's "full income" in real terms. We implement this measure in our CEX-CPS data for both measures of real wages, with leisure defined as a 16-hour daily time endowment net of daily hours worked.

Figures 2b and 2d summarize the resulting welfare estimates, which show that the consumption deflator's understatement of real wage growth translates into similar underestimates of welfare growth. The welfare

[4] Starting in 1989, the CPS directly reports wages for hourly workers. We consider this variable in Section 4 but omit it here, since it neither spans the full sample period nor covers the entire population.

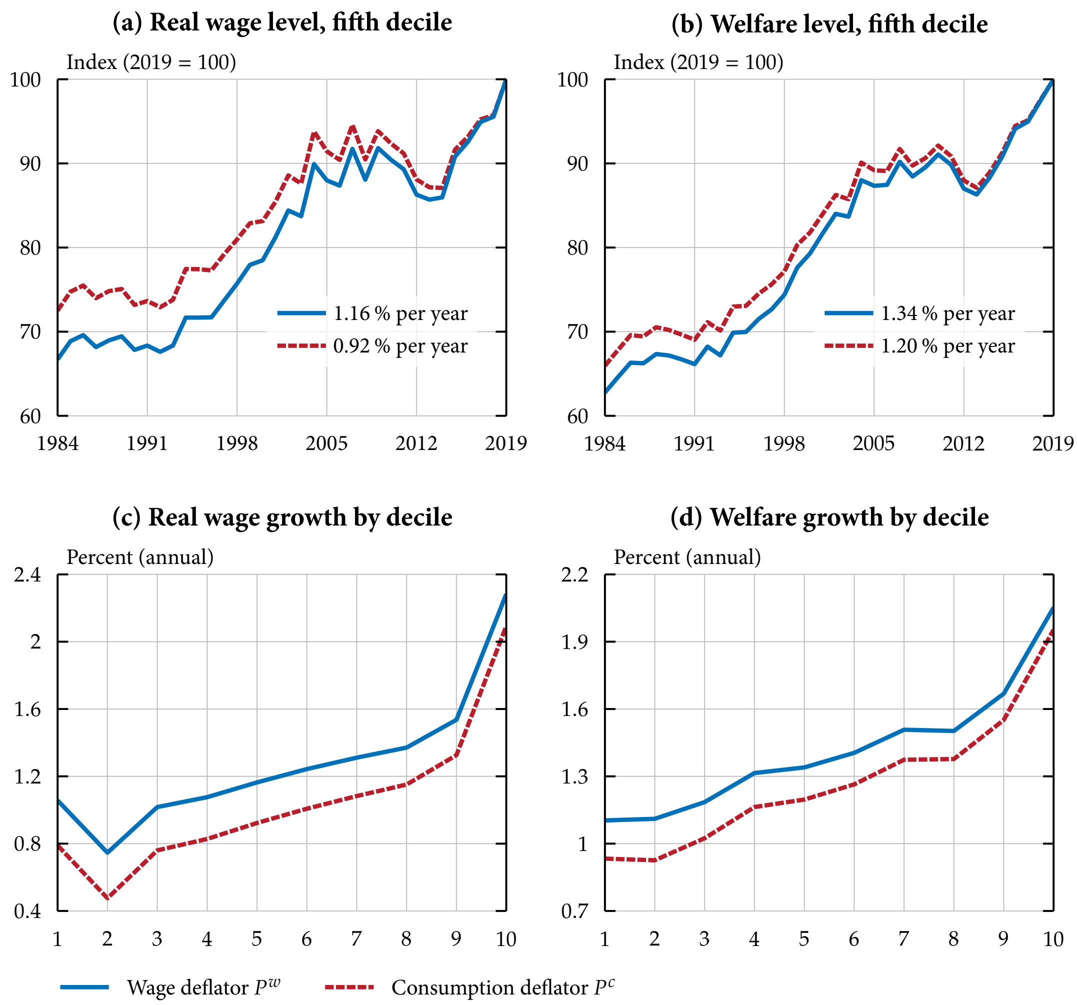


**Figure 2.** Real wages and welfare by deflator and income decile, 1984–2019.

*Notes.* Wages refer to hourly earnings as observed in the Annual Social and Economic Supplement of the CPS. Welfare is measured as the sum of real consumption and real leisure expenditure, assuming a total time endowment of 16 hours per day. All variables are measured in 2019 prices.

growth bias is necessarily smaller than the real wage growth bias, since wages form a subset of welfare, but it nevertheless remains sizable. Switching to the wage deflator, we find upward adjustments in annual welfare growth ranging from 0.18 percentage points at the second income decile to 0.14 and 0.10 percentage points for the median and top income deciles, respectively. Relative to the corrected welfare growth rates, these adjustments suggest a bias of 17 percent at the bottom, 11 at the middle, and 5 percent at the top—figures that remain large compared to the reference points above.

Taking stock, these findings suggest that the consumption deflator introduces a sizable measurement bias—larger than several other biases identified in the price index literature—that leads to understated long-run growth in both real wages and welfare. Because we express real variables in 2019 prices—the final year of our sample—a direct implication of the faster growth under the wage deflator is that the corresponding *levels* of wages and welfare are, in fact, lower than what conventional measures imply across the sample period. Figures 2a and 2b, for instance, show that real wages and overall well-being for the fifth income decile are 8.0 and 4.8 percent lower in 1984 when measured with the wage deflator. The flip side of adopting the wage deflator, in other words, is that US households appear worse off before 2019 than the consumption deflator alone would suggest.

## 4 On the Recent Compression of the US Wage Distribution

Having established that the consumption deflator introduces a sizable bias in real wages, an immediate question arises in light of recent economic developments: how has this bias shaped the wage dynamics during the post-pandemic inflation surge? Amid concerns about the distributional impacts of this episode, Autor, Dube and McGrew (2023) document a compression of the real wage distribution to the benefit of low-wage workers. However, their real wage estimates rely on the standard CPI deflator, which is the same for all households, irrespective of income. To what extent are their findings driven by this choice?

To answer this question, we estimate the evolution of real wages from 2016 to 2023 using two distinct nominal wage measures: (i) hourly earnings for all US workers, constructed as before by dividing annual wage and salary income by annual hours worked; and (ii) reported wages for hourly workers, which are directly available in the CPS for an 8.7 percent subsample of all workers. These measures are again obtained from the March CPS supplement under the same sample restrictions and winsorization as in Section 3.[5] Similar to Autor, Dube and McGrew (2023), we additionally control for compositional changes during the Covid-19 pandemic by reweighting each year's workforce to keep the composition of the 2019 workforce constant.[6]

For each nominal measure, we construct real wages using three different price indices: our wage deflator and the Jaravel-Lashkari consumption deflator, as in Section 3, and the standard CPI for all urban consumers from the BLS, as in Autor, Dube and McGrew (2023). For the former two, we can no longer directly use Jaravel and Lashkari's (2024) estimates, as they are only available until 2019. We therefore implement their algorithm ourselves, using Jaravel's (2024) distributional CPI series by income—which are methodologically consistent with the official CPI—together with the underlying CEX data on total consumption expenditures. As before, we match the resulting income-specific deflators to CPS observations based on family income, which allows us to compute real wages for each worker. To track the evolution of the wage distribution, we then assign workers to nominal wage deciles within each year and report average real wages by decile and deflator.[7]

Figure 3 plots the resulting wage series for the first, fifth, and tenth wage deciles—Figure 3a for inferred hourly earnings of all workers and Figure 3b for reported wages of hourly workers. Between 2019 and 2023, our wage deflator suggests that real hourly earnings among all workers rose by a cumulative 8.0 percent in the bottom decile but remained roughly flat at 1.8 and 2.4 percent in the fifth and tenth deciles. The smaller sample of hourly workers is more affected in March 2020, but conveys a similar pattern: a 6.9 percent gain at the bottom and a 1.9 percent decline at the top. In both cases, the estimates indicate a clear compression of the wage distribution throughout the Covid period.

How sensitive is this compression to the choice of deflator? Figure 3 reveals that the differences between the CPI and our wage deflator are modest. Among all workers, the wage ratio between the tenth and the first decile declined by 5.2 percent from 2019 to 2023. This reduction is smaller than the 6.4 percent implied by the CPI, which is known to understate inflation at the bottom of the distribution and overstate

[5] Wages of hourly workers are available in all months, but we use March data since we only observe total family income in the March supplement, which is needed for deflator assignment.

[6] This inverse probability reweighting is estimated with a logit model with controls for age, education, race, Hispanic origin, gender, nativity, and region of residence.

[7] Grouping workers by nominal wages isolates the impact of deflators on real wages themselves, but fails to account for subsequent changes in the real wage distribution. Figure B.2 in Online Appendix B corroborates our comparisons here with estimates based on real wage quantiles.

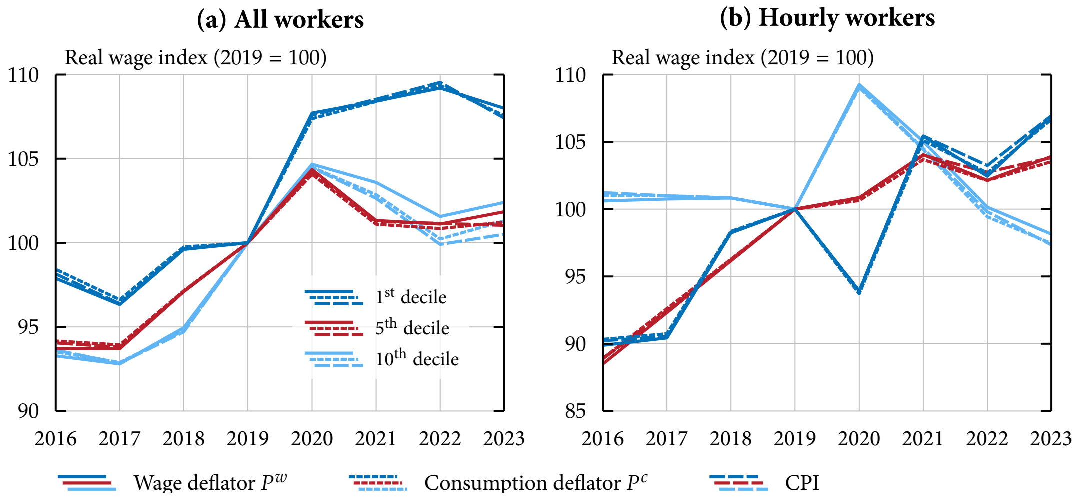


**Figure 3.** Recent evolution of real wages by deflator and nominal wage decile.

*Notes*. Figure 3a plots average real hourly earnings for all workers in a calendar year, deflated using annual deflators with 2019 as base year. Figure 3b plots real wages for hourly workers in March of each year, deflated with monthly deflators of that month, with March 2019 as base month.

it at the top (see Jaravel, 2021), with inverse effects on real wage growth. Similar differences hold for these ratios in the population of hourly workers: 8.2 percent under our wage deflator, versus 9.0 percent under the CPI. These differences—which are similar prior to 2019—remain small relative to the overall magnitude of the observed wage compression.

Several reasons explain the seemingly limited role for the deflator in this context. A partial explanation is that while these results concern the wage distribution, the underlying deflators are still constructed along the income dimension. Since households within a given income group include workers from across the wage spectrum, both high and low hourly wages may be deflated using similar deflators. As a result, the average deflators across wage groups exhibit a flatter profile than those across income groups, thus pushing the former closer to the CPI. Figure 4a, which plots growth rates of our wage deflator across both the income and wage distributions in the short-run sample, exhibits precisely this pattern. Only under a one-to-one positive correlation between income and wages would the deflators align across the two distributions. This is also not unique to our wage deflator or the recent inflation surge: Figure 4b, for example, shows the same result in our long-run sample.

Another explanation relates to the short time horizon investigated. As discussed in Section 2.2, the growth differences across deflators do not accumulate into large biases in real wage *levels* when measured close to the base period. Meaningful differences only arise over longer periods. As an illustration, in Section 3 we found that $P^c$-deflated wages exceed $P^w$-deflated wages by a cumulative 8 percent in 1984 for the fifth income decile. But in 2016, the first year of the short-run analysis, the gap is less than a tenth of that—around 0.7 percent. This is similar to the estimates in Figure 3: the fifth wage decile of all workers, for instance, exhibits $P^c$-deflated wages that are 0.5 percent larger than $P^w$-deflated wages in 2016, and 0.6 percent smaller in 2023, thus highlighting that the short-run biases do not radically differ from their long-run counterparts during comparable years.

Ultimately, however, the stark compression in nominal wages far outweighs the impact that the inflation heterogeneity in Figure 4a has relative to other deflators. The picture therefore remains consistent with Autor, Dube and McGrew's (2023) findings. Was this result inevitable? Not necessarily. To fully eliminate

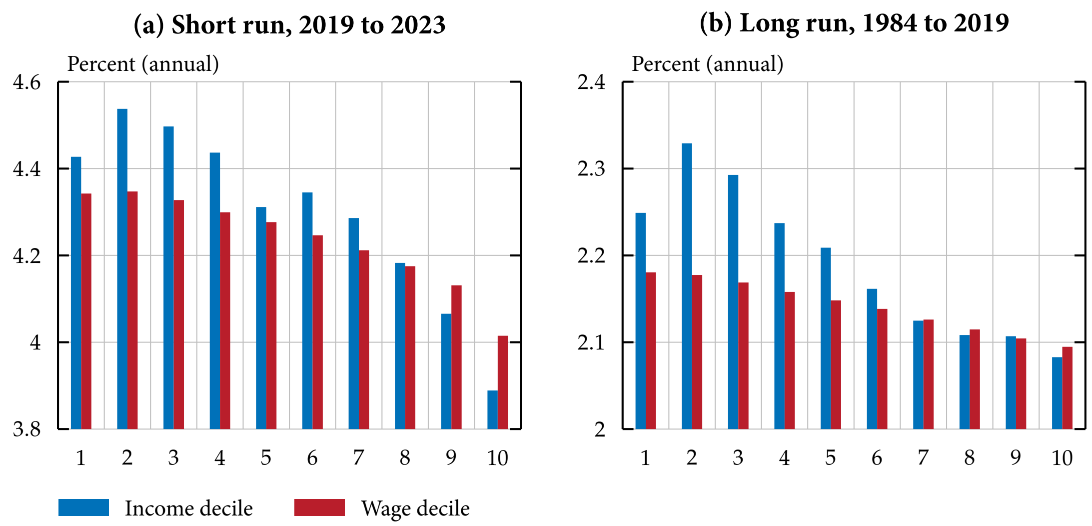


**Figure 4.** Growth in the wage deflator $P^w$ across the income and wage distribution.

*Notes.* We use the hourly earnings of all workers (salaried earners and hourly workers alike) in both subplots.

the 5.2 percent decline in the real wage ratio between the top and bottom deciles in Figure 3, the bottom decile's wage deflator would need to exceed the top's by 1.73 percentage points annually. While significantly larger than the 0.33 and 0.54 percentage point gaps we estimate for the wage and income distributions in Figure 4a—numbers broadly in line with the inflation inequality literature—such scenario is not unthinkable. Hochmuth, Pettersson and Weissert (2024b), for instance, document a 1.8 percentage point gap in PCE inflation between the top and bottom consumption deciles throughout 2022, with a peak of 2.8 percentage points in June of that year. While not critical in our setting, their findings underline that the choice of deflator may still shape short-run wage inequality in other contexts.

## 5 Conclusion

Virtually all existing measures of real wages are constructed by deflating nominal wages with price indices originally designed for consumption, such as the CPI. At the core of this paper lies the idea that such practices can introduce systematic biases in real wage estimates when households value both consumption and leisure and exhibit nonhomothetic preferences. We provide a remedy grounded in standard index number theory and illustrate that these biases can be large in practice. While our findings suggest that wage and welfare estimates based on CPI-deflated real wages should be interpreted with caution, we also show that the CPI nevertheless provides an accurate description of the real wage compression that followed the post-pandemic inflation surge.

Moving forward, a key advantage of our approach is that it can be implemented using standard price index techniques—even under arbitrary preferences—as long as cross-sectional consumption data are available. This is a relatively weak data requirement that is met in many contexts, including various micro-level surveys and distributional national accounts. As such, our contribution offers a broadly applicable tool with clear appeal to researchers and policymakers concerned with wage and income dynamics, inequality, and welfare evaluation.

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# Getting Real About Wages: A Nonhomothetic Wage Deflator Online Supplement

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This supplement provides (a) additional information on the data used and the empirical implementation method and (b) additional figures.

## Appendix A Data and Methods

### A.1 Matching wages to Family Income

We use total family income to match deflators to wages. Income-specific deflators are based on CEX micro data, in which we compute the minimum family income for each unit of time and income decile. We then use these bounds to assign workers in the CPS to income deciles and the corresponding deflators.

**Family income in the CEX** Since we rely on the underlying CEX micro data provided by the D-CPI project (see Jaravel, 2024) for the computation of family income bounds also in the long run, we observe family income starting only in 1999. We therefore use family expenditures by income decile—available in the replication package of Jaravel and Lashkari (2024)—to impute family income for the years preceding 1999 as follows.

For a given decile, we estimate a log-linear relationship between the decile's minimum family income and minimum family expenditures, using the annual data between 1999 and 2019. These regressions have a relatively high fit: the corresponding $R^2$ depends on the decile and varies between 0.84 and 0.95. We then use these decile-specific estimated relationships to predict the minimum family income for the years before 1999. The resulting family income data yields smooth patterns without discernible patterns around 1999, when the imputation stops.[1]

**Family income in the CPS** The monthly CPS files provide `faminc`, where households are asked to estimate their family income bracket. The March supplements additionally ask all household members about their total income, and provide `ftotval`, a computation of total family income. We found that these two measures disagree significantly, and therefore only rely on `ftotval` and the March CPS to match deflators to wages.[2]

## A.2 Consumption and Wage Deflator in the Short Run

The nonhomothetic consumption deflator is computed using Algorithm 1 in Jaravel and Lashkari (2024). For a detailed description of the algorithm, the interested reader is referred to that paper. Intuitively, the way the algorithm works is to compute a nonhomotheticity correction factor by regressing the inflation rates of an income-specific geometric price index from period $t$ to $t+1$ on real income to fit a quadratic function.[3] The first derivative of this quadratic function evaluated at the income level of specific percentiles can then be used to calculate real consumption of that income percentile in period $t+1$. The algorithm starts in the base period, in which real income is equal nominal income. For annual deflators in our analysis between 2016 and 2013 we set this base period to 2019 for annual deflators and March 2019 for monthly deflators. Subsequently, the correction factor facilitates the computation of real income in the next period. This allows to fit the quadratic function of inflation on real income in $t+1$ and repeat the steps to continue the algorithm. We apply the algorithm once forward until 2023 and once backward until 2016 and concatenate the results. Eventually, we obtain the nonhomotheticity correction factors $1+\Lambda_t$ for all periods and can use them directly to compute the wage deflator as outlined in the main text.

## A.3 Wage Data

**Data sources and sample construction** Our primary data source is the Annual Social and Economic Supplement to the CPS (ASEC), which asks individuals sampled in March about their income and hours worked in the previous year. We use total labor income, hours usually worked per week, and weeks worked last year, to compute hourly earnings for the previous year.

For the short-run analysis, we also create a separate sample where we restrict ourselves within the ASEC to workers that are paid by the hour, and use their reported hourly wages—excluding workers that have imputed reported hourly wages.

We restrict ourselves to workers with a reported family income in the ASEC (variable `ftotval`), and who are aged 18–64. Wages and hourly earnings are winsorized at the 1st and 99th percentiles.

[1] The annual growth in family income in the non-imputed data post 1999, averaged across years and income deciles, is 0.030, whereas the average annual growth in the first imputation year of 1999 is 0.033, reasonably close.

[2] Only 30 percent of househould heads were assigned to the same CEX income decile when using independently `faminc` and `ftotval`.

[3] When running their algorithm we directly use the distributional CPI inflation rates by income percentiles instead of computing them based on observed expenditure shares in the CEX micro data to retain consistency with the official CPI.

# Appendix B Figures

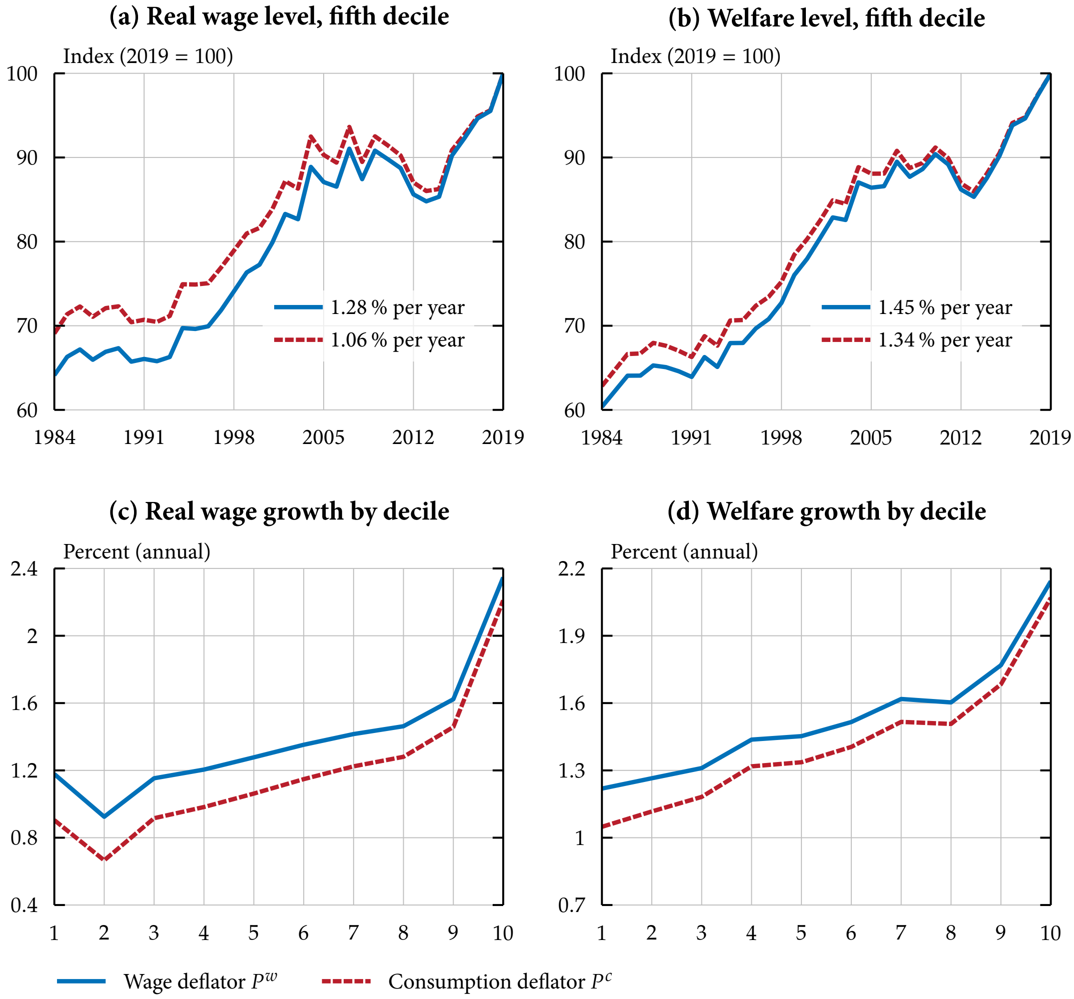


**Figure B.1.** Real wages and welfare by deflator and income decile, 1984–2019, using 1984 as base year.

*Notes.* Wages refer to hourly earnings as observed in the Annual Social and Economic Supplement of the CPS. Welfare is measured as the sum of real consumption and real leisure expenditure, assuming a total time endowment of 16 hours per day. All variables are measured in 1984 prices instead of 2019 prices as in Figure 2. The upper panels are still normalized to 100 in 2019 for comparability.

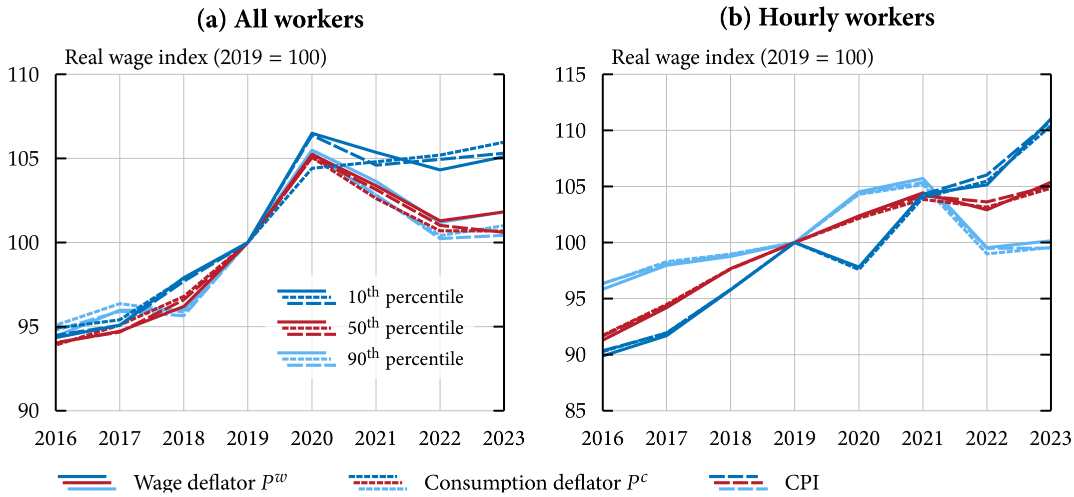


**Figure B.2.** Recent evolution of real wages by deflator and real wage percentile.

*Notes.* Figure B.2a plots real hourly earnings for all workers in a calendar year, deflated using annual deflators with 2019 as base year. Figure B.2b plots real wages for hourly workers in March of each year, deflated with monthly deflators of that month, with March 2019 as base month. In both panels, percentiles are computed along the distribution of real wages corresponding to each deflator instead of the distribution of nominal wages as in Figure 3.

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