Cyclical Demand Shifts and Cost of Living Inequality

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Abstract

This paper studies how income-level inflation rates vary over the course of the business cycle and documents two new facts: (1) during recessions, prices rise more for products purchased relatively more by low-income households (necessities); and (2) the aggregate share of spending devoted to necessities is counter-cyclical. I present a mechanism where adverse macroeconomic shocks cause households to shift expenditure away from luxuries toward necessities, which leads to higher relative prices for necessities. I embed this mechanism into a quantitative model which explains around half of the cyclical variation in necessity prices and shares. The results suggest that low-income households are hit twice by recessions: once by the recession itself and again as their price index increases relative to that of other households.

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1 Introduction

Since the 2008 financial crisis, a flurry of research has shown that recessionary shocks have heterogeneous effects on households and can exacerbate inequality.[1] Much of the past literature has focused on the cyclical behavior of nominal consumption and income inequality and has overlooked cost of living differences across households, which is the denominator of real inequality. This paper shows that failing to include differential changes in the cost-of-living can dramatically understate the true distributional consequences of recessions.

This study asserts that higher consumer price inflation for low-income households is a feature of recessions. I present a novel mechanism, "Cyclical Demand Shifts," where contractionary shocks lead households to cut back on luxuries (e.g., vacations and pet services), but households continue to buy necessities (e.g., groceries). This shift in relative demand increases the relative price of necessities, which disproportionately affects poorer households since a larger share of their consumption basket is devoted to necessities. The mechanism implies that poor households are hit twice by recessions: once by the recession itself and again when the price of their basket increases relative to other households.

This paper makes three main contributions. First, I show empirically that while consumption falls during recessions, it does not fall equally for all products; specifically, consumption falls more for luxury products than necessities. Second, I show that the relative price of necessities is counter-cyclical. Third, I present a theoretical framework that incorporates the "Cyclical Demand Shifts" mechanism into a standard business cycle model. This model can explain a significant percentage of the cyclical behavior of relative necessity prices and consumption and estimates sizable increases in the relative cost-of-living for low-income households during recessions. Krueger et al. (2016) find that during the Great Recession, nominal consumption growth fell by 0.3 percent more for households in the lowest wealth quintile compared with those in the highest. A back-of-the-envelope calculation incorporating this paper's cost-of-living inequality estimates suggests that the actual difference in the fall of *real* consumption is almost four times as high at 1.15 percent.[2]

[1]See Heathcote et al. (2020), Feiveson et al. (2020), Krueger et al. (2016), Meyer and Sullivan (2013) and Hoynes et al. (2012)

[2]Krueger et al. (2016) classify households based on wealth levels, where this paper sorts households based on income.

In order to study differences in household-level price indices across time, I create 118 product sectors in the Consumer Expenditure Survey (CEX) that represent the same types of spending from 1991 to 2021. I then sort households into five different income quintiles. Next, I construct a measure of the relative importance of a product in a low-income household's consumption basket by dividing the pooled average of the product's nominal expenditure share for households in the first income quintile by the average expenditure share for that product of households in the highest income quintile (expenditure ratio).[3] I define necessities as products purchased more by low-income households (expenditure ratio greater than one) and luxuries as products purchased more by high-income households. Next, I match these 118 product sectors with publicly available price data from the consumer price index (CPI).

Based on this categorization, I investigate how aggregate consumption shifts between luxuries and necessities over the business cycle. The aggregate expenditure share devoted to necessities increased during all three of the recessions in my sample (2001, the Great Recession, and the COVID-19 recession). In fact, during both the 2001 recession and the Great Recession, all of the fall in real PCE (personal consumption expenditures) can be attributed to large declines in luxury expenditure, while nominal expenditures on necessities remain roughly constant at pre-recession levels. I formally test the relationship between the two variables of interest (1) aggregate spending on necessities and luxuries and (2) economic slack in a panel regression using all 118 product sectors. I find that a 1 percentage point increase in the unemployment rate is associated with a 0.9-2 percent increase in the aggregate share of spending on necessities. This relationship continues to hold even when controlling for whether products are durables, services, or in the energy or transportation sector. [4]

Next, I examine the cyclical behavior of prices for necessity products. Because I have price data for a subset of products from 1967 to 2021, I can observe the cyclical behavior of necessity and luxury prices over seven different recessionary periods. I construct composite price indices for necessities and luxuries. I find that the price index for necessities relative to luxuries has increased during five out of the past seven recessions.[5] Separately, in a panel

[3]An expenditure ratio greater than one implies that the product's Engel curve is downward sloping.

[4]This relationship is not simply mechanically related to higher necessity prices, as a necessity product's relative real expenditure (nominal aggregate expenditure divided by the product-specific price index) is also positively related to unemployment.

[5]Relative necessity prices have increased in six out of the last seven recessions when the volatile energy

regression using all 118 products, I find that a 1 percent increase in the unemployment rate is associated with a 0.7-1.5 percent increase in the relative price of necessity products. This relationship is also robust to including controls for whether products are services, durables, or in the energy or transportation sector.

Having documented that both necessity relative prices and aggregate shares increase during recessions, I formally introduce a static model that can rationalize these facts. The critical components of this model are non-homothetic preferences at the aggregate level and a concave production possibilities frontier. The non-homothetic preferences lead to cyclical demand shifts between necessities and luxuries that track the evolution of aggregate consumption expenditure. The concave production possibilities frontier leads to higher relative costs for the expanding sector. These components are sufficient for an aggregate decrease in expenditure to lead to a relative expansion in the necessity sector and higher relative necessity prices.

Is aggregate demand non-homothetic? While the cross-sectional data show that low-income and high-income households buy different bundles, this finding does not necessarily imply that aggregate preferences are non-homothetic; i.e. in response to an exogenous shock that changes aggregate consumption, does the aggregate consumption bundle change?[6] I test this assumption along with the model's primary conclusion, an increase in necessity prices following a decrease in aggregate expenditure, using monetary policy news shocks (Gürkaynak et al. 2004). Since the mechanism operates through changes in expenditure, I first show that 24 months after a 25 basis point contractionary monetary policy shock, aggregate expenditure falls by approximately 2 percent. Next, I show that the same contractionary shock leads the aggregate share of spending devoted to necessity products to increase by around 15 percent and relative necessity prices increase by around 5 percent. These results are robust to conditioning on whether the product is a durable good or a service, sectors that typically have high-interest rate elasticities or sticky prices. These results show that an exogenous shock that lowers aggregate expenditure also leads to higher relative

and transportation sectors are included.

[6]This question is also related to the relationship between income and expenditure elasticities. I define products as necessities/luxuries based on income elasticity and then test the aggregate expenditure elasticity of these products. The relationship between household income and aggregate expenditure elasticities is partially responsible for cyclical price index disparities across income groups.

necessity prices and consumption.

Next, I present a quantitative New Keynesian model that incorporates non-homothetic preferences and can be calibrated to the U.S. economy. Household preferences are represented by the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer 1980). While these preferences have been used in the trade literature, to my knowledge this is the first paper to incorporate these preferences into a New Keynesian style model. The AIDS inherits well-behaved aggregation properties from the Generalized Linear class of demand systems (Muellbauer 1975), which allows me to solve for aggregate necessity shares and relative necessity prices using a representative agent framework. I calibrate the model to match the United States' aggregate expenditure and necessity share in 2005-06, right before the Great Recession.

The quantitative model can explain a significant fraction of the cyclical variation in relative necessity prices and shares. In a validation exercise, I introduce a series of shocks to the model so that expenditure in the model exactly matches the cyclical component of the PCE from 1994 to 2021, which results in model-produced time-series of necessity prices and shares. The model-produced time-series are highly correlated and of the same scale as their data counterparts: the model's necessity price series has a 44 percent correlation with cyclical necessity prices in the data, and the necessity share series has a 55 percent correlation. Cyclical relative necessity prices peak in the Great Recession at around 5 percent in the model and 6 percent in the data.

With the model in hand, I examine the welfare consequences of the Great Recession when households have different price indices.[7] Using the non-homothetic price index implied by the AIDS, I estimate that the price index for low-income households increased by 0.85 percentage points relative to the price index of high-income households during the Great Recession (2007Q3-2009Q2). This large relative increase in cost-of-living can have considerable welfare consequences. I perform a test of the expenditure equivalent welfare loss due to the Great Recession, and I find that the Great Recession was 22 percent more costly for households in the bottom income quintile compared with households in the top quintile.

[7] Since the model abstracts from differences in employment loss or ability to borrow during the recession, these results are due only to differences in relative prices

Taken together, the results suggest that the difference in cost-of-living between low- and high-income households varies systematically over the business cycle: increasing during recessions and subsiding during expansions. This cost of living channel is yet another reason why recessions are particularly costly for low-income households.

This paper is most closely related to a small but fast-growing literature examining changes in the cost of living across household groups. Early research by Amble and Stewart (1994), Garner et al. (1996), Hobijn and Lagakos (2005), and McGranahan and Paulson (2005) found only limited differences in inflation rates across demographic groups.[8] However, more recent work has leveraged detailed product categories as well as barcode level data to document substantial differences in inflation-rates across households (Kaplan and Schulhofer-Wohl 2017, Jaravel 2019, Cavallo 2020, Gürer and Weichenrieder 2020, Argente and Lee 2021, Lauper and Mangiante 2021) This literature has focused on either trends in inflation rate disparities (Jaravel 2019, Gürer and Weichenrieder 2020) or particular events such as the Great Recession (Argente and Lee 2021), the 1994 Mexican devaluation (Cravino and Levchenko 2017), and the COVID-19 pandemic (Cavallo 2020, Jaravel and O'Connell 2020). In contrast, this paper shows empirically and theoretically that inflation inequality increases following any shock that affects aggregate consumption expenditure.[9]

This paper also contributes to the literature on endogenous demand shifts. For example, Jaimovich et al. (2019) show that households switched from high- to low-quality products during the Great Recession and this shift in demand led to lower labor demand since low-quality products use less labor in production. Over a longer horizon, Boppart (2014) and Comin et al. (2021), show that non-homothetic demand can explain the shift from agriculture to manufacturing and services in advanced economies. Comin et al. (2020) show how long-term shifts can contribute to labor-market polarization. Work by Bils and Klenow (1998) uses product expenditure elasticities to test competing business cycle models. This paper shows that over the short term, shifts in demand can lead to higher prices in the expanding

[8]An exception in this early-period is work by Crawford and Oldfield (2002) who found that few households in Britain have inflation close to the official Retail Price Index

[9]Inflation inequality may be a confusing term since price inflation traditionally has been defined as a general increase in the prices of goods and services in an economy or a decrease in the purchasing power of a particular currency. In the emerging literature on changes in the cost-of-living across income groups, "inflation inequality" is generally defined as differences in the change of the cost of achieving a particular level of utility across household groups (Jaravel 2021).

sector, which can have heterogeneous effects on income-level cost of living.

The remainder of the paper proceeds as follows: Section 2 details the data I use in the analysis, Section 3 presents the twin motivating facts (counter-cyclical necessity prices and aggregate shares), Section 4 formally presents the cyclical demand shift mechanism, Section 5 tests the conclusions of the mechanism empirically via monetary policy news shocks, Section 6 presents the quantitative model, and Section 7 concludes.

2 Data

This project's primary data sources are the Consumer Expenditure Survey (CEX) and publicly available product-level Consumer Price Index (CPI) series, both from the Bureau of Labor Statistics (BLS). The BLS uses the CEX and micro-level price data to construct the CPI-U. In doing so, they aggregate micro-price data into 243 different item strata and construct weights using the CEX (U.S. BLS, 2020). However, price time series for the 243 item strata are not publicly available. Instead, the BLS publishes CPI price series for a variety of more aggregated products, which I use in the analysis.

I create a cross-walk by hand between the publicly available item-level CPI categories and CEX MTBI micro-data. In this cross-walk, I create CEX products from base level Universal Classification Codes (UCC) [10] that were consistent across the 1991-2020 survey waves.[11] While some categories do not exist in earlier years (e.g., internet expenditures were not recorded before 1995 in the CEX), the categories are created so that comparison between years is possible and represent the same breadth of spending in each year. Next, I match these CEX categories to CPI item-level price data. Where this was not possible (e.g., CPI has separate price series for premium and regular gasoline), I created broader CEX products to match with the CPI or use a broader CPI category (e.g., gasoline). The result is 120 distinct products that represent the same types of spending from 1991 to 2021 (118 excluding rent and owners equivalent rent). Taken together, these product categories

[10] A UCC is the most disaggregated expenditure category in the CEX.

[11] While the CE survey was fielded in earlier years, the more detailed MTBI files are only available starting with the 1990 survey. Most product categories in this analysis start in the 1991 Quarter 2 survey.

represent approximately 97.5 percent of all consumption spending in the CEX.[12]

The CPI price series for these categories is not available across the entire sample period, as there was an expansion in published categories in 1967, 1977,1987, and 1997. For this analysis, I use either a balanced sample of products with continuous price information over some period (for example, 1987-2019) or an unbalanced sample. Results are similar using either method.

I exclude rent and owners-equivalent-rent since most high-income households are homeowners while low-income households generally rent their homes. While the BLS constructs an imputed owners' equivalent rent series, homeowners do not actually pay this price. When rent prices change, homeowners can still consume at their initial endowment point and are shielded from increases in home prices. While studying the effects of owning versus renting on real income and wealth inequality is an interesting area of research, it is not the focus of this article.

I divide households into five different income groups following Aguiar and Bils (2015). Namely, I keep only households that participate in all four CEX interviews and are complete income reporters. I also include only urban households and households whose household head is between 25 and 64. This process leaves me with 81,946 distinct households from 1991-2021. I divide households into five different income groups based on their pre-tax income. In addition to pre-tax income reported in the CEX, I include income from alimony, gifts, gambling winnings, inheritance, and any other payments from persons outside the household; similarly, I subtract from income the alimony, child support, etc. paid by the household. Next, I regress this income measure on dummies of the household size, max age of household head, and the number of income earners in the household. Then, I organize households into groups based on their income percentile in the quarter they report their income (their fourth CEX interview). Similar to Aguiar and Bils (2015), the top income group is households in the 80th-95th percentile of income (this lessens the degree to which changes in top-coding and outliers can change the composition of the top group). The bottom income group is households in the 5th-20th percentile of income. Groups 2, 3, and 4 are households in the 20th-40th percentile, 40th-60th percentile, and 60th-80th percentile, respectfully.

[12] Further details on this cross-walk are in Section B.1 of the appendix.

Households are interviewed four times three months apart and are asked about their spending in each of the previous three months in small categories (UCCs). These interview times do not necessarily correspond to calendar quarters. For example, a household interviewed in May would be asked about their April, March, and February spending. In principle, I should be able to use the CEX data to create monthly expenditure variables for each household or quarterly expenditure based on each household's reported expenditure in that quarter. However, there is widespread expenditure smoothing across months within an interview (Coibion, Gorodnichenko, Kueng, Silva 2017), meaning that reported expenditure in UCC u for a household interviewed in May would be relatively smooth from February to April but would have a much larger change when compared with January spending (which would come from the previous survey). For this reason, I base household spending at time t on the quarter or month they were interviewed rather than the quarter or month for which they report their spending (Coibion et al. 2017). In the main analysis, the measure of aggregate spending share in a category j in month t is smoothed across the three preceding months to capture all households in the interview wave.

I create quarterly expenditure shares for the 118 product groups for each household by dividing expenditure in category j by total consumption expenditure. Total consumption expenditure is defined as quarterly household expenditure minus savings in pension plans, life insurance, health insurance rebates, and cash contributions to those outside the household.

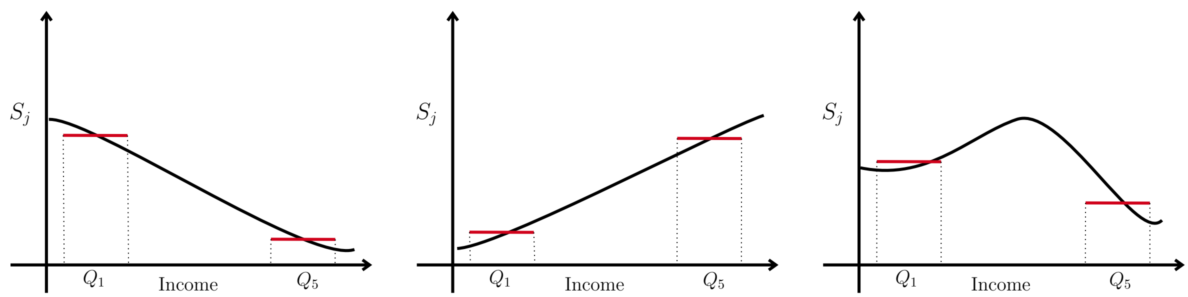
I create income group expenditure shares as the weighted average of household expenditure shares for all households in the income group. I use the household survey weights computed by the BLS. Note that this procedure is different from how the BLS creates expenditure shares for the CPI, since they also base their shares on the contribution of the household to total spending, which puts more weight on higher spending households. Since this paper is focused on non-homotheticities in consumption shares, weighting based on expenditure is problematic, as it would give more weight to households at the upper end of an income group (say those nearer to the 20th percentile versus those nearer the 5th percentile). This weighting could also be a problem when some households report more of their expenditure than others (see Aguiar and Bils (2015) for under-reporting in the CEX).

I pool the quarterly expenditure shares across quarters to create a single expenditure share for each income group and product. I define R_j, as the ratio of the share of consumer spending in the lowest income quintile to the share of spending in the highest quintile:

$$R_j = \frac{\sum_t \frac{1}{N_{t,Q1}} \sum_{h \in Q1} s_{jth}}{\sum_t \frac{1}{N_{t,Q5}} \sum_{h \in Q5} s_{jth}}. \tag{2.1}$$

R_j is equal to one if, on average, poor and rich households spend the same percentage of their expenditure on product j. I define products as necessity goods if poor households have a higher expenditure share on these goods relative to rich households ($R_j > 1$), and I define luxury goods as products with $R_j < 1$.

Figure 1: Expenditure Ratio Based on Engel Curve



(a) Necessity **(b) Luxury** **(c) Necessity**

Note: Panel (a) shows a product j with a downward sloping Engel curve (necessity). Panel (b) shows a luxury product. Panel (c) shows a product with a hump shaped Engel curve; in this example, it is a necessity since the average expenditure share for j is higher for the lowest income group, Q_1, than the highest, Q_5.

Figure 1 shows how this approach is is similar to comparing the level of the share based Engel curve at the top and bottom of the income distribution. If the Engel curve is linear, then the "necessity" rank of the good using this method would be the same as the rank derived from the slope of the Engel curve (where a slope of zero would correspond to an expenditure share ratio of one). If the underlying Engel curve is non-linear (as suggested by Atkin, Faber, Fally, and Gonzalez-Navarro (2020)), then this method continues to rank goods by their importance in the consumption basket of low-income versus high-income households regardless of consumption patterns for the middle income-groups.

Table 1 Panel A shows the top 10 luxury goods. The consumption category that has the highest comparative expenditure by those in the top income group is "Club memberships for shopping clubs, fraternal, or other organizations", which has an expenditure ratio, R_j, of

Table 1: Top luxury and necessity products

Panel A: Top Luxury Goods		
CPI Category	**Expenditure Ratio**	**Percent Agg. Spending**
Club memberships for shopping clubs, fraternal, or other organizations	0.31	0.34
Other lodging away from home including hotels, and motels	0.33	0.80
Pet services	0.33	0.09
Day care and preschool	0.34	0.75
Fees for lessons or instruction	0.36	0.59
Other intercity transportation	0.36	0.2
Airline fares	0.37	0.82
Alcohol away from home	0.40	0.44
Other furniture	0.40	0.19
Elementary and high school tuition and fees	0.40	0.38
Panel B: Top Necessity Goods		
CPI Category	**Expenditure Ratio**	**Percent Agg. Spending**
Cigarettes	3.28	0.84
Electricity	1.68	3.11
Tobacco products other than cigarettes	1.63	0.07
Food at home	1.51	12.04
Intracity transportation	1.49	0.20
Water and sewerage maintenance	1.45	0.8
Prescription drugs	1.44	0.6
Used cars and trucks	1.41	4.4
Telephone services	1.40	2.9
Gasoline (all types)	1.38	4.71

Note: Expenditure ratio is defined as the average expenditure share of households in the bottom income group divided by the average expenditure share of households in the top income group. Percent Aggregate Spending is computed based solely on households within the income-group sample.
Source: Consumer expenditure survey and author's own calculations.

0.31. This finding means that on average, households in the highest income group spend 3.2 times as much of their budget on this category compared to households in the lowest income group. Other top luxury goods include Airline flights, Daycare, Hotels, Private Lessons, and alcoholic beverages away from home.

Panel B shows the top 10 necessity goods. These include tobacco products, food at home, electricity, and intracity transportation (e.g., bus or subway). Table 2 shows that luxuries tend to be more concentrated in services and durable goods, while necessities are more concentrated in energy and transportation.

Table 2: Descriptive statistics for luxuries and necessities

Descriptive Stats		
	Necessity	**Luxury**
Number	31	87
Number durables	3	33
Number services	17	33
Number Energy	5	4
Average percent aggregate expenditure	1.3%	0.4%
Percent expenditure durables	11%	31%
Percent expenditure services	44%	54%
Percent expenditure energy	22%	4%

Note: These 118 products exclude the two housing products: rent and owners equivalent rent. Energy: denotes that the product is part of the energy or transportation sectors.
Source: Consumer expenditure survey and author's own calculations.

3 Two Facts

In this section, I use the combined CEX and CPI data to examine the consumption and pricing behavior of luxuries and necessities. To this end, I begin by creating composite necessity and luxury products so that the reader can visualize the relationship between (1) relative shares and prices and (2) the business cycle. I also perform panel regressions and show a strong positive correlation between the unemployment rate and the relative aggregate shares and prices of necessities.

3.1 Fact 1: Relative Spending on Necessities is Counter-Cyclical

Visual Evidence

First, I show that aggregate spending on necessities rises relative to luxuries during recessions. Using aggregate expenditures in the CEX on each of the 118 categories, I construct the aggregate necessity share as:

$$s_{N,t} = \frac{\sum_{j \in Necessity} x_{jt}}{X_t} \tag{3.1}$$

where x_j is the total aggregate expenditure in the CEX on necessity sector j and X is the total non-housing expenditure in the CEX. Panel A of figure 2 shows how the aggregate necessity share changes over time. The necessity share increased during the early 1990s, fell during the dot-com boom and increased during the mild recession of 2001. Then there was a drastic increase in the necessity share starting in 2007, the beginning of the Great Recession, which peaked between 2013 and 2014 around the same time that real per-capita gross domestic product (GDP) recovered from its 2007 peak. The necessity share then falls during the expansion of the mid-2010s and rises again during the Covid-19 recession. Figure A5, in the appendix, shows that these same patterns are still present when we restrict the sample to non-durables.

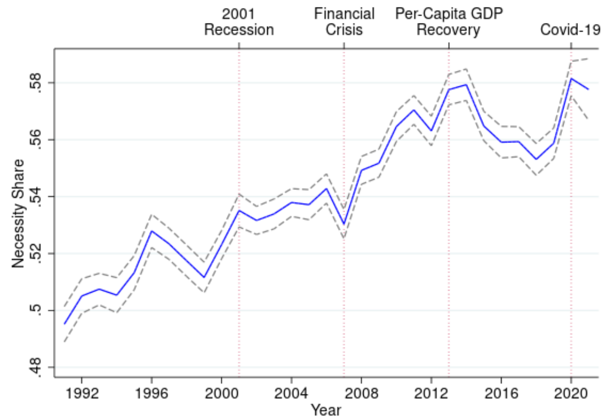
Not only does the aggregate spending share of necessities rise in recessions, but almost all of the fall in consumption spending during recessions can be attributed to *falls in luxury expenditure* rather than falls in necessity expenditure. Panel B of figure 2 shows imputed aggregate expenditure on luxuries and necessities by multiplying equation (3.1) by real PCE. The vast majority of the fall in consumption during the 2001 recession and the Great Recession can be attributed to a decline in luxury spending, while necessity expenditure either remains at the same level as before or even *increases*! [13] This fact remains when deflating luxury and necessity expenditure by each sectors relative prices (see figure A6).

The increase in the aggregate necessity share during the Great Recession was precipitated by all income groups. Figure A7 in the appendix shows the percentage point increase in the average necessity share for each income quintile during the Great Recession, (2007:Q3-2009:Q2), and the subsequent slow recovery (2009:Q2-2012:Q4). All income groups increased their share of necessity consumption expenditure by at least 2.5 percentage points during this period. The increase does vary by income group; for example, the lowest income quintile had the lowest increase in necessity share, especially during the official recession as defined by

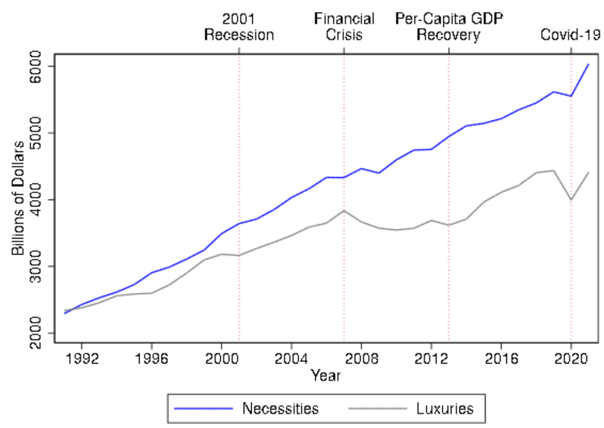
[13] The larger increase in necessity rather than luxury expenditures from 1991 to 2021 could seem at odds with the rise in aggregate income and spending over this period, as well as papers in the structural change literature such as Comin et al. (2021), which document the change from agriculture to manufacturing and then to service expenditure. I should note two things about the patterns I find: (1) the long-term increase in necessity expenditure relative to luxury expenditure is moderated considerably when expenditure is deflated by sector-level prices (see figure A6); and (2) in this period of U.S. Economic history there is a shift from manufacturing towards service expenditure (Schettkat and Yocarini 2006), both of which are more likely to be classified as luxuries in my categorization.

Figure 2: Aggregate Expenditure on Necessities and Luxuries

Panel A: Necessity Share of Aggregate Expenditure



Panel B: Necessity and Luxury Imputed Expenditure



Note: Shaded lines indicate bootstrapped 90-percent confidence interval. Excludes housing.
Source: Consumer Expenditure Survey and author's own calculations.

the National Bureau of Economic Research (NBER), which may indicate a lack of an ability to substitute away from luxuries (Argente and Lee 2021). It is important to note that while the shift in necessity expenditure varied by income group, the income group ranking of necessity shares does not change. The lowest income group had the highest necessity share of expenditure during the Great Recession (around 72 percent), and the highest income quintile had the lowest (around 52 percent).

Regression Evidence

The visual evidence in the previous subsection shows that generally, relative necessity shares increase during recessions. Now I formally test the relationship between relative necessity shares and aggregate economic activity using a simple regression:

$$x_{j,t} = \beta_0 + \beta_1 Unemployment_t \times R_j + \beta_1 Unemployment_t \times Z_j + \delta_t + \gamma_j + \varepsilon_{j,t}. \tag{3.2}$$

Here, the dependent variable, $x_{j,t}$ is the log-relative price of products in sector j at time t or the log-aggregate share (presented in the next subsection). The dependent variable is regressed on the interaction of the unemployment rate with R_j the relative expenditure ratio, which is increasing for necessities. I also include time δ_t and sector γ_j fixed effects (which absorb the level effect in the interaction). Finally, Z_j is an indicator for whether the product sector is a service, durable, or in the energy/transportation sector.

The regression results have several advantages over the visual evidence. For example, I no longer have to rely on a binary definition of the necessity product since R_j is a continuous variable. Also, in the regression, I can control for a variety of confounding factors that may be correlated with a product's income elasticity and cyclicality. For example, services have stickier prices than goods (Nakamura and Steinsson 2008) and high-income households also buy more services. In addition, durable purchases are particularly sensitive to interest rates (McKay and Wieland 2021, Barsky et al. 2007) and could be another confounding factor.

Table 3 shows the correlation between the log-aggregate share of necessities and the unemployment rate. Panel A replaces R_j with a binary definition of necessity, while panel B shows the results of the regression in equation (3.2). Column 1 shows the baseline results. In column 2, to determine that the results are not dependent on some arbitrary classification of spending into 118 categories, I weigh each observation by the sector's share in aggregate spending. In columns 3-5, I add in controls of the interaction of the unemployment rate with various aspects of the product j that may confound the results, including whether the product is directly related to oil prices (energy and transportation), whether the product is durable, or if the product is a service. Results are highly statistically significant and around the same size in all specifications. Overall, I find that a one percentage point increase in the unemployment rate is associated with a $0.9 - 2$ percent increase in relative share of aggregate spending on necessities. This relationship is not simply the result of higher prices for necessities when unemployment is high (see next subsection); in the appendix Table 7 I show a strong positive relationship between necessity product's sector-real expenditure and the unemployment rate.

3.2 Fact 2: Counter-cyclical Necessity Prices

Visual Evidence

Next, I show a visualization of the relative prices of necessities and luxuries over the business cycle. I create a geometric-price index for a representative necessity (luxury) good:

$$P_t^K = \prod_j \left(\frac{p_{j,t}}{p_{j,b}}\right)^{\omega_j}, \tag{3.3}$$

where $K = \{N, L\}$ for necessity and luxury respectively, and ω_j is the pooled aggregate share of product j in total necessity or luxury spending from 1991-2020.[14] Note that b refers to the prices in some base period, which I define as the first period in the sample. I then construct the relative necessity price as the ratio of the price of the composite necessity over that of the composite luxury:

$$RP_t^N = \frac{P_t^N}{P_t^L}. \tag{3.4}$$

The series, RP_t^N is then filtered following Hamilton (2018) to isolate the cyclical component of relative necessity prices. Figure 3 panel A shows the results of this visualization. I have price data for some products since 1967, while for others, the publicly available series is much shorter. I construct multiple different versions of equation (3.4) corresponding to more inclusive balanced samples of products. For example, the series in blue comes from a balanced sample of 17 products with continuous price data from 1967-2020, while the series in red contains a much higher number of products (98) over a shorter period (1997-2020). For visualization purposes, I remove the volatile energy and transportation sectors from this graph (appendix figure A3 shows the results with energy and transportation). Each version of the filtered series closely track each other.

[14] In the appendix, I show that my results are robust to pooling the aggregate share and income-share data over a smaller time period.

Table 3: Relationship Unemployment and Relative Necessity Shares

Panel A: Binary necessity good

	Log-Share				
	(1)	(2)	(3)	(4)	(5)
Right hand side variables:					
UR × Necessity	0.019***	0.018***	0.014**	0.009*	0.020***
	(0.006)	(0.006)	(0.006)	(0.005)	(0.007)
UR × Energy			0.023*		
			(0.012)		
UR × Durable				-0.046***	
				(0.013)	
UR × Service					0.013
					(0.011)
Sector FE	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes
Weighted	No	Yes	Yes	Yes	Yes
Observations	42,700	42,700	42,700	42,700	42,700

Panel B: Scale by expenditure ratio

	Log-Share				
	(1)	(2)	(3)	(4)	(5)
Right hand side variables:					
UR × Exp. Ratio	0.026***	0.023***	0.019***	0.014***	0.027***
	(0.006)	(0.005)	(0.004)	(0.004)	(0.006)
UR × Energy			0.022*		
			(0.012)		
UR × Durable				-0.045***	
				(0.013)	
UR × Service					0.017
					(0.011)
Sector FE	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes
Weighted	No	Yes	Yes	Yes	Yes
Observations	42,700	42,700	42,700	42,700	42,700

Notes: The unit of observation is the sector-month. Exp. ratio is the ratio of expenditure shares of poor over rich households for the sector. Standard errors, in parentheses, are clustered at the time level and are robust to auto-correlation. Significance at the 1, 5, and 10 percent levels indicated by ***,**, and *. Share is defined as the aggregate expenditure on sector j divided by total aggregate expenditure.

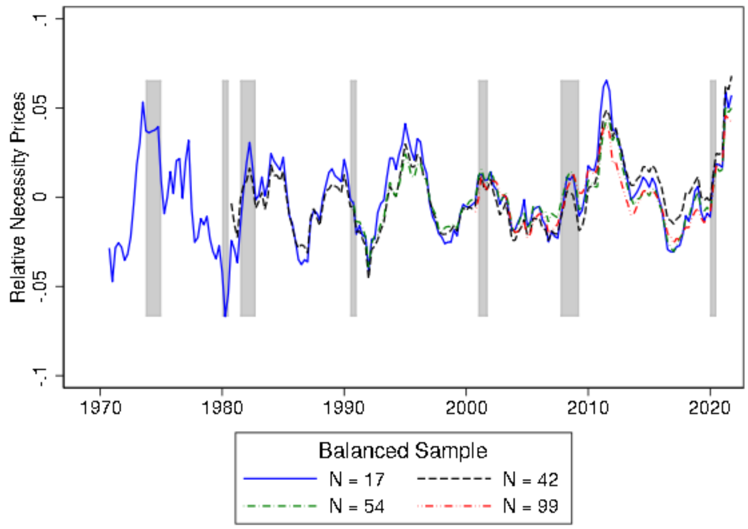
Panel A also shows that relative necessity prices have increased in five of the last seven recessions [15]. This pattern is robust to varying the definition of necessities and luxuries. For example, if I instead define necessities or luxuries based on cross-sectional spending patterns based in a particular decade (e.g. 2010-2019) rather than rather than pooling data from 1991-2020 together (see figure A4 in the appendix).

Panel B shows a bin-scatter plot comparing the level of slack in the economy (measured by the unemployment rate) and the cyclical component of relative necessity prices. The left panel uses the long time series (1967-2021) with 17 balanced product sectors, while the right panel uses the shorter time series (1997-2021) with 98 balanced product sectors. In both cases there is a strong positive relationship between relative necessity prices and the unemployment rate. However, the relationship is tighter in the more recent period.

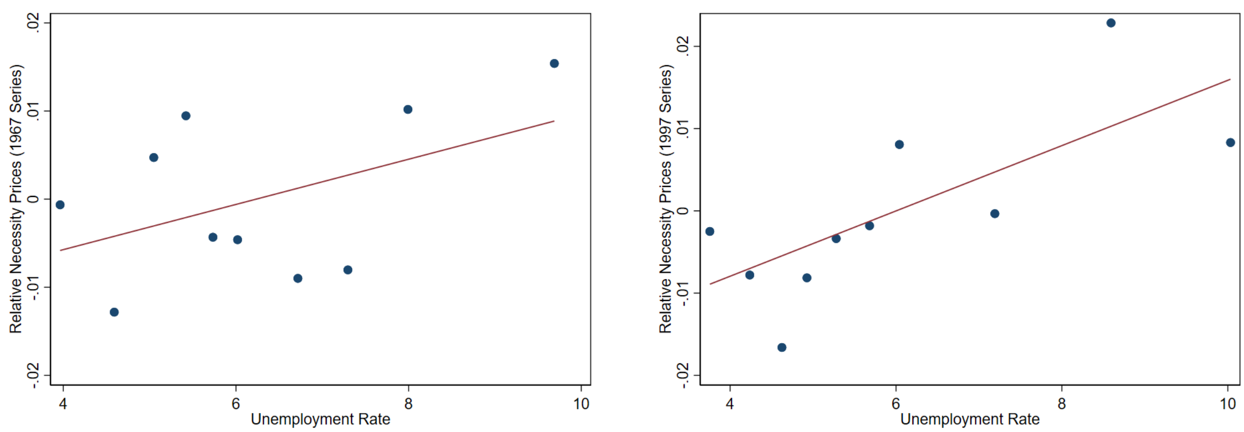
[15] This increases to six of the last seven recessions when including prices from the volatile energy and transportation sectors. See appendix figure A3

Figure 3: Relative Necessity Prices Over the Business Cycle

Panel A: Time Series



Panel B: Scatter Plot



1967-2021 ($N = 17$)

1997-2021 ($N = 98$)

Note: Excludes rent, owners equivalent rent, and energy/transportation. For panel A, data filtered following Hamilton (2018). Shaded area indicates NBER Recessions. In panel B, the y-axis is the (binned) residuals of the relative necessity price following the filtering method in Hamilton (2018), while the x-axis is the unemployment rate. The red line represents a bivariate regression line between these two variables. The left plot uses a balanced panel of products from 1967-2021, while the right panel uses the larger balanced panel under a shorter time horizon (1997-2021).
Source: Bureau of Labor Statistics and author's own calculations.

Table 4: Relationship Unemployment and Relative Necessity Prices

Panel A: Binary necessity good

	Log-Relative Price					
	(1)	(2)	(3)	(4)	(5)	(6)
Right hand side variables:						
UR × Necessity	0.015	0.015***	0.010**	0.007**	0.014***	0.013**
	(0.009)	(0.004)	(0.005)	(0.003)	(0.003)	(0.006)
UR × Energy				0.036***		
				(0.008)		
UR × Durable					-0.006	
					(0.017)	
UR × Service						-0.008
						(0.013)
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Weighted	No	Yes	Yes	Yes	Yes	Yes
Balanced Sample	No	No	Yes	No	No	No
Observations	49,963	49,963	24,072	49,963	49,963	49,963

Panel B: Scale by expenditure ratio

	Log-Relative Price					
	(1)	(2)	(3)	(4)	(5)	(6)
Right hand side variables:						
UR × Exp. Ratio	0.018**	0.020***	0.012***	0.013***	0.019***	0.018***
	(0.008)	(0.004)	(0.004)	(0.003)	(0.004)	(0.006)
UR × Energy				0.035***		
				(0.008)		
UR × Durable					-0.005	
					(0.018)	
UR × Service						-0.006
						(0.013)
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Weighted	No	Yes	Yes	Yes	Yes	Yes
Balanced Sample	No	No	Yes	No	No	No
Observations	49,963	49,963	24,072	49,963	49,963	49,963

Notes: The unit of observation is the sector-month. Exp. ratio is the ratio of expenditure shares of poor over rich households for the sector. Necessity good is defined as a sector with an expenditure share over one. Relative prices are the sector level CPI divided by the CPI-U. Standard errors, in parentheses, are clustered at the time level and are robust to auto-correlation. Significance at the 1, 5, and 10 percent levels indicated by ***,**, and *. The balanced sample are 59 sectors with continuous price data from 1987-2021.

Regression Evidence

I repeat the regression exercise from the previous subsection, but I use the log-price of each sector as the dependent variable in equation (3.2). Results from these regressions are shown in table 4. Panel A replaces R_j with a binary definition of necessity, while panel B shows the results of the regression in equation (3.2). Column 1 shows the baseline results. In column 2, to determine that the results are not dependent on some arbitrary classification of spending into 118 categories, I weigh each observation by the sector's share in aggregate spending. Column 3 shows the results with a balanced sample. In columns 4-6, I add in controls of the interaction of the unemployment rate with various aspects of the product j that may confound the results, including whether the product is directly related to oil prices (energy and transportation), whether the product is durable, or whether the product is a service. Results are highly statistically significant and around the same size in all specifications. Overall, I find that a 1 percentage point increase in the unemployment rate is associated with an $0.7-1.5$ percent increase in relative prices for necessity products or a $1.2-2.0$ percent increase in the relative prices of products with an expenditure ratio 1 unit higher.

To summarize, I find a statistically and economically significant correlation between relative necessity prices and shares with the unemployment rate. This result is not driven by differences in the service, energy, or durability composition of necessities. In the next section, I present a mechanism that can explain these two facts.

4 A Static Model of Relative Supply and Demand

In this section, I formalize the intuition behind the cyclical demand shift mechanism. I present a static model with a necessity and a luxury sector represented by perfectly competitive firms with concave production over labor. Households have non-homothetic preferences over those two sectors. This model is presented in partial equilibrium, and I abstract from the household labor market and savings decisions. Instead, the level of household expenditure, X, is exogenous. I show that a decline in the expenditure level, X, leads to higher equilibrium consumption shares and prices for the necessity sector.

4.1 Firms

There are two sectors $\{N, L\}$. Each sector is competitive and is represented by a firm with a homogeneous production function over labor:

$$Y_i = F(H_i). \tag{4.1}$$

I assume that $F(\cdot)$ is positive and homogeneous of degree $k \in (0,1)$, implying that the firm has concave production over labor. Firms can hire labor at an exogenous fixed wage rate w. Profit maximization implies that the ratio of the wage and the sector price is equal to the marginal productivity of labor:

$$\frac{w}{p_i} = F_H(H_i). \tag{4.2}$$

Lemma 1 (see mathematical appendix), shows that the marginal rate of transformation (MRT) between the two sectors is increasing (i.e. the production possibilities frontier (PPF) between the two sectors is concave). Since markets are competitive, this is akin to saying that:

$$\frac{p_i}{p_j} = \frac{F_{j,H}(H_j)}{F_{i,H}(H_i)} = \frac{F_{j,H}(F_j^{-1}(Y_j))}{F_{i,H}(F_i^{-1}(Y_i))} \tag{4.3}$$

is sloping upward in $\left(\frac{Y_i}{Y_j}, \frac{p_i}{p_j}\right)$ space over some range Y. Intuitively, in the <u>short-term</u> firms, can expand only by changing their labor input. If one sector expands relative to the other, they must expand by increasing their relative share of labor, which increases their relative marginal cost. An example of this type of production function pair would be $F_i(H_i) = A_i H_i^{\alpha}$ where $\alpha \in (0,1)$ and is common across sectors. If both sectors have linear production over labor, then the relative marginal cost curve would be flat. An increasing marginal product of labor would lead to a downward-sloping curve.[16]

[16] If sectors each have production over labor, but not of the same curvature (i.e. it violates the assumption of production being homogeneous of degree $k \in (0,1)$ for each sector) then the relative supply curve is not necessarily upward sloping across the domain. For example, suppose that both sectors decrease production, but one sector j decreases production more. Sector j will shrink relative to the other sector, but the actual change in relative marginal costs will depend on the size of the decrease in average production versus the relative decrease in production in sector j.

4.2 Households and Intratemporal Substitution

The representative household is given an exogenous endowment of expenditure, X. They have non-homothetic preferences over consumption in the necessity and luxury sectors $U(c_N, c_L)$ such that for prices p_N, p_L and nominal expenditure X over some interval around X, the ordinary demand of the luxury good $C^L(\cdot)$ increases in relation to that of the necessity good with an increase in X:

$$\frac{\partial}{\partial X}\frac{C^L(X, p_N, p_L)}{C^N(X, p_N, p_L)} > 0. \tag{4.4}$$

Since we have only two goods, this equation implies that when X increases, the share spent on the necessity good s_N decreases.

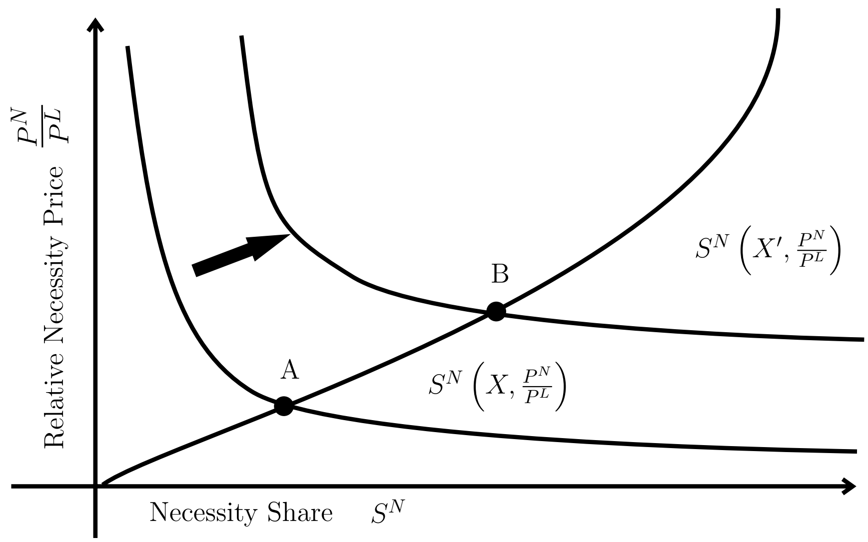
Figure 4 shows a representation of how the relative marginal cost curves (relative supply) and relative demand could look in $(s_N, \frac{p_N}{p_L})$ space. The relative supply curve slopes upward because of the homogeneous production of degree $k \in (0,1)$ in each sector. The relative demand curve can slope upward or downward (as pictured, the downward sloping relative demand implies that the goods are gross substitutes). If there is a decrease in expenditure X, then relative demand for necessities will rise, and the relative demand curve will shift to the right. Equilibrium necessity expenditure share and the relative price will both increase (as pictured, this is a move from point A to point B).

The intuition behind figure 4 is stated formally in the following proposition (the proof is included in the mathematical appendix). [17]

Proposition 1 *In a two-sector competitive economy with a representative household that has preferences satisfying equation* (4.4)*, production function in each sector* $F_i(H_i) : [0,\infty) \to [0,\infty)$ *both homogeneous of degree* $k \in (0,1)$ *and standard market clearing conditions, then an decrease/increase in household expenditure will lead to an increase/decrease in the relative price of necessities.*

[17] In the proposition, the representative household is assumed to have non-homothetic consumption preferences. However, this is not always the same assumption as the micro-level households having non-homothetic consumption preferences. I discuss this issue in more detail in the mathematical appendix.

Figure 4: Relative supply and relative demand



5 Empirical Strategy

The empirical approach centers around (1) testing how the aggregate relative demand curve shifts in response to a macroeconomic shock and (2) measuring the slope of the relative marginal cost curve. These two questions are directly related to the assumption that the representative consumer has non-homothetic preferences and that the relative supply curve is upward sloping. In order to address both of these questions, I need a macroeconomic shock that will shift *only* the relative demand curve and leave the relative supply curve unchanged. This is important as any shock that directly affects the slope/position of the relative supply curve will obscure efforts to test its slope.

I use monetary policy shocks to test the non-homotheticity of aggregate demand and the corresponding effect on relative prices. Interest rate shocks are typically treated as demand rather than supply shocks, as they directly affect households expenditure and savings, but not relative costs across sectors.[18] I address potential violations of this assumption by also conditioning on the interest rate semi-elasticites of durables, services, and products directly related to oil (energy and transportation).

[18]In the textbook New Keynesian model, the interest rate appears only in the household side of the model and operates through the Euler Equation (Galí 2015). This simple New Keynesian model does ignore the potential cost channel of monetary policy discussed in Barth III and Ramey (2001) and others.

Since central banks respond to macroeconomic events, making interest rate changes endogenous, there is a large literature using monetary policy news as an external shock on interest rates (Gürkaynak et al. 2004, Swanson 2021, Bauer and Swanson 2022a). As a proxy for a monetary policy shock, I use the estimated monetary policy news shock from Bauer and Swanson (2022b)[19]. This news shock is computed by looking at the change in a variety of asset prices in a 30-minute window around each Federal Open Market Committee (FOMC) meeting and Fed Chair speech from 1988 to 2019 [20]. I use the version of Bauer and Swanson's shock that is orthogonal with respect to macroeconomic news. [21]

In order to test the differential response of interest changes on necessity and luxury product shares and prices, I estimate a local projection of the dependent variable (x_j) on the interaction between the monetary policy shock and the product's expenditure ratio (Jordà 2005):

$$x_{j,t+h} = \sum_{k=0}^{12} \left[\sum_{y \in \{s_j, p_j\}} \left(\beta_j^k y_{j,t-k} \right) + \boldsymbol{\gamma^h} i_{t-k} \times R_j + \sum_{S \in type} \left(\delta_n^h i_{t-k} \times 1(S_j) \right) \right] + \alpha_{j,t+h}. \quad (5.1)$$

In the above equation, the dependent variable ($x_{j,t+h}$) is either the log-aggregate share of product j at time $t+h$ or the log-price. The coefficient of interest γ^h (the coefficient of the interaction of the monetary policy shock i_t and expenditure ratio R_J) is the differential response of sector shares/prices based on expenditure ratio, which corresponds to the Blinder-Oaxaca extension to the local projection framework discussed in Cloyne et al. (2020). In each regression, I include a year of lags of both dependent variable, $\sum_{k=0}^{12} \sum_{y \in \{s_j, p_j\}} \left(\beta_j^k y_{j,t-k} \right)$. I also include time fixed effects, δ_t, which absorb the direct effect of monetary policy on shares/prices, as well as any other macroeconomic events occurring at time t. I also include product fixed effects, ψ_j, which control for the average level of share/prices for product j.

The main identifying assumption is that monetary shocks affect product prices differently only to the extent that they shift demand through non-homothetic preferences. However,

[19] See also Swanson and Jayawickrema (2022).

[20] An earlier version of this paper used the monetary policy shocks from Swanson (2021), which only included events around FOMC meetings. Results were similar, but less precise than depicted here.

[21] Bauer and Swanson (2022b) use the first principle component of changes in this vector of asset prices, which corresponds to a change in the interest rate (rather than changes to forward guidance or Quantitative Easing). They then regress this shock on a vector of macro news variables known to traders before the FOMC announcement.

demand for durables can be more sensitive to interest rate changes than for non-durables (McKay and Wieland 2021, Barsky et al. 2007), services tend to have stickier prices (Nakamura and Steinsson 2008), and the central bank can react to oil shocks directly. To control for these confounding factors, I also include interactions between the monetary policy shock and dummies for whether the product is a durable, a service, or in the energy or transportation sector (S_j). I include a year of lags of all monetary policy shock interactions to account for serial correlation of the monetary policy shocks (Ramey 2016).

If aggregate demand responds non-homothetically to monetary policy shocks, then I would expect γ^h to be positive when the dependent variable is the log-share. A positive coefficient means that products bought more by poor households (the expenditure ratio R_j is higher) increase in price following a contractionary monetary policy shock compared with other products (which the model in the previous section predicts). Furthermore, an upward sloping relative supply curve implies that γ^h in the price regression should have the same sign as γ^h in the demand regression. If γ^h is positive when the dependent variable is log-share, this implies that demand shifts towards necessities (away from luxuries) after a contractionary monetary policy shock and an upward sloping relative supply curve require γ^h to also be positive in the price-regression.

In the model presented in the preceding section, a fall in expenditure causes households to shift their demand to necessities because non-homothetic preferences. Accordingly, I test directly how the monetary news shocks affect aggregate expenditure using a simple local projection of log-real PCE on the monetary policy shock (Jordà 2005). I follow Ramey (2016) and include lags of the monetary instrument and lags of the dependent variable. I also include lags of the price level (CPI), one-year Treasury yield, and the unemployment rate (Leahy and Thapar 2019).

All regressions use standard errors that are clustered at the time level and are robust to serial correlation.[22] Results are scaled so that a one-unit monetary shock corresponds to a 25-basis point increase in the one-year Treasury bill. For the regressions with log-price as the dependent variable, I use a balanced sample of 60 sectors that have price data available

[22]Standard errors are similar when using heteroskedasticity-consistent robust standard errors that are not robust to auto-correlation (Herbst and Johannsen 2021, Montiel Olea and Plagborg-Møller 2021).

for the entire 1991-2021 period. Finally, regressions are weighted by the pooled aggregate share of sector j in consumer spending.

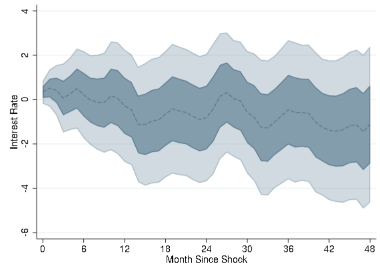
5.1 Results

Figure 5 shows the impulse response functions (IRFs) estimated following equation (5.1). Panel (a) shows the response of the One-Year Treasury yield to the monetary policy news proxy. This result was scaled so that on impact, the one-year Treasury yield increases by 25 basis points. Panel (b) shows the response of log-real consumption; consumption falls by approximately 2 percent two to three years following the monetary shock. Panel (c) shows that aggregate expenditure shifts towards necessity products following a contractionary monetary shock. The IRF peaks at around 0.2 following the shock, which means that products with an expenditure ratio of 1-point higher than average increase their aggregate share by approximately 20-percent relative to other products. Finally, panel (d) shows how the relative price of necessity goods increases following the monetary contraction. A product with expenditure ratio 1 point higher than average increases in price by around 10-percent, compared to other products, two years following the shock.[23]

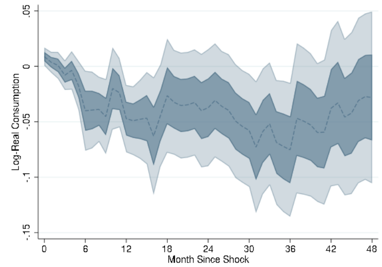
The empirical results provide evidence for the mechanism presented in the static model. Following shocks that lower aggregate expenditure, aggregate spending shifts towards necessities raising their relative prices. Robustness tests in the appendix, figure figure A8, show that this conclusion holds when excluding data after the beginning of the Great Recession and the Zero-Lower-Bound period (pre-2008), using a non-balanced sample of products, and estimating the IRFs without sector expenditure weights. Furthermore, using a binary definition of necessity rather than the continuous expenditure ratio measure R_j in equation equation (5.1) leads to broadly similar results (figure figure A9). Finally, results in the appendix show that relative necessity real expenditure also increases following a contractionary monetary shock.

[23]In the appendix, figure figure A9, I show that replacing R_j in equation equation (5.1) with a simple binary variable equal to one for necessities leads to similar results. A monetary shock leading to a 25-basis point increase in the 1-year Treasury yield leads to a 15 percent increase in necessity relative shares and a 5 percent increase in necessity relative prices two-years following the shock.

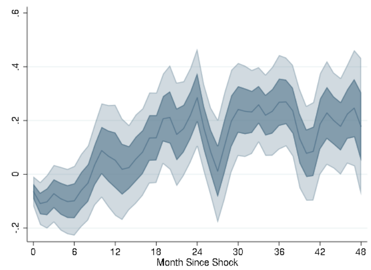
Figure 5: IRFs: Response to Monetary Policy Shock



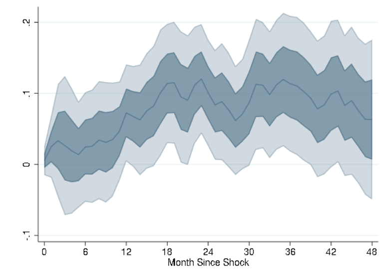
a) One-Year Treasury Yield



b) Log-Real Consumption



c) Log-Necessity Share



d) Relative Log-Necessity Price

Note: Monetary shock data from 1991-2019. Price and Share data from 1991-2021. Estimated coefficients, γ^h from Local Projections in equation (5.1). The unit of observation is the month in panels a) and b), and the sector-month in c) and d). Robust standard errors are shown by one- and two- standard error confidence bands indicated by the dark and light shaded areas respectively. Standard errors are robust to auto-correlation and are clustered at the monthly level for panels c) and d). Sectors weighted by their share in pooled aggregate expenditure. Monetary Policy shock normalized to 25-basis point increase in 1-year treasury in month $t = 0$. Figure d) uses a balanced sample of 60 sectors with price data available for the entire period.

6 New Keynesian Model with Non-homothetic Consumption Preferences

I have already formally presented the cyclical demand shift mechanism and shown that this mechanism is qualitatively consistent with the empirical results. This section shows that the theoretical results also quantitatively match the cyclical behavior of necessity prices and aggregate shares in the data. I include non-homothetic consumption preferences in a two-sector New Keynesian model with sticky wages and calibrate this model to the U.S. economy in 2005-06. I then use the model to examine the welfare consequences of the cost-of-living channel of recessions for low- and high-income households.

6.1 Households

6.1.1 Intratemporal Consumption Choice: The Almost Ideal Demand System

Household preferences follow the Almost Ideal Demand System (AIDS) first introduced by Deaton and Muellbauer (1980). I choose the AIDS for two reasons. First, the model relies on aggregate demand shifts, and since the AIDS is a form of PIG-Log (Price Invariant Generalized Logarithmic) preferences, they are within the Generalized Linear class of preferences and can be aggregated (Muellbauer 1975). Aggregation is a clear advantage over other types of non-homothetic demand systems, such as the non-homothetic CES (constant elasticity of substitution) system presented in Comin et al. (2021). AIDS aggregation properties allow me to estimate aggregate parameters using micro-data since the parameters for the representative and micro-level households are the same. The second reason, is that the AIDS was originally designed to be extremely flexible; in fact, it is a first-order approximation to any demand system (Deaton and Muellbauer 1980).[24]

The functional form for the household level indirect utility function is

$$V(X^h, \mathbf{p}) = \left(\frac{X}{a(\mathbf{p})}\right)^{1/b(\mathbf{p})}, \tag{6.1}$$

where $a(\mathbf{p})$ and $b(\mathbf{p})$ are price aggregators over a vector of sector level prices $\mathbf{p}$ defined by:

$$log(a(\mathbf{p})) = a_0 + \sum_k a_k \log(p_k) + \frac{1}{2}\sum_j \sum_k \gamma_{jk} \log(p_j) \log(p_k) \tag{6.2}$$

$$\log(b(\mathbf{p})) = \sum_j \beta_j \log(p_j) \tag{6.3}$$

where γ_{jk} are cross-price semi-elasticities and β_j are expenditure semi-elasticites. Parameters have the following restrictions: $\sum_{j=1}^N a_j = 1, \sum_{j=1}^N \beta_j = \sum_{j=1}^N \gamma_{jk} = 0$ and $\gamma ij = \gamma ji \; \forall i, j$.

The indirect utility function equation (6.1) has a corresponding cost function:[25]

$$\log c(u_h^0, \mathbf{p}) = log(a(\mathbf{p})) + (b(\mathbf{p})) \log(u_h). \tag{6.4}$$

[24] A disadvantage is that the AIDS is not generally regular. There are levels of expenditure and prices for which the AIDS is not a valid utility function. However, this is not an issue for the calibration and expenditure levels that I study.

[25] This functional form differs from the cost function in Deaton and Muellbauer (1980) because of a slight change in the definition of b(p). If written out entirely, the two cost functions are identical

The cost function shows that households must pay some cost for subsistence level consumption $\log(a(\mathbf{p}))$, where $a(\mathbf{p})$ is a homothetic translog price aggregator. The second aggregator, $b(\mathbf{p})$ introduces non-homotheticities into the cost-function. A household's cost to reach a higher level of utility (expenditure) increases with $b(\mathbf{p})$. This specification allows me to construct the theoretically consistent non-homothetic price index for a household with fixed utility u_h:

$$\log P\left(\mathbf{p}^1, \mathbf{p}^0, u_h^0\right) = \log\left(\frac{a(\mathbf{p}^1)}{a(\mathbf{p}^0)}\right) + \log\left(u_h^{b(\mathbf{p}^1)-b(\mathbf{p}^0)}\right) \tag{6.5}$$

The greater the household's utility (expenditure) x^h, the higher is the welfare gain from reductions in $b(\mathbf{p})$. Similarly, households with a low-expenditure level have changes in the cost of living closer to changes in the subsistence price index $a(\mathbf{p})$.

Roy's identity applied to equation (6.1) yields the following Marshallian demand share for products in sector j:

$$s_j = a_j + \sum_k \gamma_{jk} \log(p_k) + \beta_j \left(\frac{x^h}{a(\mathbf{p})}\right). \tag{6.6}$$

A household's share of expenditure on a particular product j is dependent on prices and real expenditure level. The demand share increases with real expenditure if $\beta_j > 0$ (luxuries). The households expenditure elasticity for good j is $1 + \frac{\beta_j}{s_j}$, while the cross price elasticity is $\delta_{jk} + \frac{\gamma_{jk} - \beta_j(\alpha_j + \sum_k \gamma_{jk}\log(p_k))}{s_j}$ where δ_{jk} is the Kronecker delta term.

Household intratemporal aggregate demand can be represented completely by a representative household. However, unlike homothetic preferences, the representative consumer does not have an expenditure level equal to the aggregate household. In the non-homothetic case, the representative consumer's expenditure level must increase with the level of expenditure inequality in the economy. A less equal distribution of expenditure means that high-expenditure households command a larger portion of aggregate spending, which means that the aggregate share spent on luxuries is higher than in an otherwise equivalent economy with lower expenditure inequality. A collection of households with PIG-Log preferences can be represented by a household with income $X^r = X^{mean} exp\left(\sum \frac{x^h}{X^{mean}} \ln\left(\frac{x^h}{X^{mean}}\right)\right)$ where the term on the right $\left(\sum \frac{x^h}{X^{mean}} \ln\left(\frac{x^h}{X^{mean}}\right)\right)$ is the Theil index of the expenditure distribution, which increases with expenditure inequality Muellbauer (1975), Deaton and Muellbauer

(1980).

6.1.2 Intertemporal Consumption Choice and Labor Supply

Each household chooses consumption expenditures to maximize their sum of discounted indirect utility over time:

$$\mathbb{E}_0 \sum_{t=0} \beta^t \left[F\left(V(X_t^h, \mathbf{p}_t) \right) - g(H_t^h) \right], \tag{6.7}$$

where $g()$ is the disutility of labor and H is hours worked. $F(\cdot)$ is taken to be the isoelastic utility function:

$$F\left(y\right) = \frac{y^{1-\eta} - 1}{1 - \eta}.$$

One feature of isoelastic preferences is, the elasticity of intertemporal substitution is generally constant. However, that is not the case in this model. Following Browning (2005), I define the elasticity of intertemporal substitution as:

$$EIS = -\frac{\nu_x(X_t, \mathbf{p}_t)}{X_t \nu_{xx}(X_t, \mathbf{p}_t)},$$

where $\nu(X_t, \mathbf{p}_t) = F\left(V(X_t^h, \mathbf{p}_t)\right)$. So in this model the elasticity of intertemporal substitution is $-\frac{b(\mathbf{p}_t)}{1-\eta-b(\mathbf{p}_t)}$, which varies with the level of relative prices in the economy (Crossley and Low 2011, Attanasio and Weber 1995). When relative prices for luxuries are higher, this increases the concavity of the indirect utility function making further increases in utility more difficult, which raises the elasticity of intertemporal substitution.

One important thing to note is, while the elasticity of intertemporal substitution is dependent on relative prices, it does not depend on the household's income or expenditure level. The household's disutility of labor also does not depend on household expenditure or income (in this model). So, household intertemporal and labor supply decisions can also be characterized by a representative household. [26] In practice, I solve for equilibrium prices and

[26] While there has been extensive work showing that households intertemporal responses vary based on income level (see Kaplan, Moll, Violante (2018) for an example), heterogeneous intertemporal responses is

aggregate shares using the representative household. I can then back out household level price indices given aggregate prices. This approach has the advantage of being able to study welfare effects with heterogeneous consumption bundles using the large toolbox of solution methods for representative agent models.

The representative household works for wages W_t and can invest in a one-period nominally riskless bond B_t that pays one monetary unit in the next period at price Q_t. The resulting household budget constraint and the no-Ponzi scheme condition are shown below:

$$\begin{gathered} X_t + Z_t Q_t B_t \leq B_{t-1} + W_t H_t + D_t \\ \lim_{T\to\infty} \mathbb{E}_t \left(\Lambda_{t,T} B_t\right) \geq 0. \end{gathered} \tag{6.8}$$

In the above expression, D_t is a dividend from firm profits and $\Lambda_{t,T} = \beta^{T-t}\frac{V_{X,T}}{V_{X,t}}$ where β is the discount factor. Z_t, is an interest rate wedge shock that is distributed $i.i.d$ and acts to dampen or increase a household's per-period expenditure.

The household's optimization problem and budget constraint yield the following Euler Equation:

$$Q = \beta\mathbb{E}\left[\frac{a(\mathbf{p})b(\mathbf{p})}{a(\mathbf{p'})b(\mathbf{p'})}\frac{\left(\frac{X'}{a(\mathbf{p'})}\right)^{\frac{1-\eta}{b(\mathbf{p'})}-1}}{\left(\frac{X}{a(\mathbf{p})}\right)^{\frac{1-\eta}{b(\mathbf{p})}-1}}\frac{1}{Z}\right]. \tag{6.9}$$

I assume that the disutilty of labor takes the familiar form (with ϕ the inverse of the Frisch elasticity of labor supply):

$$g(H_t) = \varphi\frac{H_t^{1+\phi}}{1+\phi}. \tag{6.10}$$

However, households do not decide how much labor to provide. Rather, they allow a labor union to bundle and sell their labor, which introduces sticky wages and nominal rigidity (see Erceg et al. (2000), Auclert et al. (2018), Auclert et al. (2020), Broer et al. (2020), Ramey

not the key feature of this paper. Some macroeconomic policies such as the 2020 and 2021 stimulus checks could have first-order effects on relative prices, as only low to moderate-income individuals were given checks. If low-income household expenditure increases sufficiently after such a policy then the Theil Index could rise enough to partially offset aggregate increases in expenditure.

(2020)). The mathematical appendix shows that the Wage-Phillips curve is:

$$
\begin{aligned}
(1+\pi_t^w)\pi_t^w =& \beta\mathbb{E}_t\left[(1+\pi_{t+1}^w)\pi_{t+1}^w\right] \\
&+\left(\frac{\epsilon_w}{\psi_w}\right)\left(\varphi H_t^{\phi}-\left(\frac{\epsilon_w-1}{\epsilon_w}\right)\frac{W_t}{a(\mathbf{p}_t)b(\mathbf{p}_t)}\left(\frac{X_t}{a(\mathbf{p}_t)}\right)^{(\frac{1-\eta}{b(\mathbf{p}_t)})-1)}\right)
\end{aligned}
\tag{6.11}
$$

6.2 Firms

There is a necessity and a luxury sector. Each sector has flexible prices and perfect competition. Firms have concave production over labor; they can scale up labor in the short run, but other factors of production are constrained. The production function for the representative firm in sector i is:

$$Y_t(i) = A_{it}H_t(i)^{(1-\alpha)} \ \alpha \in (0,1). \tag{6.12}$$

Firms sell their good for price $p_t(i)$ in a competitive market. Firms take prices and wages as given. Firm optimization implies that

$$p_t(i) = \frac{W_t}{(1-\alpha)\,A_{it}H_t(i)^{\alpha}}. \tag{6.13}$$

This equation yields a relative supply curve, that is upward sloping:

$$\frac{p_t(i)}{p_t(j)} = \frac{A_{jt}H_t(j)^{\alpha}}{A_{it}H_t(i)^{\alpha}}. \tag{6.14}$$

The elasticity of marginal cost to an increase in output, which governs the slope of the relative supply curve, is $\frac{\alpha}{1-\alpha}$.

6.3 Equilibrium

An equilibrium for this model is defined as a series of prices $\{W_t, \mathbf{p}_t\}$ and quantities $\{Y_{N,t}, Y_{L,t}, H_t,$ $\mathbf{h}_{j,t}, X_t, D_t, \mathbf{s}_{j,t}\}$ such that households optimize intertemporally and intratemporally given prices, the union chooses labor to maximize household utility, firms maximize profits given prices, and markets clear.[27]

[27]There is also a central bank that uses a Taylor rule to set interest rates:

$$-\log(Q_t) = i_t = F(\pi_t^w) \tag{6.15}$$

6.4 Calibration

The two most important parameters for the model are (1) $\beta_L = -\beta_N$ the degree of non-homotheticity, and (2) α, which is one minus the labor share. The first is important since it governs the degree to which representative household spending shifts between sectors over the course of the business cycle. For example, a value of $\beta_L = -\beta_N = 0$ would imply that the household has homothetic preferences, and macroeconomic shocks would not affect the relative demand for necessities or luxuries. The second, α, controls the price response of the expanding sector.

In the baseline calibration, I choose β_L so that the steady-state necessity share for low- and high-income households in the model matches that for low- and high-income households in the data. In an alternative calibration, I estimate β_L and the other (AIDs) parameters directly from the microdata; the results of this alternative calibration are in the appendix.

Table 5: Baseline Calibration

Parameter	Desc.	Value	Source
α	Capital share	0.26	(Midpoint Fernald (2014) and Feenstra and Weinstein (2017))
β	Discount rate	.99	
$1/\eta$	EIS at steady state	0.5	
ϕ	Inverse Frisch elasticity	1	
ψ_w	Wage adjustment penalty	20.7	(Wage Phillips Slope 0.29 Galí and Gambetti (2019))
ϵ_w	Substitutability of labor	6	(Colciago 2011)
β_L	Degree of non-homotheticity	0.29	(Target High- and Low- income steady state necessity shares)
γ_{LN}	Cross-price semi-elasticity	0.95	(Feenstra and Weinstein 2017)
α_N		2.9	(Target necessity share 0.53)

There are a variety of estimates of α, the capital share, in the literature. These can range from as low as 0.16, the implied value based on the estimated elasticity of marginal cost to quantity produced from Feenstra and Weinstein (2017), to as high as 0.37 estimated directly in Fernald (2014). For the baseline specification, I choose α as the midpoint of these

where $F(\cdot)$ is increasing in wage inflation.

extreme values ($\alpha = 0.26$). Alternate calibrations with other values of α are included in the appendix.

The remaining parameters I take either from the literature, or from targeting the steady-state expenditure and necessity share of the representative agent to match representative expenditure and aggregate necessity shares in the period immediately preceding the Great Recession (2005-2006).[28] I target the calibration, so that in the steady-state necessity and luxury prices are equal (which means that the Elasticity of intertemporal substitution is equal to $1/\eta$). Table 5 shows the chosen calibration.

6.5 Results

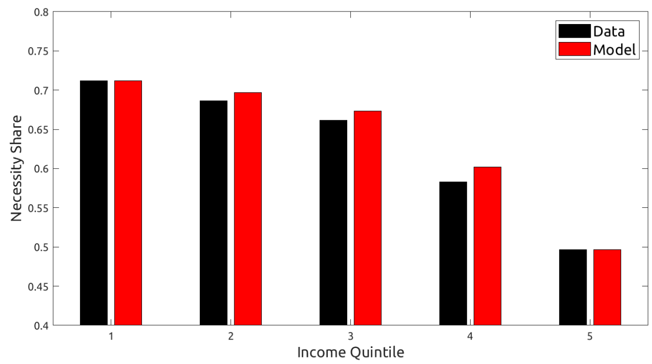
How well can the calibrated model explain the distribution of household consumption and historical changes in necessity shares and prices? I start by comparing the steady-state necessity shares in the model with those in the data. While I targeted the aggregate steady-state share of necessities and those from the top and bottom income groups, the other income groups' necessity share was not targeted. Figure 6 shows the model implied necessity shares for the five different income groups alongside their actual values in the data (2005-06). In the data, low-income households spend around 70 percent of their budget on necessities compared with around 50 percent for high-income households, which by design, the model matches exactly. The model also matches the necessity shares for the non-targeted income groups within 2 percentage points.

6.5.1 Historical Simulation

How well does the model predict necessity prices and shares over time? As a validation exercise, I shock the model with a series of i.i.d. interest wedge shocks so that the expenditure series in the model exactly matches the filtered real personal consumption series from the Bureau of Economic Analysis. I then compare the necessity share and price series in the simulated model with their filtered counterparts in the data. Figure 7 shows the results of this simulation. The data series of prices and shares excludes the volatile energy and

[28] Representative expenditure in the data is average expenditure multiplied by the calculated Theil index.

Figure 6: Model and Data: Necessity Shares by Income Group



Note: Data from 2005 to 2006. Model income-group shares at steady state. Author targeted calibration so model necessity shares for the top and bottom income quintiles would match empirical necessity shares. Necessity shares for the middle income quintiles are untargeted.

transportation sectors.

The top panel shows the path of both model and data expenditure from 1994 to 2021. The second panel shows the untargeted model necessity share series compared to the data.[29] Similar to the data, the model necessity share series falls during the late 1990s, rises around the 2001 recession, falls again during the housing boom, increases drastically during the Great Recession, falls again in the subsequent recovery and then rises during the COVID-19 pandemic. The time series in the model and data are highly correlated (0.55), and a simple regression of the data series on the model series yields a coefficient of 0.6.

The bottom panel compares relative necessity prices in the data with the cyclical component of the composite necessity price in the data. I use a balanced sample of products with continuous price data from 1987-2021 (this is the red series in figure 3). The data and the model series match each other quite closely, however the model overstates the fall in necessity prices during the dot-com boom (late 1990s) and the rise in necessity prices during the COVID-19 recession. A simple regression of the data series on the model series yields a coefficient of 0.54.[30] I conclude that the model is highly effective at predicting the cyclical path of relative necessity shares and prices.

[29]The expenditure share series begins in 1991, but filtering necessitates dropping the first few years of data.

[30]The correlation coefficient is 0.44.

6.5.2 Welfare Implications

What are the welfare implications of this model? In this model, the expenditure inequality of households is fixed at the steady-state level. However, households price indices can diverge since low-expenditure households spend more of their budget in the necessity sector. How much can this divergence matter? Table 6 shows the difference in the non-homothetic price index (equation (6.5)) between households with expenditure matching expenditure in the bottom income quintile compared with households with expenditure matching expenditure in the top income quintile. During the Great Recession, the price index of poor households increased by 0.85 percent more than rich households. This result closely matches the difference in the change in core inflation in the data over this same period (0.86 see figure A1). Failing to incorporate changes in the price index could lead to large underestimates of the change in consumption inequality over the Great Recession. For example, Krueger et al. (2016) use the Panel Study of Income Dynamics and find that household consumption in the first wealth quintile fell by approximately 0.3 percent more than consumption in the highest quintile from 2006-2010. A back of the envelope calculation suggests that the change in real consumption is $\Delta \ln\left(\frac{c}{p}\right) = \Delta \ln(c) - \Delta \ln(p) = 0.0115$ or 1.15 percent, which is nearly a fourfold increase compared with Krueger et al. (2016).

While the model predicts that this price index gap will eventually close (as the model returns to steady-state), the price index of the lowest income quintile remains elevated during the slow recovery (GDP per-capita did not return to pre-Great Recession levels until 2013Q1). The average difference in the cost of living from the beginning of the great recession until GDP per capita recovered is 0.5 percentage points.

Next, I calculate the expenditure equivalent welfare loss of the Great Recession for a household in the lowest income group and the highest. This measure is the present discounted value of all future expenditure streams that the household would relinquish in order to avoid the Great Recession:

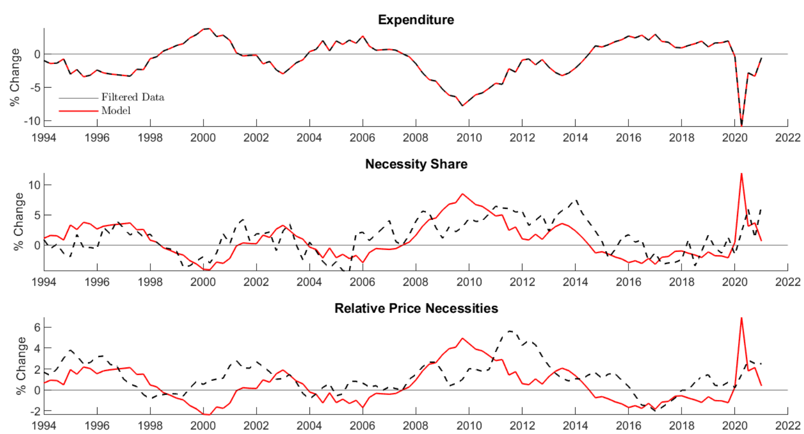
$$\mathbb{E}^{No\ Recession}\left[\sum_{t=0}^{\infty}\beta^t\left(V((1-\xi)X_{ht},\mathbf{p}_t)-g(H_t)\right)\right]=\mathbb{E}^{Recession}\left[\sum_{t=0}^{\infty}\beta^t\left(V(X_{ht},\mathbf{p}_t)-g(H_t)\right)\right] \tag{6.16}$$

Table 6: Welfare Difference Low v. High Income Households

Panel A: Difference in Price Index		
Time Period	**End Period**	**Average**
Great Recession (2007Q3-2009Q2)	0.85	0.42
Recession to Recovery (2007Q3-2012Q4)	0.12	0.51
Panel B: Expenditure Equivalent Welfare Loss		
	Low Income	**High Income**
Expenditure Equivalent Welfare	0.59 %	0.48 %
Ratio		1.22

Note: Price index difference is defined as the percentage point difference in the change of the cost-of-living for Q1 versus Q5 households as calculated in the model. Expenditure equivalent welfare is the present discounted value of *all* future expenditure the household would be willing to forgo in exchange for avoiding recessionary shock.

Figure 7: Model v. Data: Historical Simulation



Note: Author targeted shock to match expenditure data (top panel). Necessity share and relative necessity price are untargeted. Data is filtered following Hamilton (2018) and excludes energy.

where ξ is the share of all future expenditure the household would relinquish so that the present discounted value of all future utility streams is equal in the counterfactual world where the Great Recession never happens. Table 6 shows that low-income households would be willing to give up 0.59% of all future expenditure, while high-income households would relinquish only 0.48%, a difference (as expressed by the ratio) of approximately 22%. A similar model where the level of non-homotheticity (β_L) is set to 0 results in no difference in welfare loss between low- and high-income households.

7 Conclusion

In this project, I present new evidence on the cyclical behavior of necessity and luxury prices. I create a new dataset combining dis-aggregated CPI price indices with micro-level CEX data, and I find that the prices and aggregate shares of products bought relatively more by low-income households are counter-cyclical. I show that these facts likely come via demand shifts by testing how aggregate necessity prices and shares respond to monetary policy shocks. I show that a model with non-homothetic preferences and an upward sloping relative supply curve can jointly reconcile these empirical facts. The calibrated model can explain around half of the cyclical variation of necessity prices and shares. I find that recessions can be more costly for low-income households as their price index increases relative to the price-index of other households.

It is important to note that this project studies changes in sector-level prices rather than prices within a sector; e.g. furniture is a category made up of many different micro-products each with their own quality and prices. This project also ignores product entry and exit, which could also affect income-level cost-of-living (Feenstra 1994). To the extent that cyclical demand shifts occur within product categories, causing price increases for low-quality products or changes in product variety (at the business cycle frequency) is a topic for future research.[31]

This study also has ramifications for the measurement of aggregate changes in the cost of living. For example, in the measurement of the CPI, the BLS uses the CEX to weigh product sectors so they are representative of spending by the average household. However, these weights are updated with a lag (two to four years). Since my study shows that *aggregate* spending shifts to necessities during recessions, that means that the CPI underweights necessities in recessions and overweights them during expansions. This result implies that measurement of inflation via the CPI is potentially biased downward during both recessions (when necessity prices are rising more rapidly) and expansions (when luxury prices are rising more rapidly).

[31] Jaimovich et al. (2019) show that household engage in quality downgrading within sectors during the Great Recession.

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A Mathematical Appendix

A.1 Proof of Proposition 1

Lemma 1 *If $F(H) : [0, \infty) \to [0, \infty)$ is homogeneous of degree $k \in (0, 1)$ then* $\frac{\partial \frac{F'(H_j)}{F'(H_i)}}{\partial \frac{F(H_i)}{F(H_j)}} > 0$.

First I show that a function that is homogeneous of degree $k \in (0, 1)$ is strictly increasing. Suppose $H_i > H_j$ then:

$$F(H_i) = H_i^k F(1) > H_j^k F(1) = F(H_j)$$

For notational convenience, let $Y_i := F(H_i)$. By Euler's Homogeneous Function Theorem, $F(H_i) = F'(H_i)H_i$, which implies that:

$$\begin{aligned}\frac{F'(H_j)}{F'(H_i)} &= \frac{Y_j}{Y_i}\left(\frac{H_i}{H_j}\right)\\ &= \frac{Y_j}{Y_i}\left(\frac{F^{-1}(Y_i)}{F^{-1}(Y_j)}\right),\end{aligned}$$

where the inverse function must exist since F is strictly increasing. Next, I take the derivative with respect to the output ratio:

$$\frac{\partial}{\partial \frac{F(H_i)}{F(H_j)}} \frac{F'(H_j)}{F'(H_i)} = \frac{Y_j}{Y_i} \frac{\partial}{\partial \frac{F(H_i)}{F(H_j)}} \left(\frac{F^{-1}(Y_i)}{F^{-1}(Y_j)}\right) - \frac{F^{-1}(Y_i)}{F^{-1}(Y_j)} \tag{A.1}$$

Since the inverse of a homogeneous function of degree k, is a homogeneous function of degree $1/k$ it follows that:

$$\frac{\partial}{\partial \frac{Y_i}{Y_j}} \left(\frac{F^{-1}(Y_i)}{F^{-1}(Y_j)} \right) = \frac{\partial}{\partial \frac{Y_i}{Y_j}} \left(\left(\frac{Y_i}{Y_j} \right)^{1/k} \frac{F^{-1}(1)}{F^{-1}(1)} \right) \tag{A.2}$$

$$= \frac{1}{k} \left(\frac{Y_i}{Y_j} \right)^{(1-k)/k}. \tag{A.3}$$

By substituting equation (A.3) into equation (A.1) I find that:

$$\frac{\partial}{\partial \frac{F(H_i)}{F(H_j)}} \frac{F'(H_j)}{F'(H_i)} = \frac{Y_j}{Y_i} \frac{1}{k} \left(\frac{Y_i}{Y_j} \right)^{(1-k)/k} - \left(\frac{Y_i}{Y_j} \right)^{1/k}$$

$$= \left(\frac{Y_i}{Y_j} \right)^{1/k} \left(\frac{1}{k} - 1 \right),$$

which is > 0 if and only if $k < 1$. ■

Corrollary 1 *If $F(H) : [0, \infty) \to [0, \infty)$ and $G(H) : [0, \infty) \to [0, \infty)$ are both homogeneous of degree $k \in (0, 1)$ then $\frac{\partial \frac{G'(H_j)}{F'(H_i)}}{\partial \frac{F(H_i)}{G(H_j)}} > 0$.*

This proof follows from the proof above, except replace $\frac{F^{-1}(1)}{F^{-1}(1)}$ in equation (A.2) with $\frac{F^{-1}(1)}{G^{-1}(1)}$, which implies that:

$$= \frac{F^{-1}(1)}{G^{-1}(1)} \left(\frac{Y_i}{Y_j} \right)^{1/k} \left(\frac{1}{k} - 1 \right),$$

■

Proposition 1 *In a two-sector competitive economy with a representative household that has preferences satisfying equation (4.4), production function in each sector $F_i(H_i) : [0, \infty) \to [0, \infty)$ both homogeneous of degree $k \in (0, 1)$ and standard market clearing conditions, then an decrease/increase in household expenditure will lead to an increase/decrease in the relative price of necessities.*

Due to market clearing, it follows that

$$C^i(X, p_N, p_L) = F_i(H_i) \ \forall i$$

From equation (4.4) we know that

$$\frac{\partial}{\partial X} \frac{C^L(X, p_N, p_L)}{C^N(X, p_N, p_L)} > 0.$$

This implies that:

$$\frac{\partial}{\partial X} \frac{F_L(H_L)}{F_N(H_N)} = \frac{\partial}{\partial X} \frac{Y_L}{Y_N} > 0. \tag{A.4}$$

Relative prices can be expressed as:

$$\frac{p_L}{p_N} = \frac{F_{N,H}(H_N)}{F_{L,H}(H_L)}$$

From lemma and corollary 1, we get that:

$$\frac{\partial}{\partial \frac{Y_L}{Y_N}} \frac{F_{N,H}(H_N)}{F_{L,H}(H_L)} > 0. \tag{A.5}$$

Combining equation (A.4) with equation (A.5) and the chain-rule implies that:

$$\frac{\partial}{\partial X} \frac{p_L}{p_N} > 0$$

So the price of the expanding sector (luxuries in this case) must increase. ■

A.2 A Note on Aggregation

In general, it is not true that if micro-households have non-homothetic preferences then the aggregate household will also have non-homothetic preferences of the same form. Very few types of non-homothetic preferences are Gorman-Polar (Stone-Geary is a notable exception), so these type of preferences cannot simply be added up across households to create an aggregate household with the same preference structure and parameters as the micro households (Muellbauer 1975).

Muellbauer (1975) shows that a necessary and sufficient condition for there to exist an income/expenditure level such that a representative household with that income/expenditure level to have preferences identical to the average of all households is that households must have Generalized Linear preferences. The expenditure/income of a slightly less general version of these preferences, Price Independent Generalized Linear is shown to depend positively on both aggregate income/expenditure and the inequality of the income/expenditure distribution. Intuitively, the reason is that in a more unequal economy, all else being equal, will have a higher portion of aggregate income/expenditure concentrated in a few hands, which means that more luxuries will be consumed. Hence, the representative household should have higher income/expenditure than those implied by the aggregate expenditure in the economy.

If the representative household proceeds to purchase relatively more necessity goods, then these purchases will cause necessity prices to increase. Since poorer households have lower expenditure than richer households, these households will have a larger percentage of their basket devoted to the necessity good. This increase in necessity prices will increase the low-income households price index relative to high-income households.

It has been documented that both recessions (Heathcote et al. 2020) and contractionary monetary policy (Coibion, Gorodnichenko, Kueng, Silvia 2018) increase inequality. Since demand for the necessity good depends on both aggregate expenditure (decreasing) and inequality (decreasing), a shock that simultaneously lowers aggregate expenditure and raises inequality would have ambiguous effects on relative necessity demand. To fix ideas, if representative expenditure x^r is a function $\mathrm{F}(\cdot)$ of aggregate expenditure $\bar{x}$ and expenditure inequality Σ_x then the elasticity of representative expenditure to a macroeconomic shock, $\mathcal{E}_{x^r,shock}$, would be:

$$\mathcal{E}_{x^r,shock} = \mathcal{E}_{x^r,\bar{x}}\mathcal{E}_{\bar{x},shock} + \mathcal{E}_{x^r,\Sigma_x}\mathcal{E}_{\Sigma_x,shock}. \tag{A.6}$$

In equation (A.6), the elasticity of representative expenditure to a shock depends on both the elasticity of aggregate expenditure to the shock and the elasticity of inequality to the shock, where each term is scaled by the elasticity of representative expenditure to either aggregate expenditure or inequality.[32] In the empirical section, I show that following a monetary policy shock the effect coming through aggregate expenditure dominates.

A.3 Derivation of Wage-Phillips Curve

I add sticky wages by following the convention in the literature and creating market power in the labor market via a labor union (see Erceg et. al. 2000, Auclert et. al. 2018, Auclert et. al. 2020, Broer et. al. 2020, Ramey 2020).

Specifically, each worker (i) in the economy provides h_{ikt} hours of labor to each of a continuum of unions indexed by $k \in (0,1)$. Total labor for person (i) is then:

$$h_{it} = \int_k h_{ikt} dk. \tag{A.7}$$

Each union k aggregates units of work into a union specific task $H_{kt} - \int_i h_{ikt} di$.

There is a competitive labor packer that takes labor from unions and packages it into one unit of "usable" labor following a CES function. Aggregate labor is then:

$$H_t = \left(\int_k H_{kt}^{\frac{\epsilon_w - 1}{\epsilon_w}} \right)^{\epsilon_w/(\epsilon_w - 1)}, \tag{A.8}$$

where ϵ_w is the elasticity of substitution between different types of labor.

Unions set a common wage w_{kt} for all members and require each member household to supply uniform hours: $h_{ikt} = H_{kt}$.

Following (Auclert et al. 2018,2020) I add an extra disutility term for households, so that households dislike adjusting wages:

[32] In the PIG-Log (AIDS) specification I adopt in the main text, the elasticity of x^r with respect to both aggregate expenditure and inequality (as measured by the Theil index) is one, so equation (A.6) reduces to just $\mathcal{E}_{\bar{x},shock} + \mathcal{E}_{\Sigma_x,shock}$. Coibion et al. (2017) finds that the elasticity of the standard deviation of expenditure increases by .03 four months after a one-standard deviation monetary policy shock, while consumption falls by approximately 0.5 percent. Given that the Theil coefficient for a log-normal distribution is $\sigma^2/2$ it follows that the aggregate expenditure elasticity dominates the inequality elasticity.

$$\frac{\psi_w}{2}\int_k (\frac{w_{kt}}{w_{kt-1}} - 1)^2 dk, \tag{A.9}$$

where ψ_w scales the degree of wage stickiness.

At time t, union k sets wage w_{kt} to maximize (on behalf of all union workers):

$$\max_{w_k t} \mathbb{E}_t \sum_{\tau>0} \beta^{t+\tau} \left(\int \left[V(X_{it+\tau}, \mathbf{p}_{t+\tau}) - g(h_{i,t+\tau}) \right] d\psi_{it+\tau} - \frac{\psi_w}{2}\int_k (\frac{w_{kt}}{w_{kt-1}} - 1)^2 dk \right)$$
$$s.t.\ H_{kt} = \left(\frac{w_{kt}}{W_t}\right)^{-\epsilon_w} H_t \tag{A.10}$$

The union takes as given the distribution ψ_{it} of workers (in this version of the model, all workers are identical) and all prices excluding w_{kt} (note that $W_t = \left(\int_k w_{kt}^{1-\epsilon_w} dk\right)^{1/(1-\epsilon_w)}$.)

The envelope theorem allows me to ignore both the intertemporal reoptimization of saving or spending in response to a marginal change in wages, along with the intratemporal reoptimization of spending across sectors. I treat any change in income as a change in consumption expenditure:

$$\begin{aligned}
\frac{\partial X_{it}}{\partial w_{kt}} &= \frac{\partial}{\partial w_{kt}} \int_0^1 w_{kt} h_{ikt} dk \\
&= \int_0^1 \frac{\partial}{\partial w_{kt}} w_{kt} \left(\frac{w_{kt}}{W_t}\right)^{-\epsilon_w} H_t dk \\
&= (1-\epsilon_w)\left(\frac{w_{kt}}{W_t}\right)^{-\epsilon_w}.
\end{aligned}$$

I next derive the change in hours worked to a change in wages for household (i) using the labor rule that $H_{kt} = h_{ikt} \forall i$ and the demand constraint:

$$\begin{aligned}
\frac{\partial h_{it}}{\partial w_{kt}} &= -\epsilon_w \left(\frac{w_{kt}^{-\epsilon_w - 1}}{W_t^{-\epsilon_w}}\right) \\
&= -\epsilon_w \frac{H_{kt}}{w_{kt}}.
\end{aligned}$$

It follows that the first order condition of the union's maximization problem equation (A.10) becomes:

$$\int H_{kt}\left[V_X(X_it,\mathbf{p}_t)(1-\epsilon_w)\left(\frac{w_{kt}}{W_t}\right)^{-\epsilon_w}+\frac{\epsilon_w}{w_{kt}}g'(h_{it})\right]d\psi_{it}-\psi_w\left(\frac{w_{kt}}{w_{kt-1}}-1\right)\frac{1}{w_{kt-1}}$$
$$+\beta\psi_w\mathbb{E}_t\left[\left(\frac{w_{k,t+1}}{w_{k,t}}-1\right)\left(\frac{w_{k_t+1}}{w_{kt}^2}\right)\right]=0.$$

This simplifies when we note that the maximization problem for all unions is identical, so in equilibrium $w_{kt}=w_t$. Denoting $\pi_t^w \equiv \left(\frac{w_t}{w_{t-1}}-1\right)$ and using the functional forms for $V[\cdot]$ and $g(\cdot)$ provided in section 6 yields:

$$\begin{aligned}\psi_w\pi_t^w(1+\pi_t^w) = &\beta\mathbb{E}_t\left(\psi_w\pi_{t+1}^w(1+\pi_{t+1}^w)\right)+\\ &H_t w_t\int\left[\frac{1}{a(\mathbf{p}_t)b(\mathbf{p}_t)}\left(\frac{X_t}{a(\mathbf{p}_t)}\right)^{((1-\eta)/b(\mathbf{p}_t))-1)}(1-\epsilon_w)+\frac{\epsilon_w}{W_t}\varphi H_{it}^{\phi}\right]d\psi_{it}.\end{aligned}$$

In the representative agent model that I am considering here, this further simplifies to:

$$\begin{aligned}(1+\pi_t^w)\pi_t^w = &\beta\mathbb{E}_t\left[(1+\pi_{t+1}^w)\pi_{t+1}^w\right]\\ &+\left(\frac{\epsilon_w}{\psi_w}\right)\left(\varphi H_t^{\phi}-\left(\frac{\epsilon_w-1}{\epsilon_w}\right)\frac{W_t}{a(\mathbf{p}_t)b(\mathbf{p}_t)}\left(\frac{X_t}{a(\mathbf{p}_t)}\right)^{((1-\eta)/b(\mathbf{p}_t))-1)}\right)\end{aligned} \tag{A.11}$$

It follows that the union will adjust wages in expectations of future wage inflation or when the marginal disutility of labor is higher than the product of marginal utility of expenditure and the optimal wage.

B Data Appendix

B.1 Cross-walk between CPI and CEX

The US Bureau of Labor Statistics (BLS) uses weights computed from the Consumer Expenditure Survey in calculating the official Consumer Price Index. In principle, this means that I could match each of the 243 item strata used to compute the CPI with corresponding consumption expenditures in the CEX. However, the BLS neither publishes the cross-walk between the CPI and the CEX, nor do they publish the price indices for each item strata. So, for this project I create my own cross-walk between the CEX and the publicly available price index series from the BLS. Given this crosswalk, I pull the CPI price series and the CEX data directly from the BLS website using their API.

I match expenditure in the CEX with prices in the CPI using the CEX UCC product hierarchy (available from the BLS) alongside the BLS CPI data finder. The goal is to create the most disaggregated product categories for which I have data in both the CPI and CEX. In general, the CEX has reported purchases at a more disaggregated level than the CPI. For example, the CPI price series "Women's suits and separates" matches with 5 different UCC codes (for 2019) in the CEX. I aggregate UCC codes from the CEX so they match the more aggregated CPI series. In the cases where the CPI data was more disaggregated, e.g., types of gasoline, I choose a more aggregate CPI series series–e.g.,gasoline. Where CPI series only exist for a subset of years, I choose the most disaggregated series available for which prices are available over the latter part of the sample (since 2007).

There are many UCC codes in the CEX that are only available for certain years. For example, Women's pants are available from (1990:Q2-2007:Q1). From, 2007-2019 Women's pants are included in the more aggregated category Women's pants and shorts. My final product categorization insures that the products represent the same breadth of spending in each year.

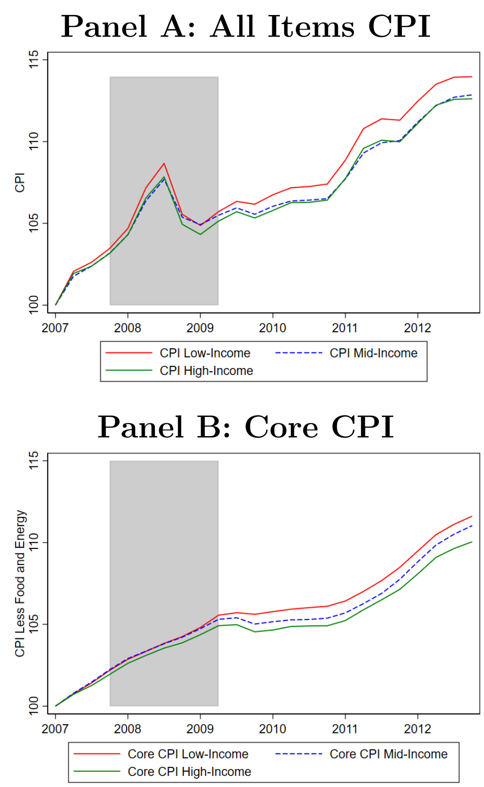
The complete cross-walk between the CEX UCC codes and the CPI price series is available from the author.

In addition to classifying products as necessities or luxuries, the crosswalk can also be used to construct income-level cost-of-living indexes. For example, figure A1 displays income level Laspeyres indices from 2007-2013:

$$P_t^I = \sum w_{Ij} p_{jt}$$

where the weights on each category for each income-group, w_{Ij} come from income level expenditure shares from 2005-06 in each of the 119 non-housing products in the crosswalk along with income level expenditure shares of rent and owners equivalent rent. The inflation gap in core-cpi from (2007:Q2-2009:Q3) between Low- and High-income households is 0.86 percentage points, almost exactly the 0.85 pp. gap over that same period in the model.

Figure A1: Income Level CPI's during the Great Recession and Slow Recovery



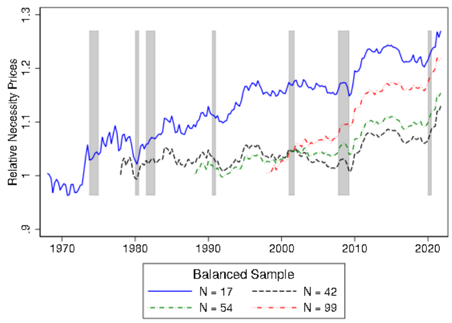
Source: Bureau of Labor Statistics and Author's own calculations.
Notes: NBER recession indicated by shaded area. Weights are democratic and based on 2005-06 consumption patterns. The base period is 2007Q1.

B.2 Necessity Relative Prices Over-time

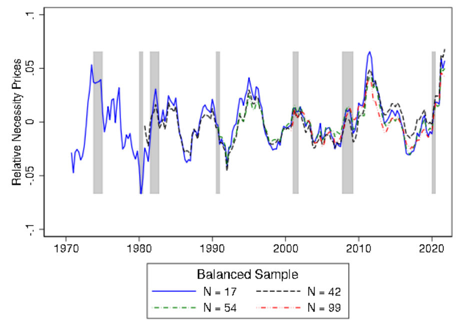
In this subsection, I present additional figures showing both the trend and cycle of necessity relative prices. In figure figure A2 Panel A I show both unfiltered and filtered versions of the series used in the main text (all prices excluding housing, energy, and transportation). Panel B, shows the same graph but removing durable goods. The left-side graph in each panel shows the unfiltered series with NBER recession dates shown in gray, while the right-side removes the trend component to produce a cyclical series following Hamilton (2018). There are very large differences between the balanced samples in the unfiltered series, but each of the filtered series closely track each other. Two patterns are apparent: (1) there is a large increase in the relative price of necessities during and around NBER recessions. This is most clearly seen in the filtered series, and is present in both the version including durables (panel A) and the version with only non-durables (panel B). The second pattern (2) is that there is an increase over time in the relative price of necessities, when including durables (similar to the results found by Jaravel (2019); however, there is a decrease overtime in relative necessity prices in the series including only non-durables. The discrepancy between the unfiltered series in panels A and B can partially be explained by durable goods such as electronics and new motor vehicles that are both classified as luxuries and have had extreme quality adjusted price reductions (e.g., the CPI for computers fell by 96 percent from 1997 to 2021). What is important for my purposes, is that the cyclical patterns present in relative necessity prices exist whether or not I consider durable goods prices. This fact is shown here in figure figure A2, or more convincingly in the main text where my regression results are virtually unchanged when conditioning on whether the product is a durable.

Figure A2: Time Series of Relative Necessity Prices

Panel A: Durables and Non-durables

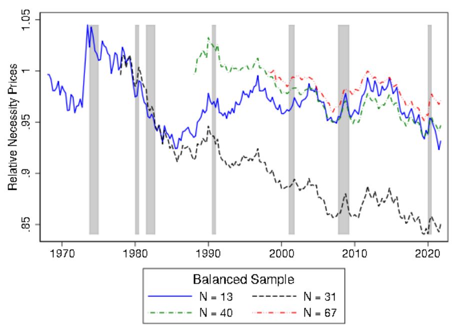


Unfiltered Series

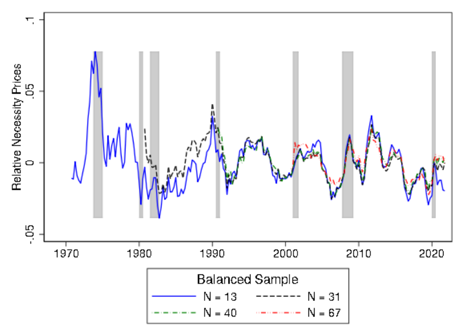


Filtered Series

Panel B: Non-durables



Unfiltered Series



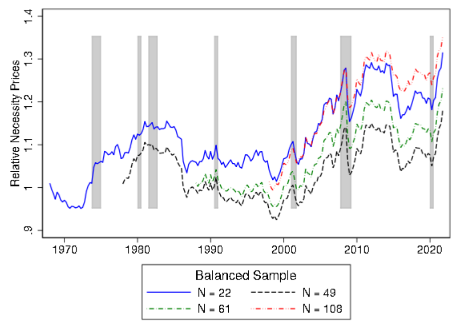
Filtered Series

Source: Bureau of Labor Statistics and Author's own calculations. Excludes rent, owners equivalent rent, and energy. Panel B also excludes durable purchases. Data filtered following Hamilton (2018). Shaded area indicates NBER Recessions.

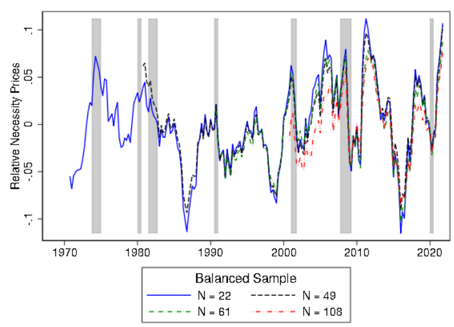
I also present alternative visualizations of necessity relative prices. Figure figure A3 presents relative necessity prices, but includes energy and transportation. Figure figure A4 varies the definition of necessity and luxury products by computing the expenditure ratio based on low-income and high-income expenditures in a particular decade (1990, 2000, or 2010) rather than pooling all expenditures directly.

Figure A3: Relative Necessity Prices including energy

Panel A: Unfiltered Series



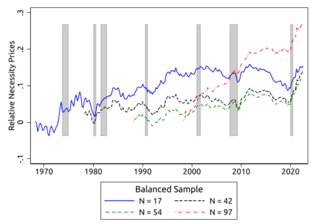
Panel B: Filtered Series



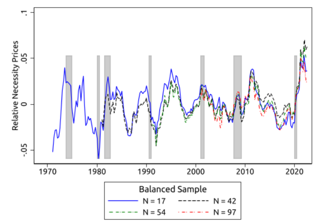
Source: Bureau of Labor Statistics and Author's own calculations. Excludes housing. Data filtered following Hamilton (2018). Shaded area indicates NBER Recessions.

Figure A4: Relative Necessity Prices: Alternate Definitions of Necessity

Panel A: 1991-1999 Consumption Patterns

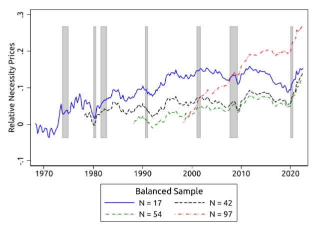


Unfiltered Series

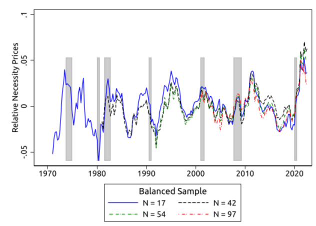


Filtered Series

Panel B: 2000-2009 Consumption Pattern

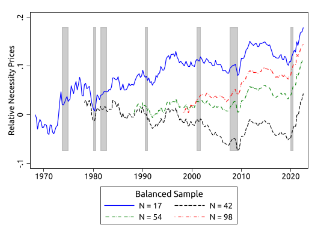


Unfiltered Series

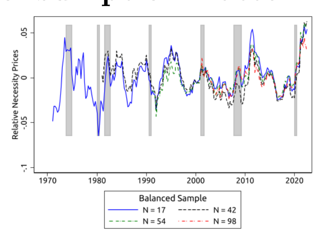


Filtered Series

Panel B: 2010-2019 Consumption Pattern



Unfiltered Series



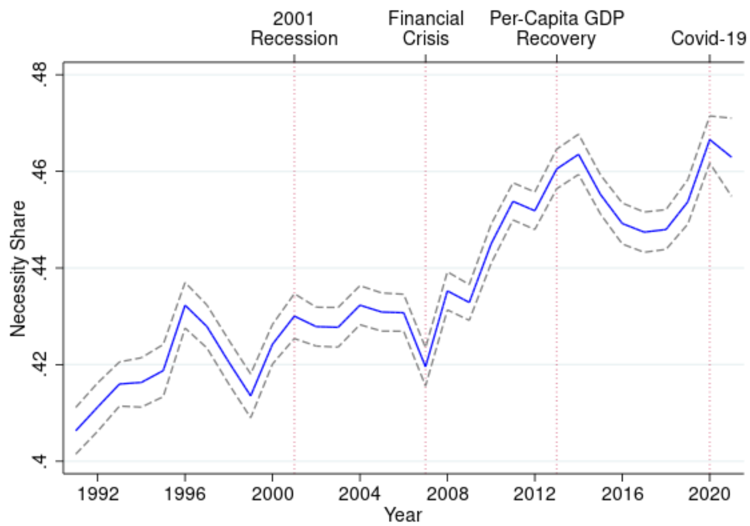
Filtered Series

Source: Bureau of Labor Statistics and Author's own calculations. Excludes housing and energy. Data filtered following Hamilton (2018). Shaded area indicates NBER Recessions. Defines necessity by using expenditures in a particular decade (1990s, 2000s, or 2010s) to compute the expenditure ratio, rather than expenditures over the entire sample.

B.3 Necessity Share: Non-durables

Figure figure A5 shows the necessity share of non-durable expenditure from 1991-2021.

Figure A5: Necessity Share: Non-durables



Source: Consumer Expenditure Survey, Personal Consumption Expenditures (BEA) and Author's own calculations. Excludes housing and durable consumer goods.

B.4 Expenditure Results Deflated by Sector Level Prices

In the main text, I present two main facts: (1) relative necessity shares are counter-cyclical and (2) relative necessity prices are counter-cyclical. An astute reader could worry that fact (2) could mechanically lead to fact (1). Namely, something increases relative necessity prices, which leads households to increase nominal necessity shares, to keep real sectoral expenditures constant. I present evidence, that the two facts are independent. In figure figure A5, I show that even when controlling for sector level prices, it is only luxury expenses that fell during the 2001 recession and the Great Recession, while necessity expenditures continued to rise. During the COVID-19 recession, real-expenditures fell for both necessities and luxuries, but they fell more for luxuries.

In table 7, I show estimates from equation (3.2) with real sectoral expenditure (sector expenditure divided by sector-specific CPI) as the dependent variable. These results are

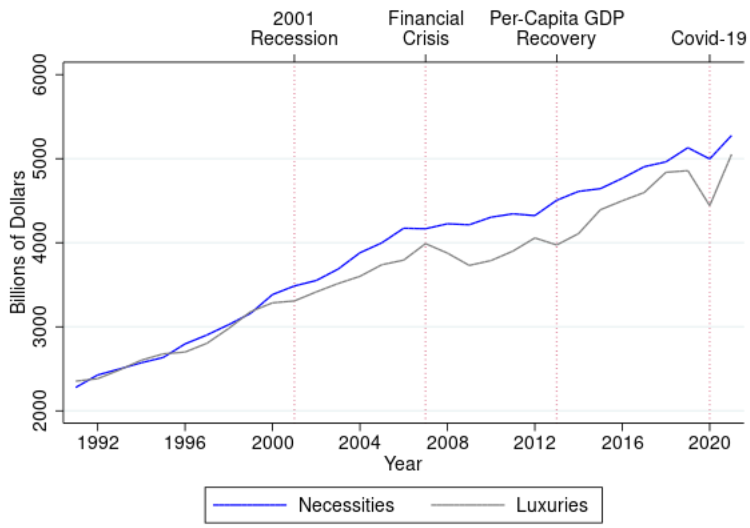
Table 7: Relationship Unemployment and Relative Real Expenditure

	Log-Real Expenditure					
	(1)	(2)	(3)	(4)	(5)	(6)
Right hand side variables:						
UR × Exp. Ratio	0.006	0.013***	0.020***	0.013***	0.006*	0.017***
	(0.0063)	(0.0042)	(0.0066)	(0.0041)	(0.0038)	(0.0045)
UR × Energy				-0.001		
				(0.0039)		
UR × Durable					-0.033***	
					(0.010)	
UR × Service						0.016***
						(0.0039)
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Weighted	No	Yes	Yes	Yes	Yes	Yes
Balanced Sample	No	No	Yes	No	No	No
Observations	36,788	36,788	21,796	36,788	36,788	36,788

Notes: The unit of observation is the sector-month. Exp. ratio is the ratio of expenditure shares of poor over rich households for the sector. Standard errors, in parentheses, are clustered at the time level and are robust to auto-correlation. Significance at the 1, 5, and 10 percent levels indicated by ***,**, and *. Real Expenditure is aggregate expenditure on sector j normalized by the sector specific price index.

largely consistent with the results in the main text: a higher unemployment rate is related to higher relative expenditure on necessity products.

Figure A6: Necessity and Luxury Expenditures Normalized by Sector Level Prices

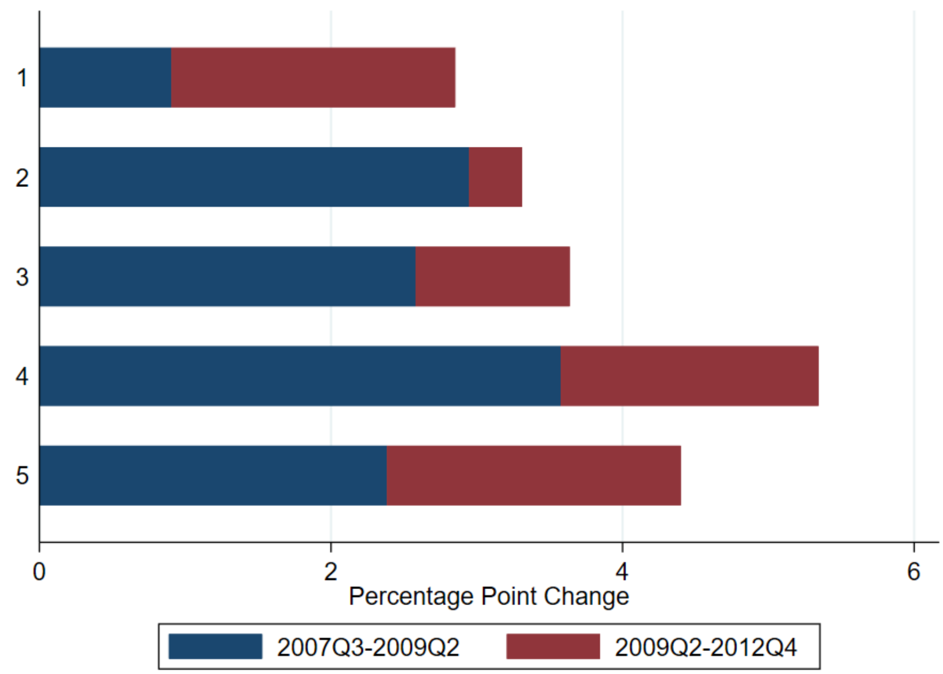


Source: Consumer Expenditure Survey, Personal Consumption Expenditures (BEA) and Author's own calculations. Real expenditure in 2007 Q1 dollars. Necessity and luxury expenditure normalized by sector specific prices. Excludes housing.

B.5 Change in Necessity Share by Income Group

Figure figure A7 shows the change in necessity share by income-group over two time periods. The official NBER 2007 recession (2007:Q3-2009:Q2) and the slow recovery while per-capita GDP was still below its 2007 peak (2009:Q2-2012:Q4). All income-groups increased their necessity shares during both periods, however, the magnitudes and timing do vary.

Figure A7: Great Recession: Change in Necessity Share by Income Quintile



Source: Consumer Expenditure Survey and Author's own calculations. Excludes housing.

B.6 IRF Robustness Checks

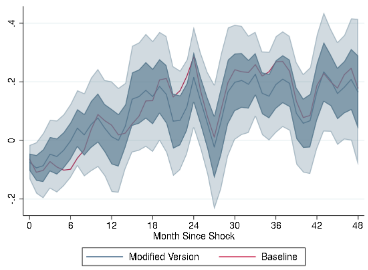
In figure figure A8, I present several robustness checks that complement my IRF results in the main text. In the first robustness check, I consider only monetary shocks coming from prior to the zero-lower bound period (pre-2008). In the second, I use a non-balanced sample for the log-price. This non-balanced sample includes all months for all products for which I have data (note that the sample for log-share is always balanced). In the third, I consider a version of the local-projection without sample weights. The non-weighted version tests whether my main results are simply driven by a few large categories or whether the counter-cyclical price/share patterns I find are a feature of necessity products. In each robustness test, results are largely similar to the main text.

In figure figure A9, I redo the IRFs and robustness tests, but the main coefficient of interest is now the interaction between a binary definition of necessity and the monetary policy shock, rather than the continuous expenditure ratio measure that I use in the main text.

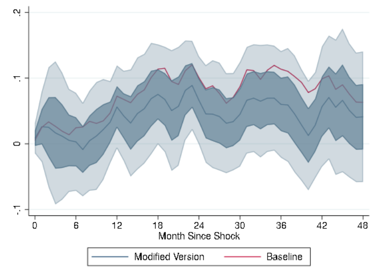
Finally, figure figure A10 computes IRFs of real-sectoral expenditure to a monetary policy shock. Similar to table 7, this set of results show that relative real demand for necessities rise following a monetary policy shock and the results for the log-share that I find in the main text are not simply mechanically driven due-to higher necessity prices.

Figure A8: Additional IRF Robustness Checks

Pre-2008 Shock Data

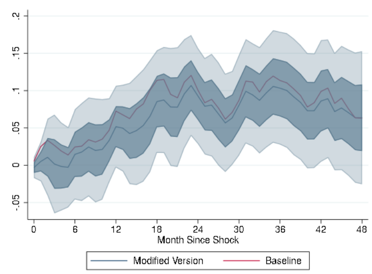


a) Log-Necessity Share



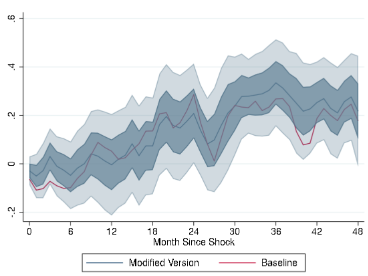
b) Log-Necessity Price

Non-Balanced Sample

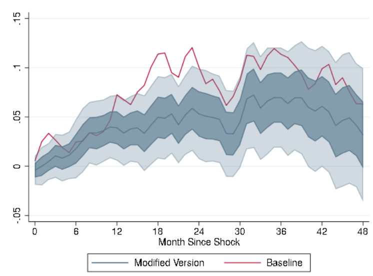


c) Log-Necessity Price

No Sector Weights



d) Log-Necessity Share

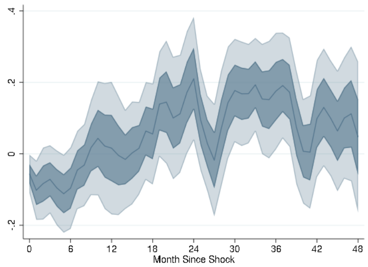


e) Log-Necessity Price

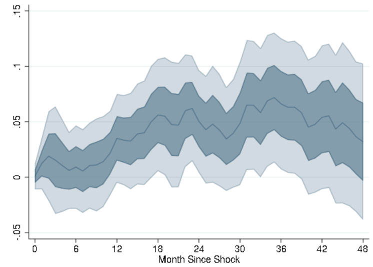
Note: Data from 1991-2019. Estimated coefficients from Local Projections explained in section 5. The unit of observation is the sector-month. Robust standard errors clustered at the monthly level are shown by one- and two- standard error confidence bands indicated by the dark and light shaded areas respectively. Sectors weighted by their share in pooled aggregate expenditure, except in panel d) and e), which are non-weighted. Monetary Policy shock normalized to 25-basis point increase in 1-year treasury in month $t = 0$. When the dependent variable is log-price a balanced sample is used of 60 sectors with price data available for the entire period, except in panel c) which is non-balanced.

Figure A9: IRFs: Coefficient Necessity × Monetary Shock

Baseline

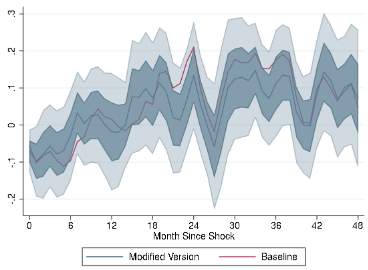


a) Log-Necessity Share

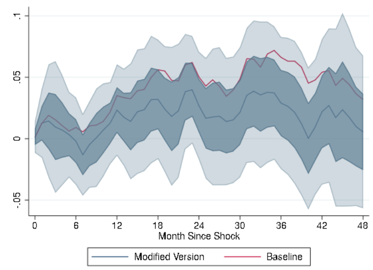


b) Log-Necessity Price

Pre-2008 Shock Data

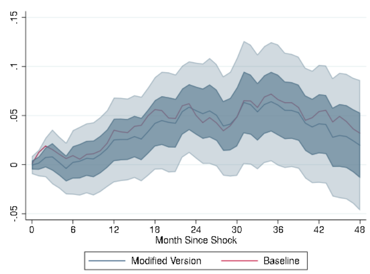


c) Log-Necessity Share



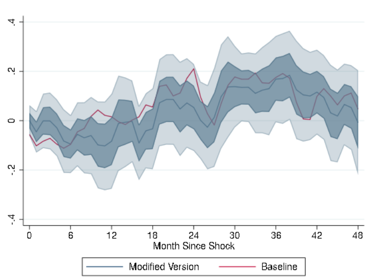
d) Log-Necessity Price

Non-Balanced Sample

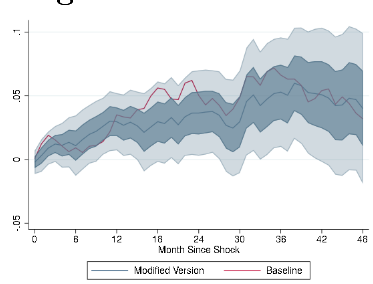


e) Log-Necessity Price

No Sector Weights



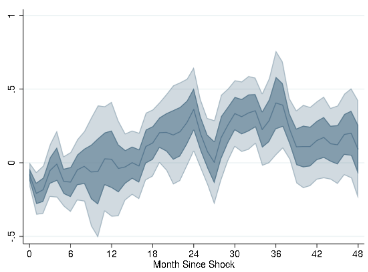
f) Log-Necessity Share



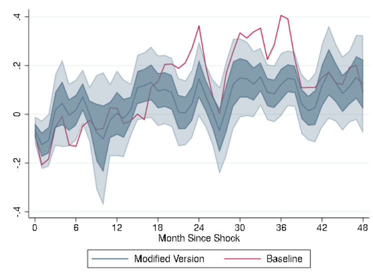
g) Log-Necessity Price

Note: Data from 1991-2019. Estimated coefficients from Local Projections explained in section 5, but using a binary definition of necessity rather than the continuous expenditure ratio. The unit of observation is the sector-month. Robust standard errors clustered at the monthly level are shown by one- and two- standard error confidence bands indicated by the dark and light shaded areas respectively.

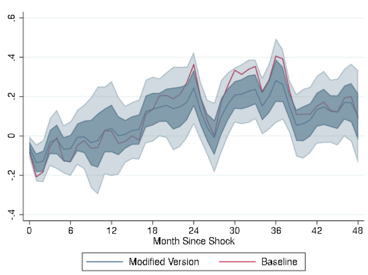
Figure A10: Impulse Response of Real Sectoral Expenditure



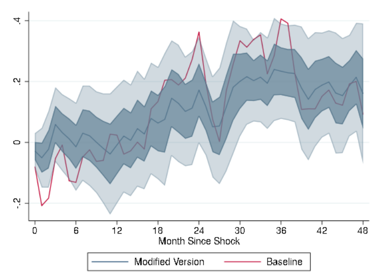
a) Baseline



b) Pre-2008



c) Non-Balanced



d) Non-weighted

Note: Data from 1991-2019. Estimated coefficients from Local Projections explained in section 5. The unit of observation is the sector-month and the left-hand-side variable is log-real sectoral expenditure. Robust standard errors clustered at the monthly level are shown by one- and two- standard error confidence bands indicated by the dark and light shaded areas respectively. Sectors weighted by their share in pooled aggregate expenditure, except in panel d), which is non-weighted. Monetary Policy shock normalized to 25-basis point increase in 1-year treasury in month $t = 0$. A balanced sample is used of 60 sectors with price data available for the entire period, except in panel c) which is non-balanced.

C Alternate Calibrations

As mentioned in the main text, I consider several alternative calibrations. I consider three different values for α; (1) $\alpha = 0.366$ from Fernald (2014), (2) $\alpha = 0.3$, which is implied by letting the marginal elasticity of marginal cost to quantity supplied in the model equal the median estimated value in Hottman and Monarch (2020), and (3) $\alpha = 0.16$, which is implied by the median results for ω in Feenstra and Weinstein (2017). I also directly estimate β_L and γ_{LN} from the micro-data, and use these values. The method of estimation is described in the next subsection.

C.1 Demand Parameter Estimation

I follow Deaton and Muellbauer (1980) and Fajgelbaum and Khandelwal (2016) when estimating the parameters in the AIDs. Specifically, I estimate equation (6.6) directly from the micro data by replacing $a(\mathbf{p})$ with a known price index (I use the CPI) so that the coefficient β_j represents changes in the share of expenditure on product j with changes in real expenditure, so that equation (6.6) becomes:

$$s_j = a_j^* + \sum_k \gamma_{jk} \log(p_k) + \beta_j \left(x_h^*\right). \tag{C.1}$$

Where x_h^* is real household expenditure, and a_j^* is a transformation of a^j.[33] Since there are only two sectors, I can estimate equation (C.1) directly via OLS by treating the price of one sector (necessities) as the numeraire and following the parameter restrictions defined earlier: $\sum_{j=1}^N a_j = 1, \sum_{j=1}^N \beta_j = \sum_{j=1}^N \gamma_{jk} = 0$ and $\gamma ij = \gamma ji \; \forall i, j$. Similar to the rest of the analysis, I control for household size, age of the household head, and the number of wage earners. I use the full household sample (1991-2019) and define the necessity good as the composite good of products with relative expenditure ratio greater than one.

Results from this estimation are shown in table A.1. Column one reports the OLS results. I estimate that $\beta^N = -0.18$, which implies a luxury sector expenditure elasticity for the representative household of 1.4. I also estimate a positive cross-price elasticity, implying

[33] In this framework, the a^j cannot be separately identified.

Table A.1: Almost Ideal Demand System Parameter Estimation

	OLS	IV − Income
	$s^h_{n,t}$	$s^h_{n,t}$
	(1)	(2)
Parameter Estimates:		
γ_{NL}	9.5×10^{-6}	1.1×10^{-5}
	$(.17)\times10^{-6}$	$(0.18)\times10^{-5}$
β^N	$-.18$	$-.24$
	(0.00075)	(0.0013)
Luxury Expenditure Elasticity	1.39	1.52
Necessity Expenditure Elasticity	.66	.55
Luxury Own Price Elasticity	-1.86	-2.45
Necessity Own Price Elasticity	-1.41	-1.8
Luxury Cross-Price Elasticity	-.86	-1.45
Necessity Cross-Price Elasticity	-.41	-.8
Observations	273,545	273,537

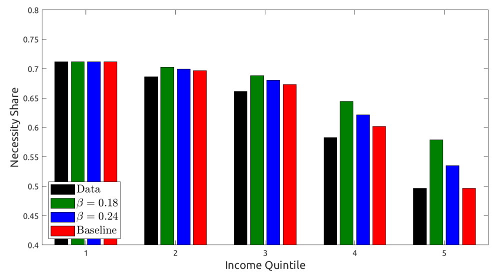
Notes: The unit of observation is the household-quarter. Robust standard errors in parentheses.

that necessities and luxuries are gross-complements. Column 2 shows an alternate estimation using household log-income and income quintiles as instruments for expenditure (Aguiar and Bils (2015) estimate expenditure elasticities using income as an instrument to correct for large under-reporting in the CEX).

C.2 Results

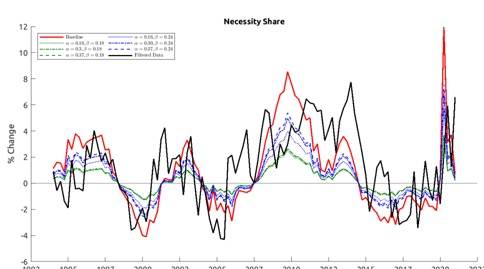
Here I show similar figures as those in the main text, but the the alternate 6 calibrations alongside the baseline calibration.

Figure A11: Model and Data: Necessity Shares by Income Group

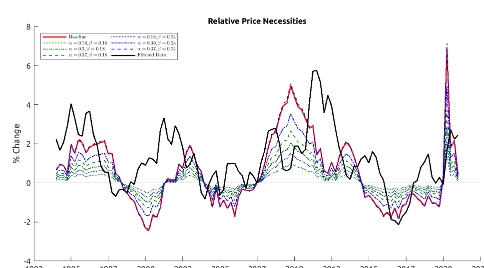


Note: Data from 2005-06. Model income-group shares at steady state. The baseline calibration is described in the main text.

Figure A12: Model v. Data: Necessity Shares and Prices



Necessity Share



Relative Necessity Price