Heterogeneity in Inflation and Preferences across Households*

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Abstract

This paper shows that heterogeneity in inflation rates across households is related to substantial heterogeneity in preferences. This heterogeneity accounts for approximately two-thirds of the overall inflation dispersion. It is larger on average for households with lower substitution elasticity, which are households that have an above-median income, that do not include retirees, that have a low number of household members and that tend to buy sticky-price goods. Furthermore, inflation dispersion varies over time, where periods with very stable aggregate rates of inflation are associated with less-dispersed inflation rates across households.

JEL classification: E31, D12, D30
Keywords: Household-level inflation rates, heterogeneity in preferences, constant-utility price index.

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1 Introduction

An emerging stream of literature in macroeconomics shows that heterogeneity across firms and households can be important for understanding the causes and consequences of aggregate fluctuations.[1] A reflection of this heterogeneity is that inflation rates across households are dispersed and that most households arguably experience an inflation rate that differs from the average rate of inflation targeted by most central banks (Kaplan and Schulhofer-Wohl, 2017). This dispersion in household inflation rates not only results in differences in the cost of living across households and heterogeneity in real variables, such as interest rates or wages, but also arguably results in heterogeneous household inflation expectations because the individual price changes that households face in their daily lives are an important component of household inflation expectation formation (D'Acunto et al., 2019b). Inflation expectations, in turn, affect household choices, such as consumption and savings decisions (see Vellekoop and Wiederholt (2019)).[2]

At the same time, recent advances in the measurement of inflation suggest that commonly used price indexes can be substantially improved (Feldstein, 2017). Most theoretical models use demand systems with constant elasticity of substitution (CES) utility functions to compute the change in price levels over time, while statistical approaches to measure inflation, such as the Laspeyres or Paasche indexes that have been used in the previous literature for household inflation, do not take into account consumers' demand functions. In particular, shifts in consumer tastes can have large effects on aggregate price indexes (Redding and Weinstein, 2020).[3] It is therefore likely that they also have large effects on household-level inflation rates and their dispersion, which is the main focus of

[1]See, for example, Kaplan and Violante (2018).

[2]Additionally, Bachmann et al. (2015) and D'Acunto et al. (2019a) show that inflation expectations are related to readiness to spend, and Armantier et al. (2015) show in an experimental setting that they are related to investment decisions.

[3]For example, Carluccio et al. (2020) and Braun and Lein (2019) document the role of import price inflation and consumer tastes in aggregate measures of consumer prices and cost-of-living indexes.

this study.

In this paper, we document the dispersion of inflation across households and evaluate the sources of this dispersion. Using household scanner data from AC Nielsen for Switzerland, we first show that using statistical approaches to measure inflation and thereby ignoring preference shifts would result in substitution patterns that are inconsistent with a standard demand function. In approximately one-third of all observations, households shift expenditures towards products that become relatively expensive. We therefore use a measure of inflation based on the economic approach to constructing price indexes for CES preferences that is fully consistent with this important pattern of the data (Redding-Weinstein index). This index allows us to estimate differences in preferences across households together with inflation rates. We therefore take into account heterogeneous preferences across households as an additional source of inflation heterogeneity as well as differences in prices paid for given varieties and differences in consumption baskets.

Our findings show that the dispersion in inflation rates over households is substantially larger when taking into account differences in preferences compared to standard statistical measures of inflation. The interquartile range of the distribution of inflation rates obtained using the Redding-Weinstein index across households is more than 2.5 times the interquartile range of the distribution of inflation rates obtained using the Fisher index.

We further document the comovement of dispersion with changes in aggregate inflation rates. We show that the dispersion of inflation across households tends to rise with absolute changes in aggregate inflation. The period of observation includes a period with close to zero inflation in the aggregate (2013–2014) and two periods with declining rates of inflation (2011–2012 and 2015). Measures of dispersion are smaller during the period with zero inflation and larger during the two periods in which inflation declined in Switzerland. These changes in aggregate inflation occurred because the Swiss Franc greatly appreciated against the euro in 2010-2011, was stable in the period 2012-2014, and appreciated again in 2015. These shifts led to declines in retail prices, mainly for imports. The variation is thus largely exogenous to price developments in Switzerland (Auer et al., 2019). Our findings thus suggest that dispersion responds to economic conditions.

Differences in preferences across households influence the level of households' inflation rates. Households with higher demand elasticities experience lower average rates of inflation than households with lower elasticities. The size of demand elasticities is related to certain household characteristics: households that have an above-median income, that have at least one retired household member, and that are large tend to have lower elasticities of substitution. Furthermore, households that tend to purchase flexibly priced varieties have greater demand elasticities, although household characteristics explain little of the overall variation in elasticities.

Differences in preferences also account for a large share of the overall dispersion of household-level inflation rates. Inflation rates can be heterogeneous for three reasons: first, because households pay different prices for the same variety; second, because households differ in their preferences for each variety and their demand elasticities; and third, because households differ in their consumption baskets. We show using counterfactual analysis that variation in preferences explains approximately two-thirds of the overall dispersion of inflation. Heterogeneity in prices paid for the same variety accounts for approximately one-fourth of the overall dispersion. Differences in households' consumption baskets explain only a small share of the overall remaining variation.

How are the three sources of heterogeneity related to household characteristics? First, for households with low demand elasticities, inflation dispersion due to differences in preferences is larger. These low-elasticity households thus have stronger tastes for certain varieties, and therefore, the prices adjusted for preferences differ more from the prices not adjusted for preferences than they do in the case of high-elasticity households. Second, households with lower demand elasticities tend to purchase varieties at prices that deviate less from the average price for that given variety. Therefore, the heterogeneity due to differences in prices paid is lower for low-elasticity households than for households with higher elasticities of demand. Third, low-elasticity households tend to have a lower heterogeneity due to differences in consumption baskets.

Previous research has documented dispersion in household-level inflation rates resulting from differences in prices paid across households and differences in consumption baskets. For similar AC Nielsen data for the US, Kaplan and Schulhofer-Wohl (2017) show that differences in the prices paid for the same variety across households is an important source of heterogeneity and is more relevant than differences in consumption baskets, which is found to be the most important source of variation in studies based on the Consumer Expenditure Survey, where individual prices paid cannot be observed (see Michael, 1979; Hobijn and Lagakos, 2005; Hobijn et al., 2009).[4] We add to these findings a third source of heterogeneity: differences in preferences. Our findings suggest that these differences are, in addition to the differences in prices paid and consumption baskets, important sources of variation. The Redding-Weinstein price index furthermore allows us to evaluate the counterfactual dispersion of household-level inflation, where all households pay the same price for the same variety, based on a demand function that takes into account the counterfactual shifts in expenditures for these varieties. Our findings suggest that differences in prices paid remain an important source of variation, but their overall contribution to heterogeneity is lower than what has been suggested in prior research.

While our focus lies more on explaining and quantifying inflation heterogeneity than on differences in inflation levels, our results also relate to the literature that connects household income to household-specific consumption patterns and costs of living. Cravino

[4]Furthermore, Kaplan and Schulhofer-Wohl (2017) show that approximately 40% of all households substitute towards goods whose relative prices have risen, similar to our findings for Switzerland. Motivated by these findings of adverse substitution patterns shown in both US and Swiss data, we employ a price index that is fully consistent with such substitution patterns because it includes preference shifts.

and Levchenko (2017) document that after a large devaluation in Mexico, the consumption price indexes of high-income households increased by far less than the consumption price indexes of the poor. Jaravel (2019) shows that low-income households experienced, on average, larger increases in the cost of living than high-income households and relates these findings to product innovations and to greater competition in products disproportionately consumed by richer households. Argente and Lee (2015) show that high-income households experienced lower inflation during the Great Recession because high-income households were able to switch to lower-quality goods and change their shopping behavior, which are changes largely available to richer households.[5] While these studies all relate inflation differences to income, we show that these differences are related to differences in elasticities of demand across households. Together with the result that low-(high-)elasticity households tend to be those with higher (lower) income, our findings suggest that differential inflation rates across income groups could be modeled based on differences in preferences.[6] Furthermore, Faber and Fally (2017) show that rich households tend to value high-quality products more than low-income households do and therefore consume products from high-quality producing (more productive) firms, which cater to the tastes of richer households. Our result that low-elasticity households, which tend to be richer households, contribute more to the heterogeneity that comes from adjusting prices for preferences is consistent with this study.

The remainder of this paper proceeds as follows. Section 2 describes the homescan data for Switzerland, and section 3 describes the construction of price indexes and the estimation of preferences. Section 4 reports the distributions of inflation rates over households and time and documents observed differences in prices paid for the same varieties and differences

[5] Using homescan data, which allow us to measure effective prices paid per household instead of store-level prices and effective expenditures per household instead of fixed consumption baskets, can be quantitatively important for aggregate fluctuations as well; see Coibion et al. (2015).

[6] This also relates to Handbury (2019), showing the importance of non-homothetic preferences for spatial price differences. Her results suggest that taking into account differences in preferences is important for the welfare differences between poor and rich cities.

in estimates of the elasticity of substitution across households. Section 5 shows in a counterfactual analysis the importance of these sources of heterogeneity for the overall dispersion of household inflation. Section 6 concludes.

2 Data

We rely on household scanner data provided by AC Nielsen Switzerland. Households in the panel are provided with a handheld scanner, which allows them to record their daily purchases. They scan the products they buy (identified by the EAN, the European Article Number, which is comparable to UPCs in US data) and enter the price paid, the quantity purchased, and the purchase date and retailer.[7] The products included in our dataset are mainly packaged goods from the product categories of food, beverages, tobacco, and household & cosmetic products.[8] The dataset covers observations between January 1, 2010, and June 30, 2016.

In addition to the information on the purchases by individual households, we were provided with information on households' socioeconomic characteristics: the age of the household head and whether a household member is retired, household size, income, and the number of children. We construct the following variables from this information: *High income*: a dummy equal to one if income is strictly larger than the median income, *Retired*: a dummy equal to 1 if at least one person in the household is retired, and *HH size*: the number of household members (summary statistics are provided in Table A.1 in Appendix A).

We furthermore include information on the degree of price stickiness of the products

[7]The products we observe were purchased in stores of 18 different chains, including supermarkets, drugstores, gas station shops, and online stores.

[8]Comparable categories in the official consumer price index (CPI) are the CPI categories of food, non-alcoholic and alcoholic beverages, and tobacco. These account for approximately 13% of the total official consumer price index (Swiss Federal Statistical Office, 2016). A list of Nielsen product categories is included in Table A.2 in Appendix A.

that households buy. Cravino et al. (2018) show that the prices of varieties consumed by high-income households are more sticky and less volatile than those of the goods consumed by the other households. We therefore test whether the degree of price stickiness also contributes to inflation heterogeneity and its sources. We define the degree of price stickiness at the product level. We first compute, per product, the modal price per quarter across all transactions observed.[9] Then, we calculate the log-differences of this modal price from one quarter to the next. If the log-difference is different from zero for a given product-quarter observation, we define a price-change indicator variable, which one for this observation and zero otherwise. If the product is not observed in a quarter, it is assigned a missing variable. Next, we average this binary variable per product over time, which gives us a measure of the average frequency of price changes per product. We then take the average of this indicator per household over time. Similar to the variables defined above, we then define a variable *Flex price*, which is equal to one if a product's average frequency of price change is above the median and zero otherwise. The variable *Flex price* thus indicates whether a household tends to buy more flexible-price goods or rather sticky-price goods.

To control for some (arguably) erratic entries in the data, we remove observations in which the package size per EAN is three times larger than the mode or the price is four times below or above the mean price within this EAN. Furthermore, we consider only households that report more than eight times per year. Some product classes have more than one unit of measurement (e.g., some sauces are measured in grams, while others are measured in milliliters). Due to the higher comparability, we keep only observations with the most frequent unit of measurement within a product class.

Since most products are not purchased every day, we aggregate all observations to quarterly frequency, that is, we calculate the total expenditure per product, household,

[9] We follow the procedures in Beck and Lein (2015).

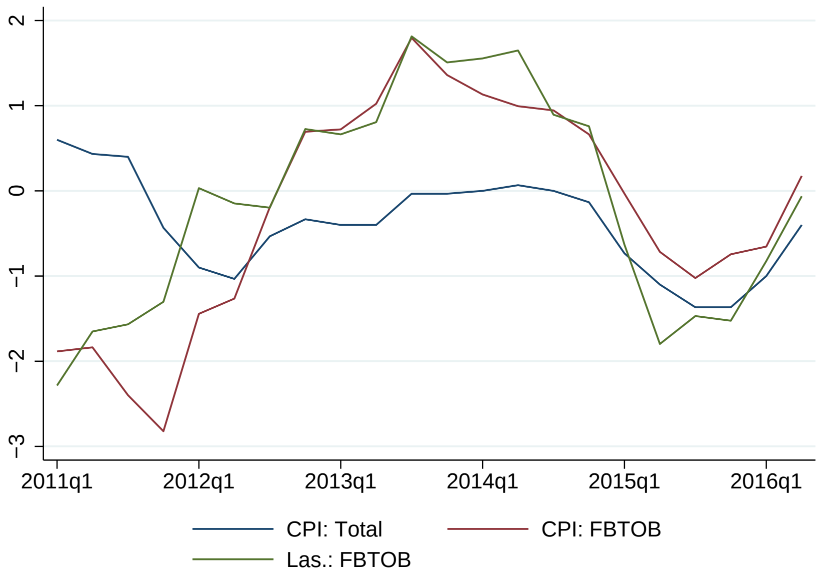
and quarter and the average price paid per quarter. These are the two variables that enter the computation of the price indices, as discussed in section 3 below.

The resulting dataset used in the estimation includes 3,918 households from all regions in Switzerland except for the canton of Ticino (4% of the total Swiss population). The panel of households is unbalanced because some exit the dataset during our observation period. They are replaced by newly entering households, which have very similar characteristics as the exiting ones. On average, the number of households observed per quarter is 2,430.

The advantage of using scanner data is that we can observe the actual prices paid and quantities bought per unique variety and per household. At the same time, the products included do not cover expenditures for services, durable goods, or gasoline, for example. The interpretation of our results is thus based on a share of the overall consumption basket. While the products included in our sample account for less than 15% of the overall consumer price index in Switzerland, we show in Figure 1 that the information on prices included in the sample comoves with the official data.

The average plutocratic inflation rate (expenditure weighted average over households, using the Laspeyres index, similar to the Swiss Federal Statistical Office's methodology) correlates with the aggregate inflation rate (CPI: Total) with a correlation coefficient of 0.22 and closely tracks the subcomponent "food at home, beverages, and tobacco" from the CPI (correlation coefficient 0.87). Furthermore, as noted in the introduction, one of the main channels through which inflation rates have implications for household choices is through their influence on inflation expectations. These, in turn, are much more strongly affected by price changes they face in their daily lives while grocery shopping than prices of consumption goods purchased with lower frequency, as shown by D'Acunto et al. (2019b) based on a similar Nielsen homescan dataset for the US combined with household-level information on inflation expectations.

Figure 1: *Comparison with official CPI inflation*



Notes: This figure compares the official CPI inflation with the Laspeyres inflation computed with the scanner data. "Total" includes all goods in the CPI, and "FBTOB" stands for "food at home, beverages, and tobacco". CPI denotes the official data from the Swiss Federal Statistical Office. "Las" is the homescan data-based Laspeyres price index.

3 Inflation Measurement

In this section, we describe how inflation at the household level is measured. In particular, we describe two different approaches used to define inflation. One is what we refer to as the statistical approach. It defines inflation as the change in the price of a fixed consumption basket between two time periods. The second is what we refer to as the economic approach. It defines inflation as the change in the price of a consumption basket that yields a fixed amount of utility between two time periods. In contrast to the statistical approach, the economic approach is consistent with the CES demand function, where substitution patterns are related to preferences. Observed expenditure shares are assumed to be the result of households' utility maximization.

3.1 Statistical approach

The two most famous indexes in this approach are the Laspeyres index and the Paasche index. Laspeyres-type price index definitions are also most commonly used by most national statistical offices to compute official inflation rates.

Their formulas are as follows:

$$\pi_{h,t,t-1}^{Las} = \ln\left(\sum_{k\in\Omega_{h,t,t-1}} s_{hkt-1}\left(\frac{p_{hkt}}{p_{hkt-1}}\right)\right)$$

$$\pi_{h,t,t-1}^{Paa} = \ln\left(\sum_{k\in\Omega_{h,t,t-1}} s_{hkt}\left(\frac{p_{hkt}}{p_{hkt-1}}\right)^{-1}\right)^{-1}$$

$$\text{with} \quad s_{hkx} = \frac{p_{hkx}q_{hkx}}{\sum_l p_{hlx}q_{hlx}}, \quad x = \begin{cases} t & \text{Paasche} \\ t-1 & \text{Laspeyres} \end{cases}$$

where $p_{hkt}(q_{hkt})$ is the price (quantity) of good k purchased by household h at time t. $\Omega_{h,t,t-1}$ is the set of all goods household h buys in both periods t and $t-1$.

Hence, the Laspeyres inflation rate is the change in prices from period $t-1$ to period t, weighted by period $t-1$ weights, while the Paasche inflation rate uses period t weights. It is well known that the Laspeyres inflation rate overstates inflation, while the Paasche inflation rate understates inflation because changes in prices and weights are negatively correlated due to substitution effects. This negative correlation creates a substitution bias. The geometric average of the Laspeyres (Las) and Paasche (Paa) inflation rate eliminates this bias (Fisher inflation rate) and is denoted by $\pi_{ht}^{Fis} = \sqrt{\pi_{ht}^{Las} * \pi_{ht}^{Paa}}$.

3.2 Economic approach

In the economic approach, households are assumed to have a constant elasticity of substitution (CES) utility function. Households maximize their utility, which yields the expenditure function. The resulting inflation rate is defined as the log difference of the two expenditure functions at two different points in time. We use the recently developed CES exact price index (Redding and Weinstein, 2020), which also incorporates preference shifts that make observed expenditures and price changes consistent with CES utility.[10] We label the CES exact price index the Redding-Weinstein (RW) index.[11] An appealing feature of this approach is that the price index and the elasticity of substitution can be estimated household-by-household. It can be calculated with household scanner data because we need to observe the prices and quantities of goods purchased by each household. More specifically, household h is assumed to have the utility function

$$\mathbb{U}_{ht} = \left[\sum_{k \in \Omega_{h,t,t-1}} \left(\varphi_{hkt} q_{hkt} \right)^{\frac{\sigma_h - 1}{\sigma_h}} \right]^{\frac{\sigma_h}{\sigma_h - 1}}$$

where $\varphi_{hkt} > 0$ is the preference parameter of household h for product k at time t, and $\sigma_h > 1$ is the elasticity of substitution across products. $\Omega_{h,t,t-1}$ is the set of goods the household buys in both periods t and $t-1$.

Household optimization yields the unit expenditure function

$$\mathbb{P}_{ht} = \left[\sum_{k \in \Omega_{h,t,t-1}} \left(\frac{p_{hkt}}{\varphi_{hkt}} \right)^{1-\sigma_h} \right]^{\frac{1}{1-\sigma_h}}.$$

The RW inflation rate is defined as the change in the unit expenditure function from period

[10] Earlier price indices based on the economic approach, such as the Sato-Vartia price index, are mostly not completely consistent with the data. For example, in the expenditure data, weights for some products rise even if the relative price of these products increases. Such observations would generate a residual in a demand function estimation. These residuals are then treated as taste shocks in the CES exact price index, instead of including them in weights or prices, which are both inconsistent with CES demand.

[11] The index can also control for newly entering and exiting products; however, at the household level, it is very likely that a household does not buy a given product even though the product still exists and is available. Therefore, we include only products that a household buys in periods t and $t-1$. This is the CES exact price index for common varieties (CCV) in Redding and Weinstein (2020).

t to $t-1$ and can be written as

$$\pi^{RW}_{h,t-1,t} = \ln\left(\frac{\mathbb{P}_{ht}}{\mathbb{P}_{ht-1}}\right) = \ln\left(\frac{\tilde{p}_{ht}}{\tilde{p}_{ht-1}}\right) + \frac{1}{\sigma_h - 1}\ln\left(\frac{\tilde{s}_{ht}}{\tilde{s}_{ht-1}}\right). \tag{1}$$

Expressions with a tilde stand for the geometric average, that is, $\tilde{x}_{ht} = \left(\prod_k x_{hkt}\right)^{\frac{1}{N}}$. The first term is the fraction of Jevons inflation rates, which is the geometric average of all goods prices existing in periods t and $t-1$. The second term is the ratio of the geometric average of the expenditure shares $\tilde{s}_{ht}$, where $s_{hkt} = \frac{(p_{hkt}/\varphi_{hkt})^{1-\sigma_h}}{\sum_{l\in\Omega_{h,t,t-1}}(p_{hlt}/\varphi_{hlt})^{1-\sigma_h}}$ is the expenditure share of household h for good k at time t for goods that are available at t and $t-1$. Preference shifts are normalized by the assumption that $\tilde{\varphi}_t = \tilde{\varphi}_{t-1}$ for all t. To estimate the elasticity of substitution, we follow the method by Broda and Weinstein (2006), which is outlined in Appendix B. Very large estimates of the elasticity of substitution are winsorized at 20. Standard errors for the estimated elasticities of substitution are calculated using the bootstrapping procedure outlined in Appendix C.

The RW inflation rate can be decomposed in a Sato-Vartia (SV) inflation rate and a term that captures the role of preferences,

$$\pi^{RW}_{ht} = \underbrace{\sum_{k\in\Omega_{h,t,t-1}} \omega_{hkt} * ln\left(\frac{p_{hkt}}{p_{hkt-1}}\right)}_{\pi^{SV}_{ht}} - \underbrace{\sum_{k\in\Omega_{h,t,t-1}} \omega_{hkt} * ln\left(\frac{\varphi_{hkt}}{\varphi_{hkt-1}}\right)}_{\text{preference shifts}} \tag{2}$$

$$\text{with } \omega_{hkt} = \frac{\frac{s_{hkt}-s_{hkt-1}}{ln(s_{hkt})-ln(s_{hkt-1})}}{\sum\limits_{l\in\Omega_{h,t,t-1}} \frac{s_{hlt}-s_{hlt-1}}{ln(s_{hlt})-ln(s_{hlt-1})}}.$$

That is, when preferences do not shift ($\varphi_{hkt} = \varphi_{hkt-1}$), the SV inflation equals the RW inflation.

4 Results

In this section, we first present the distributions of household-level inflation rates and show how they move over time. We then document the heterogeneity in prices paid across households and the heterogeneity in elasticities of substitution. We also relate elasticities of substitution and average inflation rates across households to household characteristics.

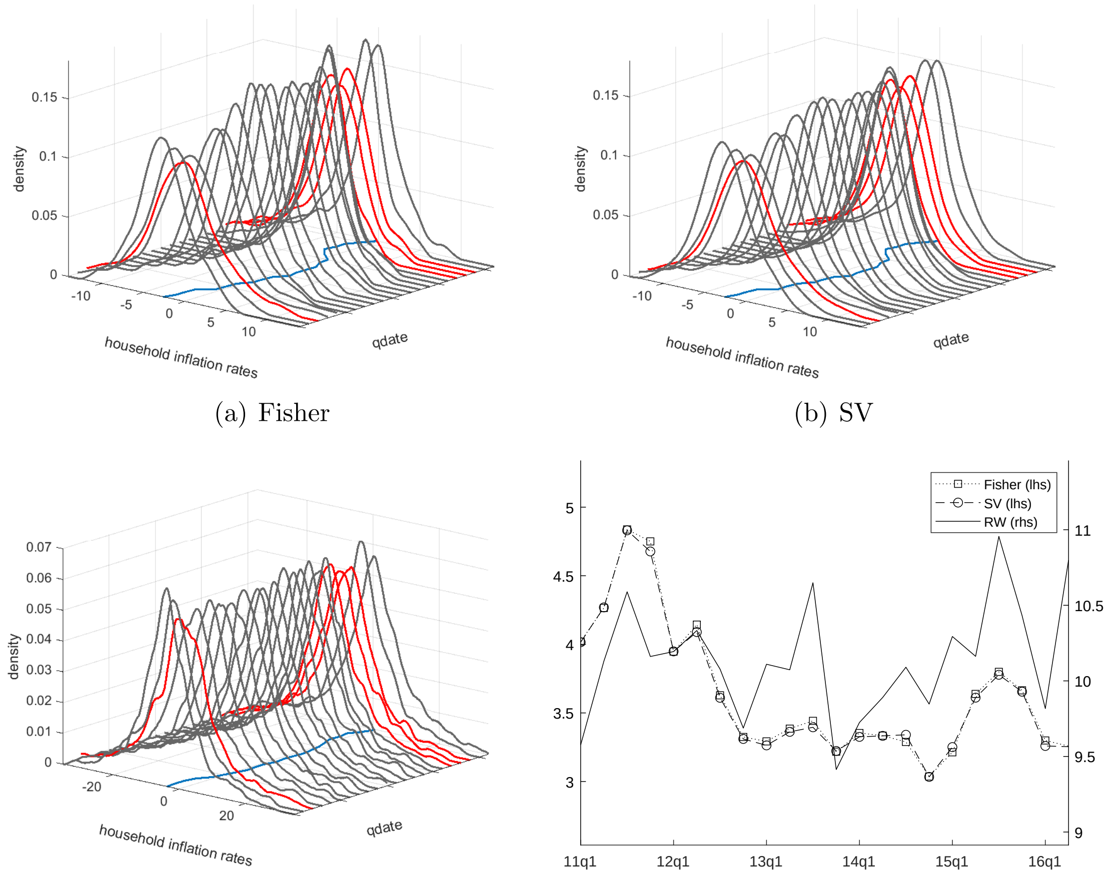
4.1 Heterogeneity in household-level inflation rates

Figure 2 shows the distributions of household-level inflation rates for the three different definitions we consider: Panel a) shows the Fisher inflation, Panel b) shows the SV inflation, and Panel c) shows the RW inflation. We report the distributions for each quarter between Q1 2011 and Q2 2016 (starting on the left side of the x-axis with Q1 2011). The blue line underneath plots the aggregate inflation rate. We exclude the largest and smallest 2.5% of all observations for each quarter.

Household-level inflation rates are substantially dispersed. The interquartile range (IQR), defined as the difference between the 75th and 25th percentiles, varies between 3.0/3.0/9.4 and 4.8/4.8/11 percentage points for the Fisher/SV/RW inflation rate (Panel d) in Figure 2). On average, the IQR is 3.6 for the SV inflation rate and 10.1 for the RW inflation rate, implying that the dispersion increases by a factor of 2.8 when moving from the SV inflation rate to the RW inflation rate.[12] This empirical finding is important because it shows that most of the heterogeneity in inflation rates reported in the literature (e.g. due to prices paid) are not reduced when controlling for changes in taste or differences in the elasticity of substitution. On the contrary, these results suggest that differences in preferences actually increase the existing heterogeneity. Swiss household inflation is therefore slightly less dispersed than household inflation in US data, where the dispersion

[12] The larger dispersion of the RW inflation rate is also shown in the wider scale of the y- and z-axes in Panel c) compared to the scales in Panels a) and b).

Figure 2: *Dispersion of household inflation rates*



(a) Fisher (b) SV

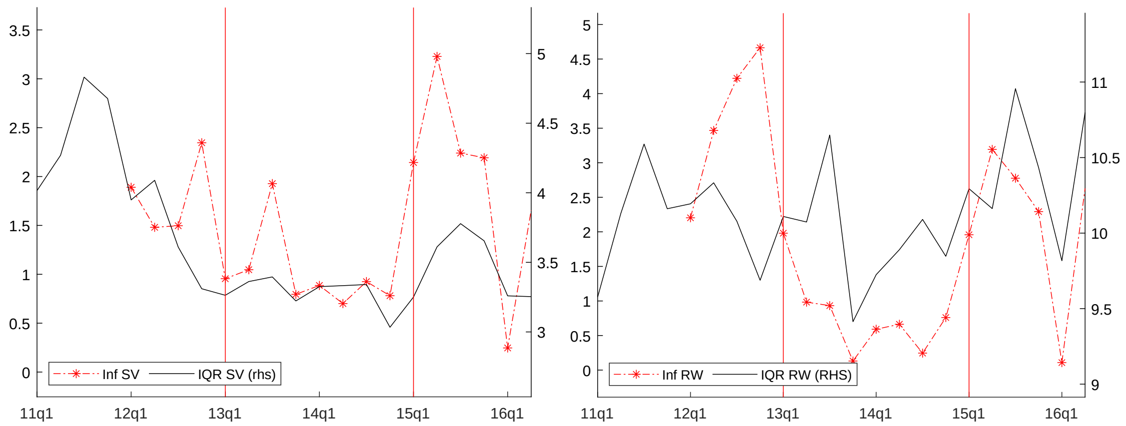
(c) RW (d) IQRs

Notes: Panel a) shows the distribution of the household inflation rates calculated with the Fisher approach. The blue line underneath the household inflation rates is the average inflation rate. Panels b) and c) show the distribution of the household inflation rates calculated with the SV and RW approach. Lines in red indicate 2011Q3 and 2015Q2-Q4, periods with relatively large declines in aggregate inflation due to appreciation-related declines in import prices. Panel d) shows the interquartile ranges of the three distributions with the Fisher and SV inflation rates on the left-hand scale and the RW inflation rate on the right-hand scale.

varies between 6.1 and 8.9 percentage points. Here, we compare the results based on the Fisher inflation rate because this approach is also reported for US data (see Table 1, second row, in Kaplan and Schulhofer-Wohl (2017)). Since inflation was on average lower in Switzerland during this period (-0.4% on average, with a standard deviation of 0.6 percentage points, compared to an average of 2.4% and a standard deviation of 1.5 percentage points in the US data), this finding suggests that the level or variance of inflation may covary with the dispersion of inflation at the household level.

Dispersion in household-level inflation rates tends to be positively correlated with aggregate changes in inflation. Figure 3 shows the comovement of the IQR and the absolute change in inflation for the SV and the RW inflation rates in panels a) and b), respectively. Both panels show that dispersion tends to be high when the change in aggregate inflation

Figure 3: *Dispersion and absolute changes in aggregate inflation*



(a) SV (b) RW

Notes: Panel a) shows the IQR of the Sato-Vartia inflation rate on the right-hand scale and the change in aggregate inflation (in absolute terms) on the left-hand scale. Panel b) shows the same figures using the RW inflation rate to calculate the IQR and the aggregate rate of inflation.

is larger than when aggregate inflation is stable (the correlation coefficients are 0.45 and 0.31 for SV and RW, respectively), which suggests that higher levels of inflation affect not only the dispersion of relative prices (Lach and Tsiddon, 1992, for example) but also the dispersion of inflation rates across households.[13] Figure 3 also divides the period of

[13]Relative price dispersion is regarded as an inefficiency because this dispersion distorts the allocative role of prices if prices are not completely flexible. Therefore, the optimal rate of inflation should be very low or even zero (Schmitt-Grohé and Uribe, 2010, for example). However, recent research casts doubt on the assumption that higher inflation actually leads to more price dispersion. Nakamura et al. (2018) show that the absolute size of price changes does not covary with the level of aggregate inflation, which suggests that there is little correlation between inefficient price dispersion and the level of inflation.

observation into three sub-periods, where the first and third are related to larger changes in aggregate inflation whereas the middle period shows very stable aggregate inflation of close to zero. The first and last sub-periods show the quarters in which the CHF appreciated substantially against the EUR (by 12% in 2011 and by 16% in Q2 2015, 14% in Q3 2015, and 10% in Q4 2015 compared to the same quarter in the previous year). These quarters are also highlighted in red in Panels a)-c) in Figure 2. This appreciation affected the average price of products in the retail data (mainly because of the direct effect on imported products' prices), with a pass-through rate of approximately 10% (Auer et al., 2019). The dispersion of inflation rates tends to increase in these periods. Even though we cannot observe time-series variation in household income or interest rates, this dispersion could arguably translate into more inequality across households in terms of real variables, such as real interest rates or real wages.

From a standard model without preference shifts, we expect that households substitute towards products that become relatively cheaper. This substitution pattern is usually calculated by taking the difference between the Fisher and the Laspeyres inflation rate, which quantifies the substitution bias and is expected to be positive.[14] We calculate the substitution bias per household and quarter. On average, it is positive in only 68.2% of all observations. That is, in approximately 30% of all cases, households substitute towards products that become relatively more expensive.[15]

Thus, every third household shows a demand pattern that would not be consistent with a standard demand function assumption that does not consider preference shifts. With preference shifts incorporated in the RW inflation rate, such observations would be consistent by definition because prices are adjusted for preferences and, thus, a shift of expenditures towards products that become relatively more expensive would be captured

[14] Figure (F.1) in Appendix (F) reports the figures for household inflation rates based on the Laspeyres and Paasche approach.

[15] This figure compares to 40% in the US data reported in Kaplan and Schulhofer-Wohl (2017).

by a price that is adjusted for preferences; the adjusted price would therefore decrease (see also equation (1)). We therefore focus on the RW-based household-level inflation rates to understand the contributions of different factors to this large heterogeneity in section 5.

Which household characteristics are related to inflation rates? To answer this question, we regress the average inflation rate per household ($\overline{\pi_h^{RW}}$) on the elasticity of substitution, the socioeconomic characteristics, and the indicator for flexible-price consumption

$$\begin{aligned}\overline{\pi_h^{RW}} = \alpha_0 &+ \alpha_1 * \sigma_h + \alpha_2 * I(HighIncome_h) + \alpha_3 * I(Retired_h) \\ &+ \alpha_4 * HHsize_h + \alpha_5 * I(FlexPrice_h) + \varepsilon_h, \qquad (3)\end{aligned}$$

where σ_h is the elasticity of substitution, $I(HighIncome_h)$ is an indicator for above-median income, $I(Retired_h)$ is an indicator for a household that includes at least one retired household member, $Hsize_h$ is the number of household members, and $I(FlexPrice_h)$ is an indicator for a household that tends to shop for goods with flexible prices. To adjust standard errors because inflation rates are based on estimates, we use feasible least squares including the correction suggested by Lewis and Linzer (2005).[16] We first include each of the regressors in equation (3) separately, together with the demand elasticity, and then estimate the equation including all regressors jointly.

Inflation rates are lower for households with larger elasticities of substitution, as shown in column (1) of Table 1. The estimated coefficient shows that an elasticity that increases by 10 results in a 0.5-percentage-point lower inflation rate. The socioeconomic characteristics are not significantly related to average inflation rates (columns 2 to 4), and households

[16] Lewis and Linzer (2005) argue that weighted least squares usually leads to inefficient estimates and overconfidence in these estimates. The proposed correction is to use an FGLS estimate that takes into account two sources of the second-stage regression residual: the difference between the true value of the dependent variable and its estimated value (sampling error) and a random shock to the residual, which would be present even if the dependent variable were not an estimate. Since we have an estimate of the sampling error (standard errors from the estimation of the dependent variable, as described in the Appendix section C), we have an estimate of its variance. An estimate of the variance of the random shock can then be backed out, as described in Hanushek (1974).

Table 1: *Average inflation rates and household characteristics*

	(1)	(2)	(3)	(4)	(5)	(6)
Elasticity of substitution	-0.0508***	-0.0513***	-0.0515***	-0.0521***	-0.0507***	-0.0539***
	(0.0163)	(0.0164)	(0.0164)	(0.0165)	(0.0165)	(0.0168)
High income		-0.0704				-0.0597
		(0.131)				(0.140)
Retired			-0.0885			-0.166
			(0.137)			(0.154)
HH size				-0.0464		-0.0582
				(0.0452)		(0.0509)
Flex prices					-0.0203	-0.0190
					(0.190)	(0.190)
Constant	-0.287***	-0.250*	-0.260**	-0.158	-0.276**	-0.0297
	(0.106)	(0.131)	(0.118)	(0.180)	(0.129)	(0.232)
Observations	3,469	3,469	3,469	3,469	3,469	3,469
R-squared	0.002	0.002	0.002	0.003	0.002	0.003

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

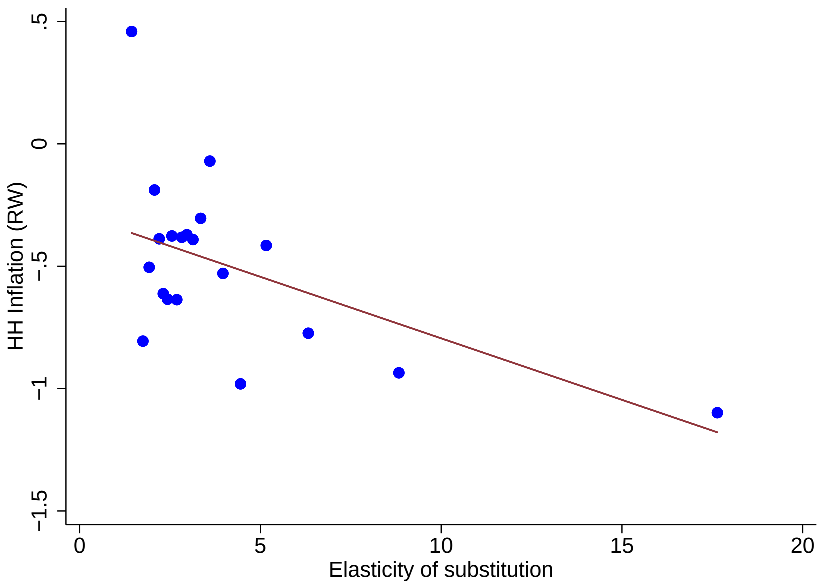
Notes: The dependent variable is $\overline{\pi_h^{RW}}$, the average RW inflation rate per household (average over all quarters). All regressions are estimated using FGLS to control for the fact that the dependent variables are estimates, using the procedure described in Lewis and Linzer (2005). The elasticity of substitution is the household estimate of σ_h, *High income* is an indicator equal to one if a household has above-median income, *Retired* an indicator equal to one if a household has at least one member that is retired, *HH size* measures the number of household members, and *Flex prices* is an indicator equal to one if a household tends to shop for products with higher price flexibility.

that include more flexibly priced varieties in their consumption baskets have no different inflation rates (column 5). They thus do not have additional information besides the elasticity of substitution, which remains robustly related to inflation rates, even after controlling for all other household characteristics (column 6).[17] Since we do not look at data for the US or Mexico, where previous research found a strong relation between inflation and

[17]These household characteristics remain insignificant also when excluding the elasticity of substitution as a regressor. Household income and retirement also remain insignificant when using the Fisher index instead of the RW index, while household size and the flexible price indicator are negatively related to Fisher inflation. See Appendix D, Tables D.1 and D.2, respectively. The finding that large households (households that tend to buy more flexible-price goods) have on average a bit smaller inflation rates when measured with the Fisher index, while they are not significantly different from other households when measured with the RW index, suggests that the measured differences are mostly due to differences in consumer valuations for different products.

household income (Cravino and Levchenko, 2017; Argente and Lee, 2015; Jaravel, 2019), the result that high-income households do not have an average inflation that is lower than low income households is arguably related to the fact that we use Swiss homescan data (see also Figure F.2 in the Appendix, which shows that the average inflation rate over time is also very similar for both income groups). The aggregate inflation in Switzerland was close to zero during the observation period and also Switzerland has a low degree of income inequality compared to the US.[18] We this add a finding suggesting that the significantly different inflation rates across income groups might be related to levels of inequality and/or trends in inflation.

Figure 4: *Elasticities of substitution and inflation*



Notes: This figure shows the relation between estimated inflation per household and the elasticity of substitution for 20 bins (sorted by the elasticity of substitution). The estimated regression line is $\overline{\pi_h^{RW}} = -0.29(0.107) + 0.05(0.016) * \sigma_h$, with standard errors in parenthesis.

The R^2's are low, suggesting that most of the variation in average inflation rates cannot

[18] According to the OECD, the poverty rate in Switzerland is very low, at 0.095 in 2019, while that of the US is almost double, at 0.178. The poverty rate is the ratio of the number of people (in a given age group) whose income falls below the poverty line, taken as half the median household income of the total population.

be related to socioeconomic characteristics or differences in elasticities of substitution. This outcome is largely because of the large heterogeneity in inflation rates across households relative to the small heterogeneity in the right-hand-side variables. In a binscatter, where households are sorted into 20 bins by the size of their substitution elasticity to average out some of the idiosyncratic variation, the relation is tighter, with an R^2 of 0.33 (see Figure 4).

4.2 Heterogeneity in prices paid

To study the differences in prices paid, we compute the average price per variety k as $p_{kt} = \frac{exp_{kt}}{q_{kt}} \quad \forall k \in \Omega_{t,t-1}$ and then the percentage deviation of an observed household-level purchase price from this average.

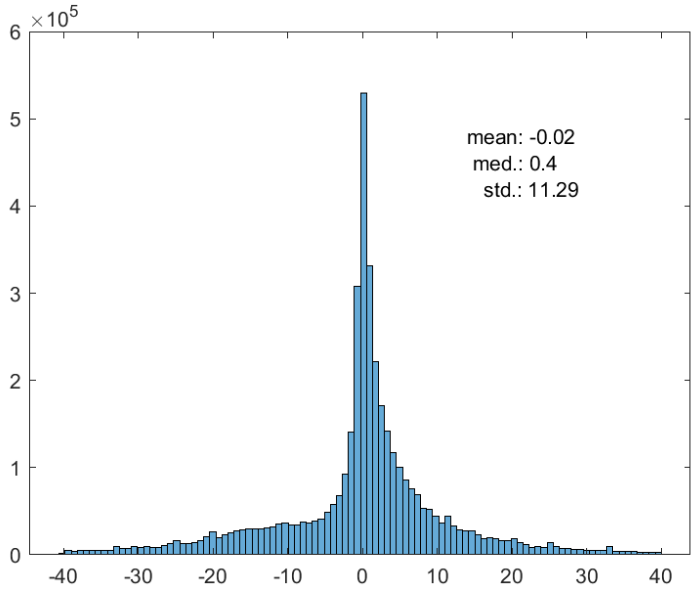
There is a substantial dispersion in prices paid across households that shop for the same variety in the same period. Figure 5 plots the percentage deviation of the price the household paid for a given variety from the average price for that variety in the same period.

The IQR of the distribution shown in this figure is 3.0, which is approximately one-third the size of the IQR of the overall dispersion of inflation rates.[19] This suggests that the price of a given product may vary substantially across households and transactions, a finding consistent with results reported for the US (Kaplan and Menzio, 2015).[20] However, these figures do not tell us how much dispersion in prices paid contributes to overall inflation dispersion because higher-than-average prices might be associated with larger preferences for a given variety or with lower elasticities of substitution, or with both. We will examine this issue in the next section using counterfactual analysis.

[19] Figure F.3 in Appendix F shows how the IQR and the distribution evolve over time.

[20] This heterogeneity in prices paid, does not matter for aggregate inflation rates, where the differences average out (F.4 in the Appendix shows that the average aggregate inflation rate using p_{kt} instead of actual prices paid looks almost identical).

Figure 5: *Difference in Prices paid per household*



Notes: This figure plots the histogram of the percent price deviation of p_{hkt} from p_{kt}. Due to better visibility, the differences are shown only for the interval [-40,0) and (0,40]. This approach suppresses the 3.1% of total observations that lie outside these bounds.

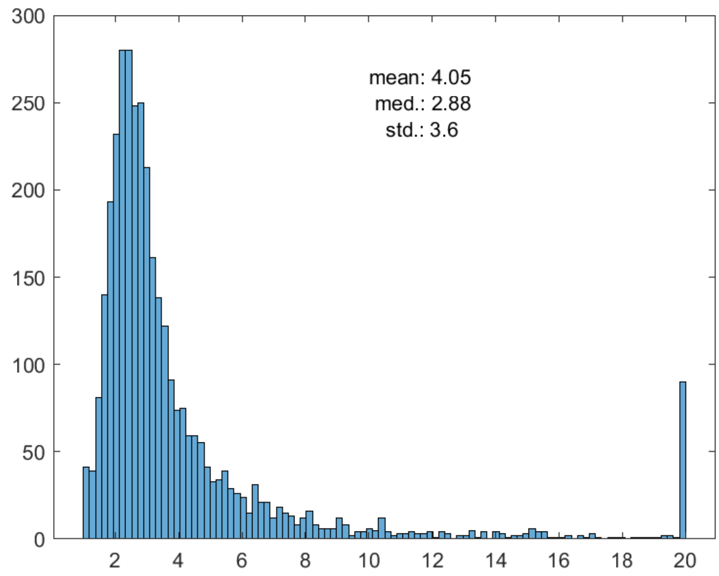
4.3 Heterogeneity in substitution elasticities

Inflation in the RW inflation rate depends not only on prices and expenditure shares but also on elasticities of substitution and associated preference shifts. In this section, we report the heterogeneity in the estimates for the elasticity of substitution.

Elasticities of substitution across households are also dispersed, as shown in Figure 6. The average (median) elasticity is at 4.1 (2.9) with a standard deviation of 3.6, and the IQR is 1.9.

Substitution elasticities vary across households with some household characteristics, particularly with household income, retirement status, household size, and the degree of

Figure 6: *Elasticities of substitution*



Notes: This figure shows the histogram of the estimated elasticities of substitution over households. We replace elasticities below 1.01 with 1.01 and elasticities above 20 with 20.

price stickiness in households' consumption baskets (Table 2).[21]

Above-median-income households have lower elasticities of substitution than households with a below-median income (column 1). Similarly, retiree households have lower elasticities than households that have not reached retirement age (column 2). These results are consistent with previous research based on US data that shows that demand elasticities fall with income (DellaVigna and Gentzkow, 2019; Stroebel and Vavra, 2019) and that retiree households tend to shop more intensively and spend more time searching for lower prices (Aguiar and Hurst, 2007). Larger households tend to have lower elasticities of substitution (column 3), while households that purchase more flexibly priced varieties tend to have higher elasticities of substitution (column 4). This finding suggests that

[21]Additional observable characteristics of the households, such as the average age of household members, employment, etc., were either not significant or not robust when including different controls. We therefore decided to report only the robust variables. The average age of household members is significant and negative in all specifications when retirement information is not included. Once this information is controlled for, it becomes insignificant.

Table 2: *Elasticities of substitution and household characteristics*

	(1)	(2)	(3)	(4)	(5)
High income	-0.305***				-0.332***
	(0.0918)				(0.0985)
Retired		-0.364***			-0.632***
		(0.0921)			(0.106)
HH size			-0.137***		-0.168***
			(0.0303)		(0.0353)
Flex prices				0.760***	0.763***
				(0.130)	(0.130)
Constant	3.833***	3.780***	4.050***	3.216***	4.019***
	(0.0694)	(0.0572)	(0.104)	(0.0760)	(0.155)
Observations	3,469	3,469	3,469	3,469	3,469
Adjusted R-squared	0.002	0.003	0.004	0.006	0.018

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable is the estimated elasticity of substitution σ_h. All regressions are estimated using FGLS to control for the fact that the dependent variables are estimates, using the procedure described in Lewis and Linzer (2005). *High income* is an indicator equal to one if a household has above-median income, *Retired* an indicator equal to one if a household has at least one member that is retired, *HH size* measures the number of household members, and *Flex prices* is an indicator equal to one if a household tends to shop for products with higher price flexibility.

households with higher demand elasticities also tend to shop for varieties with more flexible prices. Since higher demand elasticities are associated with lower income, this finding is also consistent with Cravino et al. (2018), even though we do not examine the direct link between income and the price flexibility of consumed varieties. All these effects remain similar when we include all variables jointly (column 5), although none of these household characteristics plays a large role in explaining the variation of elasticities across households: the R^2 is very low in all specifications.

5 Contributions to Heterogeneity

In this section, we decompose the heterogeneity of inflation rates into three main components that could contribute to this heterogeneity. The first is that different households pay different prices for identical goods. The second is that different households have different preferences. The third is the remaining difference that results from differences in consumption bundles.

We first show how each of these components of heterogeneity relates to household characteristics. Then, we quantify the contribution of each component to overall heterogeneity. To do so, for the first two components, we compute the absolute average difference between the actual inflation rate based on the RW inflation rate (π_h^{RW}) and the counterfactual (π_h^{ctf}) by household over time. This variable measures how much each household's counterfactual inflation rate differs from its actual rate. We describe each counterfactual below, which measures counterfactual inflation rates if prices were all identical to the average price paid for the same variety (counterfactual with equal prices) or if preferences were all identical (counterfactual with equal preferences). We regress this variable of average differences (that varies over households) on the elasticity of substitution, the socioeconomic household characteristics, and the indicator for flexible-price consumption baskets. We run the following regression,

$$\begin{aligned} \overline{|\pi_h^{RW} - \pi_h^{ctf}|} = \alpha_0 \quad &+ \quad \alpha_1 \sigma_h + \alpha_2 I(HighIncome_h) + \alpha_3 I(Retired_h) \\ &+ \quad \alpha_4 HHsize_h + \alpha_5 I(FlexPrice_h) + \varepsilon_h, \end{aligned} \tag{4}$$

in which we first include the elasticity of substitution together with each household characteristic separately and then include all of them jointly.

For the third component (differences in consumption baskets), we compute a counterfactual with equal prices and equal preferences. We then evaluate the remaining variation in inflation rates, which come from differences in the composition of consumption baskets.

5.1 Household characteristics and the role of heterogeneous prices, preferences, and consumption baskets

Counterfactual with equal prices. What is the role of the dispersion in prices paid on the overall dispersion of household-level inflation rates? To respond to this question, we hypothetically ask how large the dispersion of household inflation would be if all households paid the same price for the same product.

Using the economic approach, the counterfactual implies that households that would pay a different price than they actually do would also consume a different quantity.[22] In the counterfactual inflation rate, we therefore set all prices to equal each variety's average price in a given period. We then calculate the counterfactual quantity using the estimated demand elasticity σ_h and the estimated preference shifters. Both remain unchanged in the counterfactual, which means that we take into account that households would shift quantities if prices changed, while the household valuation of each product remains the same, as in the actual inflation rate. The counterfactual RW inflation rate (denoted by RW_{SP} for this same-price counterfactual) with the counterfactual expenditure shares is therefore given by

$$\pi_{h,t-1,t}^{RW_{SP}} \quad = \quad \frac{1}{1-\sigma_h} \ln \left(\frac{\sum\limits_{k \in \Omega_{h,t,t-1}} \left(\frac{p_{kt}}{\varphi_{hkt}}\right)^{1-\sigma_h}}{\sum\limits_{k \in \Omega_{h,t,t-1}} \left(\frac{p_{kt-1}}{\varphi_{hkt-1}}\right)^{1-\sigma_h}} \right).$$

[22] Using the statistical approach, we calculate household-level inflation rates by including average prices instead of actual prices paid and leave the expenditure shares unchanged, as in the data. We show the results for this exercise in Appendix E. Approximately 30% of the overall dispersion is due to differences in prices paid for the same product, assuming that households that pay a lower (higher) price in the counterfactual than in the actual data would not consume a higher (lower) quantity.

The results for our regressions described in equation (4) are shown in Table 3. Households with a larger elasticity of substitution show larger absolute differences between actual and counterfactual inflation rates (column 1, Table 3). That is, households that are more price sensitive tend to shop for products with prices that deviate more from the average price than do households that are less price sensitive. For a household with an elasticity of substitution of 2, the difference between the actual and the counterfactual is 1.9 percentage points on average. This difference increases by more than half, to 3.2 percentage points, for a household with an elasticity of 10. Richer households, retiree households, and larger households shop at prices closer to the average price p_{kt} than households that have below-median income, do not include retirees, and are smaller, respectively (columns 2-4). Households that tend to buy flexibly priced products tend to show differences between actual and counterfactual inflation that are 99 basis points larger than households that do not buy flexibly priced products (column 5). All these findings are similar when including all explanatory variables jointly (column 6), which together explain 14.3% of the overall heterogeneity in inflation variation that comes from differences in prices paid.

Table 3: *Dispersion and differences in prices paid*

	(1)	(2)	(3)	(4)	(5)	(6)
Elasticity of substitution	0.165***	0.163***	0.163***	0.162***	0.157***	0.149***
	(0.0159)	(0.0159)	(0.0159)	(0.0159)	(0.0156)	(0.0157)
High income		-0.192***				-0.207***
		(0.0609)				(0.0652)
Retired			-0.181***			-0.287***
			(0.0361)			(0.0413)
HH size				-0.105***		-0.118***
				(0.0196)		(0.0214)
Flexible prices					0.986***	1.002***
					(0.0828)	(0.0839)
Constant	1.577***	1.681***	1.654***	1.873***	1.012***	1.567***
	(0.0607)	(0.0729)	(0.0647)	(0.0863)	(0.0737)	(0.104)
Observations	3,465	3,465	3,465	3,465	3,465	3,465
Adjusted R-squared	0.100	0.102	0.104	0.106	0.127	0.143

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable is $\overline{|\pi_h^{RW} - \pi_h^{RW_{SP}}|}$, the absolute average difference per household between the RW inflation rate and the counterfactual inflation with identical prices for the same product. All regressions are estimated using FGLS to control for the fact that the dependent variables are estimates, using the procedure described in Lewis and Linzer (2005). The elasticity of substitution is the household estimate of σ_h, *High income* is an indicator equal to one if a household has above-median income, *Retired* an indicator equal to one if a household has at least one member that is retired, *HH size* measures the number of household members, and *Flexible prices* is an indicator equal to one if a household tends to shop for products with higher price flexibility.

Counterfactual with equal preferences. The second counterfactual asks: what is the role of heterogeneous preferences across households for the dispersion in inflation rates? These preferences are reflected in differences in elasticities of substitution across households and differences in preference shifts. All other variables are at their actual values. We study differences in elasticities and preference shifts jointly because in a counterfactual with no preference shifts, heterogeneity in substitution elasticities is irrelevant.[23] This phenomenon can be seen in the Sato-Varita inflation rate, which is independent of σ and is the counterfactual inflation rate for the assumption of equal preferences across households (denoted by π^{SV}),

$$\pi^{SV}_{ht,t-1} = \sum_{k\in\Omega_{h,t,t-1}} \omega_{hkt} * ln\left(\frac{p_{hkt}}{p_{hkt-1}}\right) \tag{5}$$

$$\text{with } \omega_{hkt} = \frac{\frac{s_{hkt}-s_{hkt-1}}{ln(s_{hkt})-ln(s_{hkt-1})}}{\sum\limits_{l\in\Omega_{h,t,t-1}} \frac{s_{hlt}-s_{hlt-1}}{ln(s_{hlt})-ln(s_{hlt-1})}}.$$

The results for our regressions described in equation (4) are shown in Table 4. Preferences play a larger role for households with lower substitution elasticities, as shown in column (1) of Table 4. Households with an elasticity of 2 have a 16.7-percentage-point dispersion of inflation rates related to differences in preferences, which decreases to 3.8 percentage points for households with an elasticity of 10. Similarly, households with an above-median income have a 0.6-percentage-point lower difference (column 2) than their counterparts. Households that are larger also have a smaller difference (column 4), while households that shop for products with flexible prices have a 0.7-percentage-point larger difference (column 5). All these results are robust to including all variables jointly, and 23.4% of the overall dispersion coming from heterogeneous preferences can be explained by these household characteristics (column 6).

[23] We cannot set all preference shifts to be nonzero and equal across households since the consumer preference parameters have to be measured in the same unit; thus, we require the normalization that the geometric average of preference shifts is one for each household and time period. Since not all households buy the same goods, it is impossible to set the same preferences, and these preferences have a geometric average of 1. The normalization itself is not important for the qualitative results: Redding and Weinstein (2020) show that a different normalization than the geometric mean leads to very similar outcomes. We therefore look at the counterfactual with no preference shifts, that is, households might have different levels of preferences across goods, but these preferences do not change over time and thus have no influence on their inflation rates.

Table 4: *Dispersion and preference shifts*

	(1)	(2)	(3)	(4)	(5)	(6)
Elasticity of substitution	-0.518***	-0.523***	-0.519***	-0.529***	-0.525***	-0.540***
	(0.0169)	(0.0171)	(0.0170)	(0.0172)	(0.0171)	(0.0174)
High income		-0.593***				-0.411***
		(0.122)				(0.126)
Retired			-0.0188			-0.302***
			(0.0935)			(0.0985)
HH size				-0.365***		-0.360***
				(0.0431)		(0.0460)
Flexible prices					0.708***	0.726***
					(0.187)	(0.184)
Constant	8.951***	9.274***	8.965***	9.979***	8.551***	9.893***
	(0.100)	(0.124)	(0.107)	(0.166)	(0.139)	(0.216)
Observations	3,456	3,456	3,456	3,456	3,456	3,456
Adjusted R-squared	0.212	0.217	0.212	0.228	0.215	0.234

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable is $\overline{|\pi_h^{RW} - \pi_h^{SV}|}$, the absolute average difference per household between the RW inflation rate and the counterfactual inflation with no preference shifts. All regressions are estimated using FGLS to control for the fact that the dependent variables are estimates, using the procedure described in Lewis and Linzer (2005). The elasticity of substitution is the household estimate of σ_h, *High income* is an indicator equal to one if a household has above-median income, *Retired* an indicator equal to one if a household has at least one member that is retired, *HH size* measures the number of household members, and *Flexible prices* is an indicator equal to one if a household tends to shop for products with higher price flexibility.

Counterfactual with equal preferences and prices. The last source of heterogeneity is different consumption baskets. To evaluate how much these differences contribute to the overall heterogeneity, we calculate the counterfactual with equal prices and preferences. The remaining heterogeneity of this counterfactual must come from differences in consumption baskets.

The resulting counterfactual inflation rate thus is a Sato-Varita inflation rate with equal prices across households[24]

$$\begin{aligned} \pi_{h,t-1,t}^{SV_{SP}} &= \sum_{k \in \Omega_{h,t,t-1}} \omega_{hkt}^{SP} \ln(\frac{p_{kt}}{p_{kt-1}}) \\ \text{with } \omega_{hkt}^{SP} &= \frac{\frac{s_{hkt}^{SP} - s_{hkt-1}^{SP}}{ln(s_{hkt}^{SP}) - ln(s_{hkt-1}^{SP})}}{\sum_{l \in \Omega_{h,t,t-1}} \frac{s_{hlt}^{SP} - s_{hlt-1}^{SP}}{ln(s_{hlt}^{SP}) - ln(s_{hlt-1}^{SP})}}. \end{aligned}$$

Because the remaining heterogeneity is captured in this counterfactual, we do not take the difference in the actual inflation rate but use the counterfactual itself as the dependent variable. We regress this counterfactual described in the paragraph above on the elasticity of substitution, the socioeconomic household characteristics, and the indicator for flexible-price consumption baskets. We run the regression,

$$\begin{aligned} \overline{|\pi_h^{ctf}|} = \alpha_0 &+ \alpha_1 \sigma_h + \alpha_2 I(HighIncome_h) + \alpha_3 I(Retired_h) \\ &+ \alpha_4 HHsize_h + \alpha_5 I(FlexPrice_h) + \varepsilon_h \qquad (6) \end{aligned}$$

where we again first include the elasticity of substitution and each explanatory variable separately, and then all of them jointly.

Differences in inflation rates that are due to differences in consumption baskets are

[24]Figure F.4 in the Appendix confirms that the average inflation rate is very similar when using same prices as when using individual prices.

Table 5: *Dispersion and differences in consumption baskets*

	(1)	(2)	(3)	(4)	(5)	(6)
Elasticity of substitution	0.115***	0.114***	0.113***	0.113***	0.107***	0.101***
	(0.0147)	(0.0147)	(0.0147)	(0.0147)	(0.0143)	(0.0145)
High income		-0.115**				-0.141**
		(0.0548)				(0.0561)
Retired			-0.183***			-0.265***
			(0.0388)			(0.0424)
HH size				-0.0812***		-0.0963***
				(0.0173)		(0.0190)
Flexible prices					1.053***	1.061***
					(0.0729)	(0.0724)
Constant	2.108***	2.169***	2.184***	2.334***	1.498***	1.948***
	(0.0549)	(0.0665)	(0.0584)	(0.0781)	(0.0674)	(0.0961)
Observations	3,500	3,500	3,500	3,500	3,500	3,500
Adjusted R-squared	0.063	0.064	0.068	0.067	0.103	0.118

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable is $\overline{|\pi_h^{SV_{SP}}|}$, the absolute value of the average Sato-Varita inflation rate with equal prices. All regressions are estimated using FGLS to control for the fact that the dependent variables are estimates, using the procedure described in Lewis and Linzer (2005). The elasticity of substitution is the household estimate of σ_h, *High income* is an indicator equal to one if a household has above-median income, *Retired* an indicator equal to one if a household has at least one member that is retired, *HH size* measures the number of household members, and *Flexible prices* is an indicator equal to one if a household tends to shop for products with higher price flexibility.

related to the estimated elasticity of substitution. Households with a higher elasticity tend to have a higher dispersion of the counterfactual inflation rate (the component of inflation that is due to differences in consumption baskets). Households with an elasticity of 2 have a dispersion of this counterfactual inflation rate of around 2.3 percentage point, which increases to 3.3 for a household with an elasticity of 10. Households that are rich, include retirees, or are large have a slightly lower dispersion that is due to differences in consumption baskets. A relatively large difference is related to flexible-price consumers, which have a 1.1-percentage-point larger dispersion than those that tend to purchase more products with stickier prices.

5.2 Relative contributions

How much of the overall dispersion in inflation rates across households is driven by differences in prices paid for the same variety, how much by differences in preferences, and how much by the remaining source of variation: differences in consumption baskets? To illustrate the contributions of the three different sources of heterogeneity, we calculate actual inflation rates and inflation rates for each counterfactual discussed above by household. We show two metrics that allow us to illustrate how important each of the three sources of variation (prices, preferences, and consumption baskets) is for the actual heterogeneity of inflation rates. First, we show the average IQRs for the actual inflation rate and each counterfactual. The reduction in IQR between the actual and the counterfactual is a measure of the contribution of a given source of variation to the actual variation in household-level inflation. The more the IQR declines in a counterfactual, the more important that source of variation is. Second, we run a univariate regression of each of the counterfactuals on the actual inflation rate,

$$\overline{\pi_h^{RW}} = \alpha_0 + \alpha_1 \overline{\pi_h^{ctf}} + u_h,$$

where $\overline{\pi_h^{RW}}$ is the average inflation over time per household and $\overline{\pi_h^{ctf}}$ is the average counterfactual inflation when households pay the same price, have the same preferences, or both, as described above. The R^2 of this regression is a measure of the variation in inflation rates across households explained by the variation in each of the counterfactuals. The advantage of the R^2-based measure is that it relates actual and counterfactual observations household-by-household, which the IQR does not. The advantage of the IQR-based measure is that it is robust to potentially large outliers. We therefore discuss and report both metrics below.

Interquartile ranges of the actual inflation rate and each counterfactual are reported in column (1) of Table 6.

Table 6: *Interquartile ranges and contribution to overall heterogeneity in inflation rates*

	(1) IQR metric	(2) R^2 metric
Inflation rate (π_h^{RW})	10.1	1.00
No heterogeneity in prices ($\pi_h^{RW_{SP}}$)	9.9	0.72
No heterogeneity in preferences (π_h^{SV})	3.6	0.08
No heterogeneity in prices and preferences ($\pi_h^{SV_{SP}}$)	2.8	0.03

Notes: Column (1) of this table shows the IQR for the actual rate of inflation (first row), the IQR for the counterfactual where prices for given varieties are the same across households (second row), the IQR of the counterfactual where heterogeneous preferences do not play a role (third row), and the IQR for the counterfactual where households all pay the same prices for given varieties and preferences play no role (last row). The latter remaining dispersion is then due to differences in varieties consumed. The second column of this table shows the R^2 of the regression $\overline{\pi_h^{RW}}$ on each of the counterfactuals described above.

The interquartile range of the inflation rates across households is 10.1. It is only slightly higher than that in the counterfactual scenario where all households pay equal prices for the same varieties but differences in preferences and consumption baskets remain (second row, "no heterogeneity in prices"). When removing differences in preferences across households, the IQR decreases by approximately two-thirds, to 3.6 (third row, "no heterogeneity in preferences"). When removing differences in prices paid and preferences, the remaining variation that must be attributed to differences in consumption baskets has an IQR of 2.8, or around only one-fourth of the overall variation (fourth row, "no heterogeneity in prices and preferences").

The second metric based on the R^2s of the univariate regressions is reported in column (2) of Table 6. The larger the R^2 is, the closer the counterfactual is to the actual inflation and therefore the lower the contribution of this counterfactual to the heterogeneity of actual inflation. This metric results in similar conclusions: heterogeneity in prices paid explains approximately one-fourth of the overall inflation variation across households. Most of the variation in inflation rates across households can be explained by variation in preferences:

the variation in inflation rates that can be explained by variation of the counterfactual inflation rate *not* including the variation in preferences is very low (8%). In other words, once this source of heterogeneity is removed ("No heterogeneity in preferences"), the remaining variation in counterfactual inflation rates explains very little of the overall variation. The variation in inflation rates across households that can be explained by the remaining heterogeneity due to differences in consumption baskets is even lower. Here, the low R^2 shows that the *remaining variation included* in this counterfactual explains only very little (3%) of the overall variation across households.

Both metrics show that differences in preferences are the main source of variation in household-level inflation, explaining at least approximately two-thirds of the overall variation. Differences in prices paid account for up to one-fourth of the overall variation, while the remaining heterogeneity due to differences in consumption baskets is rather low.

6 Conclusion

Households are heterogeneous in many aspects. This paper documents one dimension of heterogeneity: large differences in inflation rates across households. We find that these differences are large and vary over time with changes in aggregate inflation.

We employ a measure of inflation based on the economic approach to inflation measurement, which takes into account that households differ in their price sensitivity and in how much they value different products in different time periods. We show that these differences in preferences are large and account for the largest share of overall heterogeneity in inflation rates. This heterogeneity therefore adds to the heterogeneity generated by differences in consumption baskets or prices paid, which have been the main focus of the existing literature. Furthermore, inflation rates are smaller for households with larger elasticities of substitution, which tend to be households that have below-median incomes, that do not include retirees, that have more household members, and that shop for more flexibly priced goods. These results suggest a way to include heterogeneity in inflation rates across households in theoretical models by assuming differential elasticities of substitution for different household types. Our findings also suggest that dispersion co-moves with aggregate changes in inflation, where periods with very low and stable rates of inflation are associated with less dispersion in inflation rates across households.

Our results have implications for measures of welfare, particularly for measures of distributions, such as the dispersion in real incomes across households and over time. Our measures suggest that the dispersion might be even larger than previously thought because the cost of living is more dispersed when allowing for differences in preferences across households.

The finding that the dispersion of inflation rates is less pronounced during periods of very low and stable aggregate inflation rates suggests that policy makers targeting low and stable inflation rates also reduce the household-level dispersion of inflation rates. Although this topic is not the main focus of our study, this finding may provide an additional argument for stabilizing aggregate inflation rates at low levels with low volatility.

Our results also have implications for the literature on the dispersion of inflation expectations. If the price changes observed in stores during daily grocery shopping are an important determinant of households' inflation expectations, as recently shown using similar data for the US, the heterogeneity we observe in inflation expectations and associated household choices might be largely driven by heterogeneity in household inflation rates. Whether prices adjusted for taste shifts or unadjusted prices are more important for consumers' inflation expectation formation remains an open question for future research.

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Appendix to "Heterogeneity in Inflation Rates across Households"

A Additional information on the data set

Table A.1: *Socioeconomic characteristics of households: summary statistics*

	High income	*HHSize*	*Retired*	*FlexPrice*
mean	.492	2.623	.269	.268
sd	.500	1.420	.443	.060
min	0.000	1.000	0.000	.134
max	1.000	9.000	1.000	.812
count	3,918	3,918	3,918	3,918

Notes: This table shows the summary statistic for the household characteristics we use in the calculations. *High income* is an indicator equal to one if a household has above-median income, *Retired* an indicator equal to one if a household has at least one member that is retired, *HH size* measures the number of household members, and *Flex prices* is an indicator equal to one if a household tends to shop for products with higher price flexibility.

Table A.2: *List of product categories*

Product class	Expenditure share (in %)
Other pastries	1.08
Other charcuterie	0.96
Other meat	0.31
Other poultry	0.07
Other sausage products	1.81
Appetizers	0.08
Aperitif	0.37
Bakery products - snacks	0.47
Nuts/Nut mixes	0.27
Apple juice	0.2
Cider	0.08
Assorted tea	0.01
Baking ingredient	0.62
Berries	0.69
Beer with alc	1.18
Beer mix	0.11
Beer alc. Free	0.08
Beer variegated	0.08
Cookies	2.18
Candy	0.63
Bread products	0.15
Bubble gum	0.01
Butter	1.96
Champagne	0.12
Dessert products	0.13
Desserts	0.78
Pickled items	0.31
Exotic fruits	0

Convenience food	0.21
Convenience food at home	1.19
Instant salad	0.25
Fish	0.19
Canned fish	0.4
Canned meat/poultry	0.22
Cream cheese	1.72
Fruit/Nut mix	0.09
Fruit gum	0.24
Fruit juice	0.91
Fruit spirits	0.16
Fruits dried	0.23
Fruits in rum	0
Fruit tins	0.28
Foreign wine assorted	0
Foreign wine rose	0.29
Foreign red wine	1.56
Foreign wine white	0.76
Cooked convenience sauces	0.09
Gellant	0.07
Vegetables other	1.91
Vegetables dried	0.18
Vegetables/Antipasti	0.1
Vegetable tins	1.12
Vegetable juice	0.05
Sweetened	0.23
Grain/products	0.25
Seasoning	0.79
Hot wine/Punch	0.02
Bread, loafs	3.7
Semi hard	0.84

Hard cheese	1.22
HB/pastries	0.07
Honey	0.22
Chicken eggs	1.92
Ice-Tea	0.62
Yogurt	3.68
Instant coffee	0.43
Coffee supplements	0.01
Veal deli	0.01
Veal meat	0.03
Veal sausage	0.29
uncooked seasoning	0.23
Potatoes	0.65
Mashed potatoes	0.16
Chewing gum	0.28
Pome fruit	0.17
Ketchup	0.11
Small bread	0.33
Crispy bread	0.06
Cook set/Meal kits	0.06
Jam	0.35
Herbs	0.23
Herbal/fruit tea	0.36
Power food	0.36
Beer lager	0.01
Lamb charcuterie	0
Lamb meat	0
Lamb sausage	0
Bakery products - long shelf live	0.63
Liqueur	0.19
Local wine assorted	0

Local wine rose	0.04
Local wine red	0.24
Local wine white	0.19
Sparkling water	0.8
Margarine	0.43
Mandarins	0.01
Mayonnaise	0.5
Seafood	0
Horseradish	0.04
Flour	0.31
Molassis	0.01
Milk fresh	3.6
Milk concentrate	0.04
Cereals	0.5
Nectar	0.49
Nuts	0.53
Still water	0.32
Olives	0.14
Horse deli	0.01
Horse meat	0
Horse sausage	0.01
Mushrooms	0.21
Pizza	0.56
Chips	0.97
Portions	2.37
Port wine/Sherry	0.04
Chicken charcuterie	0.07
Chicken meat	0.58
Chicken sausage	0
Powder	0
Curd	0.68

Cream	2.25
Rice	0.51
Beef charcuterie	0.25
Beef meat	0.4
Beef sausage	0.01
Rtec	0.41
Sake	0
Salads	1.88
Salt	0.09
Sandwiches	0.27
New wine	0.03
Processed cheese	0.66
Chocolate branchlis	0.42
Chocolate dragees	0.22
Chocolate napolitans	0.12
Chocolate pralines	0.97
Chocolate bars	1.05
Chocolate seasonal articles	1.02
Chocolate	1.46
Chocolate other	0.24
Chocolate/Cocoa powder	0.03
Chocolate marshmallow	0.08
Black tea	0.08
Swedish bread	0.01
Pork charcuterie	1.37
Pork meat	0.16
Pork sausage	1.32
Sparkling wine pure	0.45
Mustard	0.22
Mustard fruits	0.02
Sirup	0.43

Snacks other	0.38
Soda concentrate	0.02
Cooking fat	0.15
Cooking oil	0.79
Beer, special	0.01
Specialties	0.06
Sport/Energy drinks	0.49
Starch products	0.02
Beer, strong	0
Fruit	0.26
Bakery products - lose ware	0.73
Sweeteners	0.08
Sweetened water	2.11
Sweet wine	0.01
Brawn	0
Table juice	0.16
Pasta products	0.94
Pasta	0.97
Pasta tins	0.17
DF Bakery products	0.55
DF Desserts	0.11
DF Convenience dishes	0.04
DF Fish	0.41
DF Meat	0.41
DF Fruits	0.11
DF Poultry	0.49
DF Vegetables/Mushrooms	0.52
DF Ice cream	1.5
DF potatoes	0.52
DF Pizza	0.42
DF Other	0.01

DF Pasta	0.37
Tofu/Soja	0.03
Tomato puree	0.09
Torts/Pies/Cake	0.68
Tortillas/Tacos	0.15
Grapes	0.12
Dry Pasta	1.16
Unsweetened food supplements	0.16
Whole-grain cracker	0.48
Pies	0.17
Soft cheese	0.98
Wine/Sparkling wine mix	0.1
Brandy	0.07
Beer, wheat	0
Tea, white	0
Whiskey	0.09
White spirits	0.09
Cigars	0.19
Cigarettes	5.98
Citrus fruits	0.44
Sugar	0.3
Rusk	0.09
Other bakery products	0.14
Eggs, other	0
Fruits, other	0.04
Other confectionery	0.05

B Estimation of the elasticity of substitution

The estimation of the elasticity of substitution is based on the methodology developed in Broda and Weinstein (2006) and Feenstra (1994), and is outlined below.

Assume the demand equation is given by

$$\Delta lns_{hkt} = \varphi_{ht} - (\sigma^h - 1)\Delta ln(p_{hkt}) + \varepsilon_{hkt},$$

where the error term ε_{hkt} includes the preference shocks. The supply equation is given bys

$$\Delta lns_{hkt} = \psi_{ht} + \frac{\omega}{1+\omega}\Delta ln(p_{hkt}) + \delta_{hkt},$$

where Δ denotes the difference over time.

Taking the difference again with respect to the geometric average over the goods eliminates the intercept and yields

$$\begin{aligned} \Delta ln\bar{s}_{hkt} &= -(\sigma^h - 1)\Delta ln(\bar{p}_{hkt}) + \varepsilon_{hkt} \\ \Delta ln\bar{s}_{hkt} &= \frac{\omega}{1+\omega}\Delta ln(\bar{p}_{hkt}) + \delta_{hkt}, \end{aligned}$$

with $\bar{s}_{hkt} = ln(\frac{s_{hkt}}{s_{\tilde{h}t}})$ Exploiting the assumption made by Feenstra (1994) that the double differences demand and supply shocks are orthogonal and heteroskedastic, Broda and Weinstein (2006) derive the estimation equation

$$\underbrace{(\Delta ln(\bar{p}_{hkt}))^2}_{Y_{hkt}} = \underbrace{\frac{\omega}{(1+\omega)(\sigma^h - 1)}}_{\Theta_1}\underbrace{(\Delta ln(\bar{s}_{hkt}))^2}_{X^1_{hkt}} + \underbrace{\frac{1-\omega(\sigma^h - 2)}{(1+\omega)(\sigma^h - 1)}}_{\Theta_2}\underbrace{\Delta ln(\bar{p}_{hkt}) \times \Delta ln(\bar{s}_{hkt})}_{X^2_{hkt}} + \underbrace{\varepsilon_{hkt} * \delta_{hkt}}_{u_{hkt}}.$$

Since u_{hkt} is correlated with X^1_{hkt} and X^2_{hkt}, Feenstra (1994) proposes to take the average over time and estimate the equation by running weighted least squares. Once the Θs are known, one can solve for σ^h. We winsorize the elasticities by replacing values below 1.01 with 1.01 and above 20 with 20.

C Bootstrapping

We use bootstrapping techniques to calculate standard errors for the estimated elasticities of substitution inflation rates. Specifically, we draw with replacement observations from each household's prices and expenditure shares. Then, we calculate the elasticity of substitution σ_h^{BS} as described in section B. For each household, we repeat this 100 times while winsorizing the elasticities between 1.01 and 20. Then, we compute the standard deviation.

We also use the elasticities to calculate standard errors for the RW inflation rate with:

$$\pi_{h,t-1,t}^{RW,BS} = \ln\left(\frac{\tilde{p}_{ht}}{\tilde{p}_{ht-1}}\left(\frac{\tilde{s}_{ht}}{\tilde{s}_{ht-1}}\right)^{\frac{1}{\sigma_h^{BS}-1}}\right).$$

Finally, for each household, we calculate the average of the inflation rates over time and then take the standard error of these 100 inflation rates. To calculate the standard errors of $\overline{\mid \pi_h^{RW} - \pi_h^{RW_{SP}} \mid}$ and $\overline{\mid \pi_h^{RW} - \pi_h^{SV} \mid}$ we run a similar procedure. That is we calculate the expressions using the 100 bootstrapped elasticities, take the absolute value of the difference, the mean over time, and calculate the standard error.

D Additional tables

Table D.1: *Average inflation rates and household characteristics without controlling for the elasticity of substitution*

	(1)	(2)	(3)	(4)	(5)
High income	-0.0515				-0.0379
	(0.131)				(0.139)
Retired		-0.0639			-0.123
		(0.137)			(0.152)
HH size			-0.0374		-0.0468
			(0.0449)		(0.0505)
Flex prices				-0.0738	-0.0763
				(0.188)	(0.189)
Constant	-0.469***	-0.477***	-0.394***	-0.450***	-0.269
	(0.0948)	(0.0798)	(0.148)	(0.108)	(0.206)
Observations	3,469	3,469	3,469	3,469	3,469
R-squared	0.000	0.000	0.000	0.000	0.000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable is π_h^{RW}, the average inflation rate per household (average over all quarters). See tables in main text for further details.

Table D.2: *Average inflation rates and household characteristics with statistical approach (Fisher)*

	(1)	(2)	(3)	(4)	(5)	(6)
Elasticity of substitution	-0.0395***	-0.0397***	-0.0385***	-0.0414***	-0.0379***	-0.0387***
	(0.0114)	(0.0114)	(0.0114)	(0.0114)	(0.0113)	(0.0113)
High income		-0.0289				0.0464
		(0.0524)				(0.0570)
Retired			0.133**			0.0740
			(0.0533)			(0.0607)
HH size				-0.0697***		-0.0671***
				(0.0178)		(0.0197)
Flex prices					-0.202***	-0.211***
					(0.0724)	(0.0726)
Constant	-0.336***	-0.321***	-0.378***	-0.141**	-0.220***	-0.0753
	(0.0457)	(0.0553)	(0.0493)	(0.0702)	(0.0568)	(0.0916)
Observations	3,463	3,463	3,463	3,463	3,463	3,463
R-squared	0.009	0.009	0.010	0.013	0.010	0.015

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes: The dependent variable is π_h^{Fis}, the average Fisher inflation rate per household (average over all quarters). See tables in main text for further details.

E Counterfactual analysis with statistical approach

In this Appendix section, we describe how we calculate the contribution of equal prices to the overall dispersion in inflation rates. Since, by definition, quantities do not respond to prices in the Laspeyres or Paasche inflation rate, we can compute the inflation rates using average prices instead of prices paid per household. Then, we calculate the resulting inflation rates, and compare the dispersion of the distribution with actual prices paid and the counterfactual with hypothetical average prices per variety k, denoted as $p_{kt} = \frac{exp_{kt}}{q_{kt}} \quad \forall k \in \Omega_{t,t-1}$ (the same as in the main text).

Therefore, the average-price Laspeyres and Paasche inflation rates are calculated by

$$\pi^{Las_{SP}}_{h,t,t-1} = \ln\left(\sum_{k\in\Omega_{h,t,t-1}} s_{hkt-1}\left(\frac{p_{kt}}{p_{kt-1}}\right)\right)$$

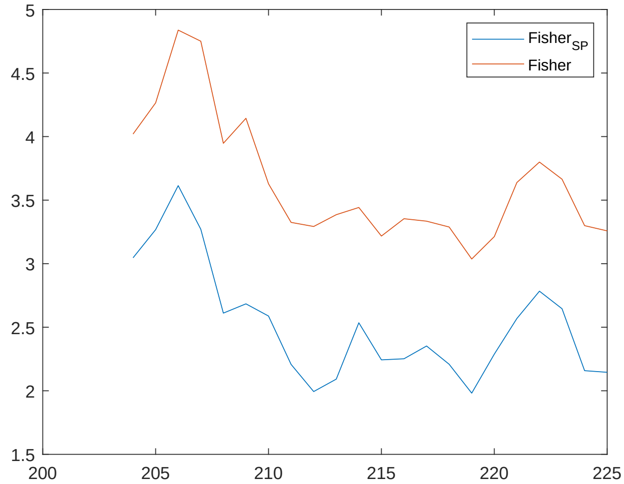
$$\pi^{Paa_{SP}}_{h,t,t-1} = \ln\left(\sum_{k\in\Omega_{h,t,t-1}} s_{hkt}\left(\frac{p_{kt}}{p_{kt-1}}\right)^{-1}\right)^{-1}$$

$$\text{with} \quad s_{hkx} = \frac{p_{hkx}q_{hkx}}{\sum_l p_{hlx}q_{hlx}}, \quad x = \begin{cases} t & \text{Paasche} \\ t-1 & \text{Laspeyres} \end{cases}$$

The Fisher is the geometric average of the two $\pi^{Fis_{SP}}_{h,t,t-1} = \sqrt{\pi^{Las_{SP}}_{h,t,t-1} * \pi^{Paa_{SP}}_{h,t,t-1}}$.

The next figure plots the dispersion between the households once if households pay their true price and once if every household pays the same price. Around 31% of the dispersion can be explained with

Figure E.1: *Interquartile range*



Note: Counterfactual IQR when households pay the same price $Fisher_{SP}$ relative to households paying their true price $Fisher$.

households paying a different price while the other 69% are due to households consuming different goods.

Alternatively, the shares could also be adjusted for the average price in the households' expenditures. Note that there is no mechanism that adjusts quantities because prices change, therefore we only mechanically adjust the price in the expenditure share but leave the quantity purchased unchanged.

$$\pi_{h,t,t-1}^{Las_{SP1}} = \ln\left[\sum_{k\in\Omega_{h,t,t-1}} s_{hkt-1}^{1}\left(\frac{p_{kt}}{p_{kt-1}}\right)\right]$$

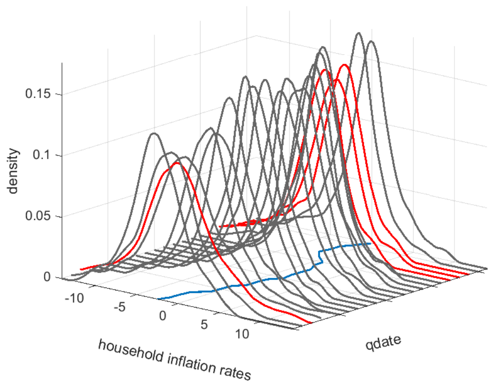
$$\pi_{h,t,t-1}^{Paa_{SP1}} = \ln\left[\sum_{k\in\Omega_{h,t,t-1}} s_{hkt}^{1}\left(\frac{p_{kt}}{p_{kt-1}}\right)^{-1}\right]^{-1}$$

$$\text{with} \quad s_{hkx}^{1} = \frac{p_{kx}q_{hkx}}{\sum_l p_{lx}q_{hlx}}, \quad x = \begin{cases} t & \text{Paasche} \\ t-1 & \text{Laspeyres} \end{cases}$$

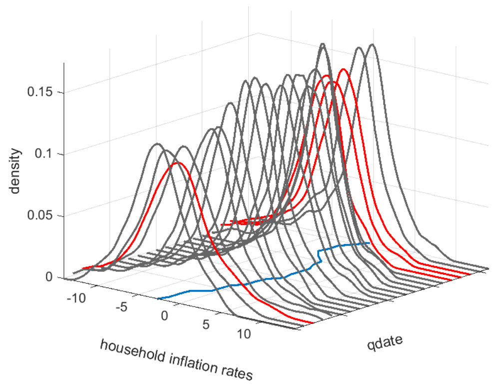
However, the results reported above change only very little when we consider this adjustment to expenditure shares. The conclusion above therefore remains unchanged.

F Additional figures

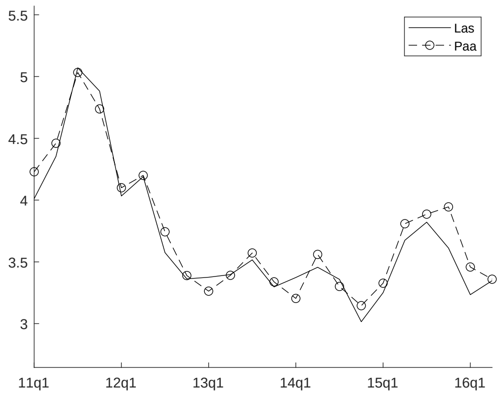
Figure F.1: *Dispersion of household inflation rates*



(a) Laspeyres



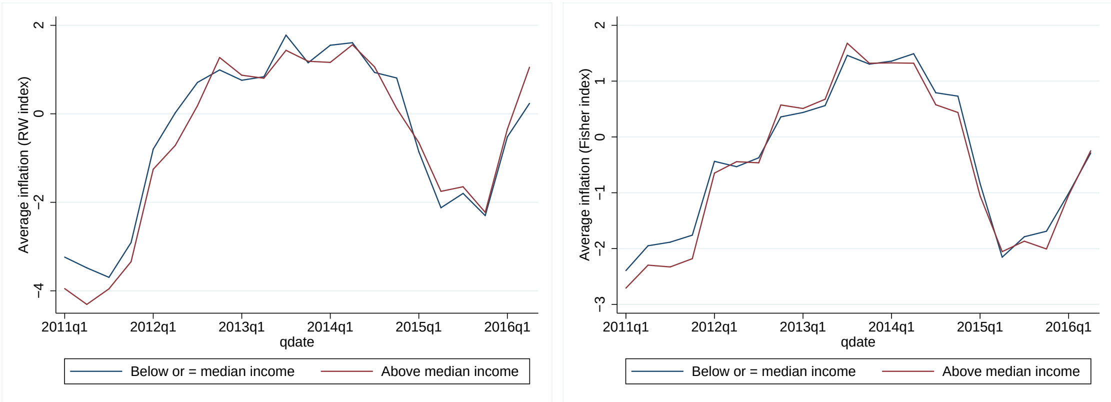
(b) Paasche



(c) IQRs

Notes: Panel a)/b) shows the distribution of the household inflation rates calculated with the Laspeyres/Paasche inflation rate. The blue line underneath the household inflation rates is the average inflation rate. Panel c) shows the interquartile ranges. Lines in red indicate 2011Q3 and 2015Q2-Q4.

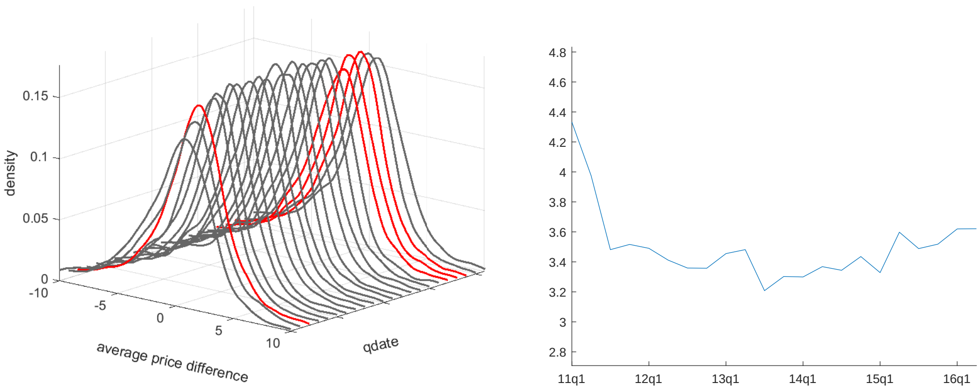
Figure F.2: *Inflation rates by income group*



(a) RW index (b) Fisher index

Note: Panel a) shows the average inflation rate by household income (above median income and ≤ median income) in the RW index. Panel b) shows the average inflation rate by household income (above median income and ≤ median income) in the Fisher index.

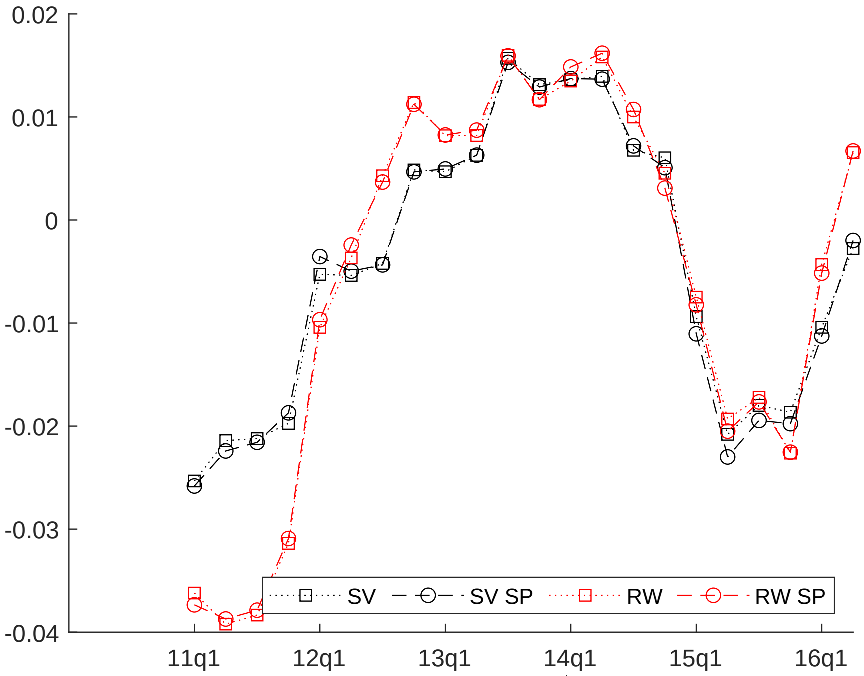
Figure F.3: *Dispersion of differences in prices paid*



(a) Dispersion (b) IQR

Notes: Panel a) shows the distribution of the average difference (over products) to the average price paid. Panel b) shows the IQR.

Figure F.4: *Aggregate Inflation Rates: Democratic*



Notes: This figure shows the average inflation rate (calculated as the mean inflation over households) for the RW and SV approach. "SP" denotes the counterfactual where all households pay the quarterly average price for a given product, instead of the actual price paid.