# Unequal Markup Responses during Recessions

Jonathan Becker[†]

First draft: January 2024

This draft: June 2024

## Abstract

Poor and rich households differ greatly in the mix of products they consume, with the poor allocating a larger share of their expenditures to relatively inexpensive goods. Moreover, during recessions households shift spending towards more affordable goods. This paper studies an economy with nonhomothetic preferences and endogenously variable markups that can reproduce these patterns. I show that in recessions, lower-quality producers gain market power and increase markups because consumers shift spending towards more affordable goods. In contrast, higher-quality producers reduce their markups. Observed changes in the expenditure distribution during the Great Recession led to a 6.8 percentage point increase in the markups of low-quality goods and a 1.8 percentage point decline in the markups of high-quality products, thus considerably increasing real consumption inequality. Embedding this unequal markup adjustment mechanism into a Bewley-Aiyagari model, I find that redistributive policy interventions amplify the unequal response of markups. Redistribution to the poor allows lower-quality producers to gain even more market share and to increase markups even further.

*Keywords: Markups, Inequality, Quality, Recessions, Nonhomotheticities.*

*JEL Codes: D11, D21, D43, E31, E32, L13.*

[†] I owe a heartfelt debt of gratitude to my advisors Virgiliu Midrigan, Corina Boar, Raquel Fernández, and Alessandra Peter for inspiration, continued guidance, and tireless support throughout this project. I thank Mark Gertler, Simon Gilchrist, Venky Venkateswaran, Diego Perez, Thomas Philippon, Ricardo Lagos, Jarda Borovička, Katka Borovičková, Gian Luca Clementi, Guido Menzio, Paul Scott, and Jess Benhabib for helpful discussions and comments. Researcher(s)' own analyses calculated (or derived) based in part on data from Nielsen Consumer LLC and marketing databases provided through the NielsenIQ Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the NielsenIQ data are those of the researcher(s) and do not reflect the views of NielsenIQ. NielsenIQ is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.
NYU; Email: jb7026@nyu.edu.

# 1 Introduction

It is widely recognized that poor and rich households systematically differ in their spending on cheap vs premium goods, and therefore face different prices. It is also well-documented that during recessions, households shift expenditures towards more affordable options.[1] Consequently, when a recession hits, producers of cheap vs premium goods face different changes in demand. This paper asks: How do markups respond to these unequal demand shifts in an environment in which firms' market power increases with their market share? And how does the corresponding change in relative prices affect households across the expenditure distribution? I find that observed changes in the expenditure distribution during the Great Recession led to a 6.8 percentage point increase in the markups of cheaper goods and a 1.8 percentage point decline in the markups of more expensive alternatives. The recession's impact on product market competition thus considerably increases real consumption inequality.

The gist of my argument is that recessions disrupt within-sector competition. In normal times, producers across all premium tiers compete for middle-class customers. This competition acts as a check on the market power of cheaper producers and keeps markups moderately low. In recessions, however, households across the entire expenditure distribution flock to more affordable goods. The corresponding shift in demand weakens the competitive link between cheap and premium goods within the same sector. Producers of cheaper goods gain market share and, in turn, market power. As a consequence, they charge significantly higher markups. Conversely, as richer households cut their spending and switch to cheaper alternatives, premium producers seek to remain competitive by lowering prices.

[1] Bils and Klenow (1998) show that luxury spending is more cyclical. Burstein, Eichenbaum, and Rebelo (2005) find that lower quality goods gain market share in recessions. Jaimovich, Rebelo, and Wong (2019) link consumption smoothing along the quality margin to exacerbated declines in labor demand during recessions. Jørgensen and Shen (2019) document that rich and middle-class households adjust consumption at the quality margin, while the poor consumers are more likely to adjust along the quantity margin.

I study a model economy with two key ingredients: preferences are nonhomothetic and sectors are oligopolistically competitive. In each sector consumers purchase a basket of imperfectly substitutable varieties. In my model, I interpret nonhomotheticites over these varieties as encoding a quality margin. Crucially, with nonhomotheticicities, the value that households place on quality depends on their expenditure levels. Households with higher expenditures gravitate to higher-quality varieties and vice versa. Nonhomothetic preferences are therefore well-suited to replicate the observation that households across the expenditure distribution differ in their spending shares on cheaper, low-quality vs more expensive, high-quality goods. Specifically, I embed the nonhomothetic CES preferences from Comin, Lashkari, and Mestieri (2021) into the inner layer of a nested CES aggregator. This choice of functional form ensures that, consistent with the data, nonhomotheticicities do not taper out asymptotically.[2]

Furthermore, product markets are oligopolistically competitive in the tradition of Atkeson and Burstein (2008). Firms derive market power from the imperfect substitutability of their outputs where, naturally, varieties are more substitutable within sectors than across them. Smaller firms mainly compete within sectors, where their outputs are highly substitutable with that of their competitors. They therefore have lower market power. In contrast, larger firms, which dominate within their sectors, compete primarily across sectors where outputs are less substitutable, allowing them to wield greater market power. As a consequence, markups are endogenously variable and increase in sectoral market share.

My mechanism relies on the interplay of these two ingredients. A recession shifts demand towards less expensive, lower-quality goods. Consequently, producers of low-quality goods gain market share, whereas firms producing higher-quality goods lose market share. Markups on lower-quality varieties increase, while markups on higher-quality goods decrease. I, henceforth, refer to this unequal markup response to recessionary changes in spending as the *markup channel.*

[2]In contrast to e.g. Stone-Geary or PIGL preferences, nonhomothetic CES preferences also allow for a meaningful distinction of an arbitrary number of quality tiers.

Using detailed choice data from the NielsenIQ Homescan Consumer Panel, I show that my nonhomothetic demand system aligns well with micro-level evidence on consumption behavior. Specifically, I establish three relevant facts that hold true in both model and data.

First off, wealthier households allocate a larger proportion of their budget to more expensive, premium goods. That is, households in the bottom quintile of the expenditure distribution buy goods that are, on average, 0.56 standard deviations less expensive than what is typically charged for close substitutes. In contrast, the typical purchase of households in the top expenditure quintile is roughly 0.42 standard deviations more expensive than close alternatives.

Second, I find that there is a great deal of consumption polarization. Poor households predominantly opt for goods priced within an interquartile range extending from 0.71 to 0.34 standard deviations below the average cost of substitutes. Similarly, wealthier households tend to purchase goods within an interquartile range of 0.16 to 0.59 standard deviations above average. In contrast, however, consumers in the middle of the expenditure quintile enjoy a broad mixture of cheap and expensive goods. While their typical purchase is priced about 0.05 standard deviation below average, there is considerable variance in the expensiveness of their product choices. Specifically, their interquartile range spans from 0.36 standard deviations below to 0.45 standard deviations above average.

Third, I find that household-level price-elasticities for cheap vs premium goods decline in household-level spending shares. For instance, poor households, who exclusively purchase the cheapest options available, are less responsive to price changes in cheaper products than wealthier households who predominantly consume premium goods. Intuitively, in markets with limited options, a modest price increase typically does not change the ranking of the cheapest option as the most economical choice. Poor households therefore routinely purchase this cheapest option irrespective of relative price fluctuations. Similarly, richer household gravitate to premium varieties without significant regard for price. In contrast, middle-class households, who consume a mixture of cheap and expensive goods, exhibit higher price responsiveness due to their willingness to substitute along the premium margin.

Having shown that my nonhomothetic preference structure is well-aligned with the data, I next discuss the firms' problem in my model economy. In particular, producers maximize profits taking as given the consumers' nonhomothetic demand system. As a consequence, within-sector competition is shaped by the expenditure distribution. When contemplating, say, a price increase, producers weigh the loss of business from comparatively price-elastic middle-class consumers against the higher rents they could extract from the less elastic segment of their respective customer base. For instance, a high-quality producer trades off the loss of business from middle-class consumers with the higher margins earned from their price-inelastic, more affluent customer base. This trade off depends on the mass of each one of those customer segments in the population and, therefore, on the overall expenditure distribution.

I calibrate my model to match evidence on relative prices, cross-sectional differences in consumption choices, as well as measures of sectoral concentration. Specifically, I parameterize the marginal cost of different-quality goods to match the average relative price of cheap vs premium goods, which stands at 0.81 in the data. I, moreover, calibrate the nonhomotheticity parameters in my model to align spending patterns on cheap vs premium varieties with the data. As a crucial determinant of these patterns, I read the expenditure distribution directly off of pre-recession PSID data. Conditional on having matched relative prices, I target the relative expensiveness of product choices across the expenditure distribution. For instance, I match the fact that purchases of households in the top expenditure quintile are on average 20% more expensive than those in the bottom quintile. Moreover, my calibration ensures that, as in the data, the variance in expensiveness in middle-class (wealthier) consumption baskets is 6.18 (4.82) times larger than it is among poor consumers. Finally, my quantitative model features a continuum of sectors where sectoral heterogeneity in the respective number of low- vs high-quality producers is immediately taken from the data. Conditional on sector composition, I match concentration measures through the calibration of demand-shifters. Finally, I calibrate the within- and across-sector elasticity of substitution to match moments of the model-implied markup distribution from Becker, Edmond, Midrigan, and Xu (2024) in the absence of nonhomotheticies. My model accurately reproduces a set of untargeted moments including cross-sectional differences in price-elasticities across premium tiers as well as relative markups for cheap vs expensive varieties.

Feeding observed changes in the expenditure distribution during the Great Recession into my calibrated model, I find an unequal markup response for low- and high-quality varieties. In particular, markups for lower-quality goods increase by an average of 6.8 percentage points while markups for higher-quality goods decrease by 1.8 percentage points. As a consequence, the relative price of cheaper goods increases by 5.42%. Naturally, this unequal markup response is more pronounced in markets with low levels of competition. In sectors with a sales HHI higher than 0.35, for instance, the relative price of cheaper goods increases by 6.12%. To isolate the impact of the markup channel, my quantification exercise keeps the marginal cost structure of producers counterfactually fixed. In the data, where price changes are also driven by the recession's impact on marginal cost, I find that the relative price of cheap vs premium goods is still countercyclical.

The markup channel is quantitatively important for the impact of a recession on consumers across the expenditure distribution. In PSID data, the Great Recession manifested in a drop in overall spending as well as a slight narrowing of the expenditure distribution. Households in the bottom expenditure quartile reduced nominal spending by 13.5%, while households in the top quartile cut spending by 16.3%. This reduction of inequality in nominal spending might speciously suggest that wealthy households were more severely affected by the recession. However, accounting for the markup channel and deflating expenditures accordingly reveals that consumption inequality actually widens. Real expenditures for the poor fell by 18.1% as compared to 15.1% among richer households. That is, poor households are disproportionately hit by recessions.

Next, I study the consequences of the markup channel for redistributive policy. As the markup channel increases real consumption inequality, policymakers who are concerned about inequality might naturally consider redistributive interventions. Embedding the markup channel into a Bewley-Aiyagari model, I examine the effects of such redistributive measures in general equilibrium. A redistributive automatic stabilizer, which increases labor taxes by 2 percentage points for every 1% drop in TFP, significantly raises the relative price of lower-quality goods during a recession – more than doubling the increase compared to a scenario without redistribution. Intuitively, when resources are redistributed to the poor, funds that would have been spent on high-quality goods are redirected to lower-quality goods. Consequently, producers of low-quality goods capture even more market share and raise their markups even further. While the markup channel itself increases inequality, redistribution amplifies the markup channel. A natural solution to this dilemma calls for product market interventions.

**Related Literature.** Cementing the premise of my paper, a large body of literature studies how households adjust their consumption during recessions. Bils and Klenow (1998) show that expenditures on luxuries are substantially more cyclical than expenditures on necessities. Other seminal contributions along those lines include Browning and Crossley (2000), Aït-Sahalia, Parker, and Yogo (2004) as well as, more recently, Jaimovich, Rebelo, and Wong (2019) and Andreolli, Rickard, and Surico (2024). Burstein, Eichenbaum, and Rebelo (2005) show that lower-quality goods gain market share in recessions. Jørgensen and Shen (2019) document that rich and middle-class households smooth consumption along the quality margin, while the poor consumers are more likely to adjust at the quantity margin.

Complementary to my paper, there is also a burgeoning literature that studies how markups, prices, and inflation rates differ across the income distribution. Sangani (2024) documents that rich households pay significantly higher retail markups for the same barcode. Here, differences in markups are due to differences in search behavior rather than product choice. Building on Kaplan and Menzio (2016), Nord (2024) connects retail price dispersion with differences in search effort across the expenditure distribution. The resulting response of low-quality markups to business cycle fluctuations is diametrically opposed to my model predictions. As a recession hits, households throughout the economy spend less and, in turn, perceive search as less burdensome. Consequently, retailers lose market power and charge lower markups across all quality tiers. This mechanism is complementary to my argument in the sense that I abstract away from search behavior and assume perfectly competitive retailers, whereas Nord (2024) abstracts away from producer competition. Kaplan and Schulhofer-Wohl (2017) and Jaravel (2019) document that poor consumers experience higher inflation rates. My findings suggest that these patterns are mostly driven by the sustained price impact of contractionary episodes.

My paper also contributes to the modeling of differences in consumption choices along the quality margin. Seminal contributions include, Kongsamut, Rebelo, and Xie (2001), Buera and Kaboski (2009), Boppart (2014), and Comin, Lashkari, and Mestieri (2021). With the notable exception of Fjagelbaum, Grossman, and Helpman (2011), however, nonhomotheticities typically do not have any bearing on product market competition. In contrast, my environment features oligopolistically competitive firms whose strategic interactions are shaped by nonhomotheticites.

# 2 Model

In this section I present a static, partial equilibrium model in which markups respond to changes in the expenditure distribution. My mechanism hinges on two critical features: nonhomothetic preferences over varieties as well as oligopolistic product market competition.

This section is organized as follows: First, I describe consumer preferences and discuss how the implied consumption behavior differs from a homothetic baseline. I then show that the resulting demand system is well-aligned with granular micro-data on consumer choices. Finally, I embed the nonhomothetic preference structure into a standard paradigm of oligopolistically competitive product markets.

## 2.1 Consumption behavior under nonhomotheticities

There is a continuum of consumers with nonhomothetic preferences over varieties. Consumers differ in their expenditure levels. For the time being, the expenditure distribution is understood as a model primitive. With varieties being differentiated along a quality margin, a change in the expenditure distribution leads to asymmetric shifts in spending shares for different-quality goods.

**Preferences.** Consumers choose allocations $\{c_{iqs}\}$ to maximize real consumption of a composite final good $c$. The indexation of varieties $(i, q, s)$ reflects their sectoral classification $s \in \mathscr{S}$, quality $q \in \mathscr{Q}$, as well as producer $i \in \mathscr{I}_{qs}$. The aggregation of varieties into overall real consumption takes place according to a nested nonhomothetic CES structure. At the outer nest, real consumption $c$ is a homothetic CES aggregate of sectoral consumption levels $c_s$. That is, I aggregate over a continuum of sectors $\mathscr{S}$ with

$$\int_{\mathscr{S}} \left(\frac{c_s}{c}\right)^{\frac{\eta-1}{\eta}} ds = 1. \tag{1}$$

Across-sector substitutability satisfies $\eta \geq 1$ such that sectoral consumption aggregates $c_s$ are gross-substitutes.

At the inner nest, nonhomotheticicies encode a quality distinction. As a consequence, varieties are not only imperfect substitutes but also asymmetrically differentiated along a quality margin. For tractability, there is a finite set of quality bins $\mathscr{Q}$ with cardinality $Q$. Each quality bin contains a finite set of producers $\mathscr{I}_{qs}$ with cardinality $N_{qs}$. Each producer markets a single variety. Sectoral consumption aggregates $c_s$ are implicitly defined through

$$\sum_{q=1}^{Q}\sum_{i=1}^{N_{qs}}\psi_q(c_s)^{\frac{1}{\sigma}}\left(\frac{c_{iqs}}{c_s}\right)^{\frac{\sigma-1}{\sigma}}=1\quad\forall\quad s\in\mathscr{S}\tag{2}$$

where $\psi_q(c_s)\equiv\varphi_q\,c_s^{(1-\sigma)(\xi_q-1)}$ is a nonhomothetic taste shifter. Here, $\sigma>\eta$ ensures that consumption is more substitutable within than across sectors. Note that when setting $\xi_q=1$ for all $q$, equations (1) and (2) specialize to the familiar homothetic nested CES structure from Atkeson and Burstein (2008).

The parameter $\varphi_q$ reflects a "consensus" on product quality, while the nonhomotheticity parameter $\xi_q$ governs cross-sectional differences in quality appreciation. Specifically, $\varphi_q$ acts as a demand-shifter that is homogenous across the expenditure distribution. Everything else equal, when increasing $\varphi_q$ for quality bin $q$, consumers shift spending towards varieties in this particular quality bin. This shift is irrespective of expenditure levels. A key-feature of nonhomothetic preferences, however, is that the appreciation of quality depends on consumption levels. To capture this formally, the nonhomothetic taste-shifter $\psi_q(c_s)$ depends on sectoral consumption $c_s$. Specifically, with gross substitutes, $\psi_q(c_s)$ is strictly monotonically increasing in $c_s$ iff $\xi_q<1$. As a consequence, rich households with high consumption levels spend relatively more on low-$\xi$ varieties, while poor households gravitate towards high-$\xi$ varieties.

**Demand for varieties.** The preferences in (1) and (2) furnish markets with a demand structure. Although Marshallian demand functions are not available in in closed-form, the nonhomothetic CES structure does allow for a great deal of characterization in terms of sharp analytical expressions.

The consumers' optimization problem is best approached by invoking a separation theorem. First off, I focus on the consumers' within-sector expenditure minimization. In each sector $s$, for a given price vector $\boldsymbol{p}_s=\big(p_{iqs}:i\in\mathscr{I}_{qs}\text{ and }q\in\mathscr{Q}\big)$, the Hicksian demand to attain aggregate sectoral consumption $c_s$ solves

$$\min_{\{c_{iqs}\}} \left\{ \sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} p_{iqs} c_{iqs} \;\middle|\; \sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} \varphi_q^{\frac{1}{\sigma}} \left( \frac{c_{iqs}}{c_s^{\xi_q}} \right)^{\frac{\sigma-1}{\sigma}} = 1 \right\}. \tag{3}$$

The solution to this consumer program is

$$c_{iqs}(c_s, \boldsymbol{p}_s) = \psi_q(c_s) \left( \frac{p_{iqs}}{p_s(c_s, \boldsymbol{p}_s)} \right)^{-\sigma} c_s \tag{4}$$

where the nonhomothetic ideal price-index is given by

$$p_s(c_s, \boldsymbol{p}_s) \equiv \left( \sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} \tilde{p}_{iqs}(c_s)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \quad \text{and} \quad \tilde{p}_{iqs}(c_s) \equiv \psi_q(c_s)^{\frac{1}{1-\sigma}} \, p_{iqs}.$$

Intuitively, we can think of $\tilde{p}_{iqs}(c_s)$ as a quality-adjusted price. With nonhomothetic preferences, the appreciation of quality depends on consumption levels and, therefore, so does the nonhomothetic ideal price-index. Note that under homothetic CES preferences, with $\xi_q = \xi$ for all $q$, the ideal price-index is homogenous in sectoral consumption and Hicksian demand is linear in $c_s$.

**Demand for sectoral aggregates.** The quality distinction at the inner nest complicates the expenditure minimizing choice of sectoral consumption. Consumers internalize the effect their allocations have on their nonhomothetic sectoral price-indices. Specifically, taking as given the price vector $\boldsymbol{p} = \big(\boldsymbol{p}_s : s \in \mathscr{S}\big)$, the Hicksian demand for sectoral aggregates to attain an overall consumption of $c$ solves

$$\inf_{\{c_s\}} \left\{ \int_{\mathscr{S}} p_s(c_s, \boldsymbol{p}_s)\, c_s \, ds \;\middle|\; \int_{\mathscr{S}} \left( \frac{c_s}{c} \right)^{\frac{\eta-1}{\eta}} ds = 1 \right\}. \tag{5}$$

Since the nonhomothetic ideal price-index depends on $c_s$, this is akin to a homothetic expenditure minimization problem with a non-linear pricing structure. Envisioning the continuum of sectors as a large set of cardinality $S$, as is common in Atkeson and Burstein (2008) settings, the corresponding first-order conditions dictate that

$$\left(\frac{c_s}{c}\right)^{\frac{\eta-1}{\eta}} = \frac{\sum_q \sum_i p_{iqs}\, c_{iqs}(c_s, \boldsymbol{p}_s)\, \xi_q}{\sum_s \sum_q \sum_i p_{iqs}\, c_{iqs}(c_s, \boldsymbol{p}_s)\, \xi_q} \quad \forall \quad s = 1, \ldots, S. \tag{6}$$

The derivation is relegated to Appendix B. For each desired level of real consumption $c \in \mathbb{R}_+$, equations (6) furnish us with a set of $S$ highly non-linear equations in $S$ unknowns. This system of simultaneous equations pins down the Hicksian demand for sectoral consumption $c_s(c, \boldsymbol{p})$. Note that under homothetic CES preferences consumers simply equate the lefthandside expression in (6) with the corresponding sectoral expenditure share.

**Marshallian demand.** The consumers' Marshallian demand allocates varieties $\{c_{iqs}\}$ to maximize the utility derived from composite real consumption $c$ for a given budget $y$. Formally, the Marshallian demand functions of a consumer of type $y$ solve

$$\arg\sup_{\{c_{iqs}\}} \left\{ c \;\middle|\; \int_{\mathscr{S}} \sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} p_{iqs} c_{iqs}\, ds \leq y \text{ and aggregators (1) and (2)} \right\}. \tag{7}$$

By duality, Hicksian demand translates into Marshallian demand. Here, "indirect" real consumption $c(y, \boldsymbol{p})$ satisfies

$$\int_{\mathscr{S}} p_s\big(c_s(c, \boldsymbol{p}), \boldsymbol{p}_s\big)\, c_s(c, \boldsymbol{p})\, ds = y. \tag{8}$$

The corresponding nonhomothetic ideal price-index is then defined as

$$p(y, \boldsymbol{p}) \equiv \frac{y}{c(y, \boldsymbol{p})}. \tag{9}$$

With homothetic preferences, $c(y, \boldsymbol{p})$ is linear in $y$ and the ideal price-index is constant across the expenditure distribution. In a slight abuse of notation, the

Marshallian demand for variety $(i, q, s)$ is, henceforth, denoted by

$$c_{iqs}(y, \boldsymbol{p}) = c_{iqs}\Big(c_s\big(c(y, \boldsymbol{p}), \boldsymbol{p}\big), \boldsymbol{p}_s\Big) \quad \forall \quad (i, q, s). \tag{10}$$

With nonhomothetic preferences the properties of these demand functions differ across the expenditure distribution. To build intuition, the subsequent paragraphs discuss these properties in a single sector environment with $|\mathscr{S}| = 1$. Derivations and general expressions for $|\mathscr{S}| = \mathfrak{c}$ are relegated to Appendix B.

**Expenditure-elasticities.** Households' expenditure-elasticities determine how households differ in their quality choice and, therefore, how changes in the expenditure distribution impact demand patterns along the quality margin. Specifically, expenditure-elasticities are given by

$$\frac{\partial \log c_{iq}(y, \boldsymbol{p})}{\partial \log y} = \sigma + (1 - \sigma)\, \frac{\xi_q}{\bar{\xi}(y, \boldsymbol{p})} \tag{11}$$

where $\bar{\xi}(y, \boldsymbol{p})$ can be read as the average nonhomotheticity parameter of a consumer with expenditures $y$. That is,

$$\bar{\xi}(y, \boldsymbol{p}) \equiv \textstyle\sum_q \sum_i x_{iq}(y, \boldsymbol{p})\, \xi_q \quad \text{and} \quad x_{iq}(y, \boldsymbol{p}) \equiv \dfrac{p_{iq} c_{iq}(y, \boldsymbol{p})}{\sum_r \sum_j p_{jr} c_{jr}(y, \boldsymbol{p})}$$

with $x_{iq}(y, \boldsymbol{p})$ being consumer $y$'s expenditure share on variety $(i, q)$. Note that $\bar{\xi}(y, \boldsymbol{p})$ is decreasing in $y$ and bounded between $\min\{\xi_q\}$ and $\max\{\xi_q\}$. Consequently, expenditure-elasticities are monotonically decreasing in expenditure levels. Among gross substitutes, we can naturally think of goods with higher expenditure-elasticities as being of higher quality.[3] This is precisely the sense in which $\xi_q$ governs quality perception (or quality appreciation for that matter). The quality of a particular good is not an intrinsic feature but rather a subjective perception that is contingent on overall spending levels. The exact same product may

[3]The conventional distinction between necessities and luxuries is more natural in a setting where goods are gross complements. With gross substitutes the spending share on low quality goods asymptotes to zero making the term "necessity" somewhat misleading.

be regarded as high-quality by a poor consumer, yet considered inferior among richer households.

**Price-elasticities.** Households' price-elasticities determine how demand responds to price-changes and are, therefore, directly related to firms' market power. With nonhomothetic preferences, price-elasticities are a function of expenditures. They formalize the channel through which changes in the expenditure distribution affect strategic interactions among oligopolistically competitive firms. In the single sector case, own price-elasticities are given as

$$\left|\frac{\partial \log c_{iq}(y,\boldsymbol{p})}{\partial \log p_{iq}}\right| = \frac{x_{iq}(y,\boldsymbol{p})\,\xi_q}{\bar{\xi}(y,\boldsymbol{p})} + \left(1 - \frac{x_{iq}(y,\boldsymbol{p})\,\xi_q}{\bar{\xi}(y,\boldsymbol{p})}\right)\sigma. \tag{12}$$

Since $x_{iq}(y,\boldsymbol{p})\,\xi_q/\bar{\xi}(y,\boldsymbol{p}) \in (0,1)$, the above price-elasticity is a convex combination of households' consumption-response absent any substitution, on the one hand, and within-sector substitutability, on the other. In markets with a single high-quality option, for instance, rich consumers' price-elasticity for this premium variety tends to one. Intuitively, these affluent consumers do not perceive lower-quality options as suitable substitutes; a 1% increase in price causes a 1% decrease in demand. Similarly, in markets with a single low-quality option, poor consumers inelastically purchase this basic variety and do not even consider (more expensive) high-quality substitutes. With multiple options within a given quality bin, this result is weakened. Here, rich consumers, for example, recognize the substitutability of different high-quality goods and are, thus, more responsive when the price for one of those goods changes. Middle-class households who consume a mixture of low- and high-quality goods are, in principle, willing to substitute along the quality margin and, therefore, moderately price-elastic.

## 2.2 Micro-evidence for nonhomothetic demand

In this section, I show that key-predictions of the previously outlined demand system are well-aligned with empirical observations on consumption patterns across the expenditure distribution. These predictions are crucial in connecting recessionary drops in spending to the shifts in demand patterns that ultimately elicit an asymmetric markup response. Specifically, I find that rich households spend relatively more on premium goods and that there is a substantial degree of consumption polarization across the expenditure distribution. Moreover, my empirical analysis reveals varying price elasticities for different-quality varieties across consumer strata.

**Data.** My primary dataset in this exercise is the *NielsenIQ Homescan Panel*. This dataset, made available by the Chicago Booth Kilts Center for Marketing Research, tracks the shopping behavior of about 50,000 US households from 2004 to 2022. It consists of unbalanced longitudinal data on barcode-level quantities and prices of fast-moving consumer goods bought from a wide range of retail outlets across the US. The data are projectable to the entire US. Panelists utilize in-home scanners to record their purchases intended for personal use. The dataset includes a wide array of self-reported demographics. Overall, the universe of NielsenIQ barcodes accounts for about 30-40% of spending on goods and roughly 15% of total expenditures.

I supplement my empirical analysis with *NielsenIQ Retail-Scanner* data, which provides weekly pricing, volume, and store information generated by point-of-sale systems from over 90 participating retail chains across all US markets. This dataset covers scanner data from 35,000-50,000 participating grocery and drug stores, accounting for more than half of the total sales volume in the US.

Furthermore, in later sections of the paper, I utilize wholesale data from *Price-Trak PromoData* to correlate retail markups with barcode-level premium scores. PromoData is a weekly monitoring service which tracks wholesale prices for a subset of NielsenIQ barcodes. The data is sourced from 12 grocery wholesaler organizations that sell products to retailers across the US and covers the period from 2006 to 2012.

**A premium-margin in the data.** Households with different expenditure levels differ in their propensities to consume cheap vs expensive goods. In order to define a meaningful measure of expensiveness in the data, I first demarcate a set of close substitutes for each barcode $i$. Here, I rely on NielsenIQ's classification of barcodes into narrowly defined product modules $m$. These modules (e.g. fresh apples, mozzarella cheese, or instant coffee) are a collection of highly substitutable barcodes. To ensure within-module comparability of price data, I convert barcode-level quantities and prices to module specific base units. Whenever a natural conversion is not feasible (e.g. count vs ounces), modules are segmented accordingly.

To define a barcode-level measure of expensiveness, I proceed as follows: For each region $r$ and year $t$, based on regular price data, I compute the average price per base unit of each barcode $i$. Averaging over households $h$ and different stores within region $r$, note that, going forward, prices are barcode-level objects. That is,

$$\text{price}_{irt} = \frac{\sum_{h \in r} \text{expenditure}_{iht}}{\sum_{h \in r} \text{quantity}_{iht}}. \tag{13}$$

In within-module comparisons, this variable $\text{price}_{irt}$ can be read as the expensiveness of barcode $i$ in region-time cell $(r, t)$. In order to make this notion of expensiveness comparable across modules, I residualize $\text{price}_{irt}$ on module, region, and time fixed-effects as well as interactions thereof. I then normalize by a module-clustered measure of residual dispersion. That is, I define

$$\text{premium}_{irt} = \frac{\text{price}_{irt} - \alpha_{\text{module}} - \alpha_{\text{region}} - \alpha_{\text{module}\times\text{region}} - \alpha_{\text{year}}}{\sigma_{\text{module}}}. \tag{14}$$

I refer to this object as a barcode-level premium score. In particular, $\text{premium}_{irt}$ measures how many standard deviations barcode $i$ is priced above what is typical for the corresponding module in region $r$ at time $t$. Besides facilitating across-module comparability, this premium-score effectively rids the data of regional heterogeneity in product availability and pricing patterns as well as overall time trends.

**Fact 1: Rich households spend more on premium goods.** Households with higher expenditures tend to spend more on pricier items, even when lower cost, nearly identical alternatives are available. To establish this fact in the data, I correlate consumption patterns along the premium margin with household expenditures. Specifically, I define the household premium-index $\mu_{hmt}$ as a household- and module-specific quantity-weighted average of the barcode-level premium scores defined in (14). That is,

$$\mu_{hmt} = \sum_{i \in m} \frac{\text{quantity}_{iht}}{\sum_{i \in m} \text{quantity}_{iht}} \text{premium}_{ir(h)t}. \tag{15}$$

Crucially, $\mu_{hmt}$ depends on consumer behavior only through quantity choices; the price component of $\mu_{hmt}$ does not reflect search behavior or store characteristics. In a nutshell, this premium-index encodes to what extent household $h$ consumes cheap vs expensive varieties in module $m$. To illustrate the correlation between premium-indices and expenditure levels, the lefthandside panel of Figure 1 is a binscatter of $\mu_{hmt}$ against households' total expenditures in module $m$. Households, who spend particularly little, tend to purchase varieties that are, on average, priced at about 0.9 standard deviations below what is typical in their corresponding module. As households spend more, they do not merely purchase higher quantities of the exact same varieties, but gravitate towards more and more expensive options. The model counterpart of $\mu_{hmt}$ is given by

$$\mu_s(y) = \sum_{q=1}^{Q} \sum_{i=1}^{N} \frac{c_{iqs}(y, \boldsymbol{p})}{\sum_{q=1}^{Q} \sum_{i=1}^{N} c_{iqs}(y, \boldsymbol{p})} \, p_{iqs}. \tag{16}$$

The righthandside panel of Figure 1 depicts this model-implied household premium-index under homothetic vs nonhomothetic preferences. With homothetic preferences, the consumption of different varieties simply scales with expenditure levels and the quantity weights in (16) are constant across the expenditure distribution. In contrast, with nonhomothetic preferences, the composition of consumption baskets does depend on overall expenditure levels. As a consequence, nonhomothetic preferences are well-suited to capture the observed tendency of affluent households to spend relatively more on pricier goods.

**Fact 2: Polarization in consumption patterns.** I find that there is significant polarization in consumption patterns across the expenditure distribution. Poor households almost exclusively opt for inexpensive goods, whereas wealthier households predominantly consume premium goods. In contrast, middle-class households purchase a broader mixture along the premium margin. To establish this fact in the data, I compute a measure of household premium-dispersion $\sigma_{hmt}$. Specifically, this is the second moment corresponding to (15) such that

$$\sigma^2_{hmt} = \sum_{i \in m} \frac{\text{quantity}_{iht}}{\sum_{i \in m} \text{quantity}_{iht}} \left(\text{premium}_{ir(h)t} - \mu_{hmt}\right)^2. \tag{17}$$

Therefore, $\sigma_{hmt}$ reflects to what extent household $h$ consumes a mixture of cheap and expensive varieties in module $m$; a low measure $\sigma_{hmt}$ indicates that consumers' purchases consistently align with their premium-index. As illustrated in the lefthandside panel of Figure 2, $\sigma_{hmt}$ is comparatively small for households in either tail of the expenditure distribution. Poor households do not only lean towards the consumption of cheaper goods, as we saw in Figure 1, but they almost exclusively purchase those inexpensive options. Similarly, richer households primarily opt for more expensive varieties. In the middle of the distribution, the middling premium-index in Figure 1, however, does not reflect the exclusive consumption of typically priced goods but is due to significant mixing along the premium margin. The model counterpart of $\sigma^2_{hmt}$ is given as

$$\sigma^2_s(y) = \sum_{q=1}^{Q} \sum_{i=1}^{N} \frac{c_{iqs}(y, \boldsymbol{p})}{\sum_{q=1}^{Q} \sum_{i=1}^{N} c_{iqs}(y, \boldsymbol{p})} \left(p_{iqs} - \mu_s(y)\right)^2 \tag{18}$$

Since cross-sectional variation captured by $\sigma_s(y)$ is exclusively driven by differences in the composition of consumption baskets, a model with homothetic preferences cannot possibly replicate the observed pattern. The righthandside panel of Figure 2, however, demonstrates that a nonhomothetic preference structure quite accurately reproduces the inverted $u$-shape observed in the data.

**Fact 3: Households' price-elasticities decline in spending shares.** I find that the well-documented empirical regularity that price-elasticities decline with spending shares holds true at the household level. That is, households are least price-elastic with respect to whichever variety they consume the most. Intuitively, rich consumers, with a strong appetite for premium goods, exhibit very little consumption response to price fluctuations for those pricier varieties. Similarly, poor households, who are routinely buying the least expensive option available, show minimal consumption adjustments in response to (minor) price changes for these lower-priced goods.

In order to establish this fact in the data, I stratify the population based on their consumption choices along the premium margin. Specifically, my categorization is based on household premium-indices as defined in (15). Premium consumers are those whose premium-index falls within the upper tertile of the cross-sectional pushforward $\{h \mapsto \mu_{hmt}\}$. Basic consumers are those with a premium-index in the lower tertile. In particular, for each module $m$ and time $t$, I define

$$\mathscr{H}\big|_{\text{premium}}^{mt} = \left\{ h \in \mathscr{H} \;\middle|\; \mu_{hmt} \text{ in upper tertile of } h \mapsto \mu_{hmt} \right\}$$

and

$$\mathscr{H}\big|_{\text{basic}}^{mt} = \left\{ h \in \mathscr{H} \;\middle|\; \mu_{hmt} \text{ in lower tertile of } h \mapsto \mu_{hmt} \right\}.$$

Then, to recover barcode-specific price-elasticities for, say, premium consumers, I estimate a log-linearized version of the demand system implied by equation (10) where an observation $(i, h, t)$ is included iff $h \in \mathscr{H}\big|_{\text{premium}}^{m(i)t}$. That is,

$$\begin{aligned} \text{log quantity}_{iht} = \; & \alpha_{ih}^{\text{prm}} + \alpha_{irt}^{\text{prm}} + \beta_i^{\text{prm}} \text{ log price}_{iht} \\ & + \sum\nolimits_{j \in \mathscr{K}_{iht}} \beta_{ij}^{\text{prm}} \text{ log price}_{jr(h)t} + \gamma_i^{\text{prm}} \text{ log expenditure}_{ht} + \epsilon_{iht}^{\text{prm}}. \end{aligned} \tag{19}$$

In this regression $\beta_i^{\text{prm}}$ can be interpreted as barcode $i$'s own price-elasticity among premium consumers. The regression controls for a judiciously constructed set of household-specific competitors for each barcode $i$. Leveraging data on shopping trips from the consumer panel and store-level pricing information from NielsenIQ's retail-scanner data, I ensure that $\mathscr{K}_{iht}$ is comprised of barcodes $j \in m(i)$ that are actually available to household $h$ at $\text{price}_{jr(h)t}$.

In order to address potential endogeneity issues in the relationship between $\text{quantity}_{iht}$ and $\text{price}_{iht}$, note that idiosyncratic determinants of the quantity choice of a particular household are, in all likelihood, orthogonal to retail prices. The reverse causality concern, therefore, boils down to the presence of local demand shocks that are observable to retailers (and thus reflected in pricing) but unobservable to the econometrician. I absorb those forces controlling for region-time fixed effects while also constructing price instruments in the spirit of Hausman (1996). That is, I instrument $\text{price}_{iht}$ with the average price for barcode $i$ in year $t$ excluding observations from region $r(h)$. Price-elasticities are, therefore, identified by within household/region-time price-variation that is explained by global price-movements. The identifying assumption is that pricing decisions that apply to barcodes throughout entire retail chains are orthogonal to local demand conditions. This exclusion restriction is consistent with evidence of uniform pricing across stores as documented by DellaVigna and Gentzkow (2019). Since all coefficients in (19) are indexed at the barcode-level, under mild clustering conditions on $\epsilon^{\text{prm}}_{iht}$, all regressions are run barcode by barcode.

Proceeding analogously for the set of basic consumers $\mathscr{H}|^{mt}_{\text{basic}}$, I define a barcode-level measure of relative price-elasticity as

$$Q\,\hat{\beta}_i \equiv \hat{\beta}^{\text{bsc}}_i / \hat{\beta}^{\text{prm}}_i. \tag{20}$$

Whenever $Q\,\hat{\beta}_i > 1$, premium consumers are less price-elastic with respect to barcode $i$ compared to basic consumers. After controlling for module fixed effects, the binscatter in Figure 3 depicts these relative price-elasticities against barcode-level premium scores on the $x$-axis. The graph reveals that basic consumers are less price-elastic than premium consumers when it comes to inexpensive varieties. Vice versa, premium consumers are less price-elastic than basic consumers when it comes to premium items. The regularity here is that, as households spends relatively more on a particular type of good, they become less and less price-elastic with respect to that type of consumption; price-elasticities decline in spending shares.

Under homothetic preferences price-elasticities are constant along the expenditure distribution. Consequently, a model with a standard homothetic demand structure inevitably fails to capture this feature of the micro-data. However, as illustrated with Figure 4, a nonhomothetic demand structure generates price-elasticities that are qualitatively well-aligned with the empirical data. Since household premium-indices increase with expenditure levels, the nonhomothetic framework formalizes an environment in which poor consumers inelastically opt for the least expensive alternative. Similarly, wealthier consumers exhibit minimal substitution responses to price fluctuations for their preferred premium varieties, whereas middle-class households are moderately price-elastic in either direction.

## 2.3 Firm behavior under nonhomothetic demand

We have seen that recessionary changes in expenditures lead to shifts in demand patterns along the quality margin. How do these shifts, in turn, affect competition among producers of cheap vs premium goods? Since household-level price-elasticities decrease in spending shares, a shift of demand towards low-quality varieties means that low-quality producers gain market power. As a consequence, low-quality producers charge higher markups.

**Firm profits.** There is a continuum of sectors. Each sector contains a finite set of firms. Each firm produces a single variety $(i, q, s)$ and is identified with the indexation of their production output. Moreover, each firm $(i, q, s)$ produces with constant marginal cost $\lambda_{iqs}$ and takes as given the downward sloping demand functions $c_{iqs}(y, \boldsymbol{p})$ defined in equation (10). In this partial equilibrium exercise, firms also take as given an exogenous expenditure distribution with density $g(y)$. Aggregate profits under a prevailing price vector $\boldsymbol{p}$ are

$$\pi_{iqs}\big(\lambda_{iqs}, \boldsymbol{p}, g\big) = \int c_{iqs}(y, \boldsymbol{p})(p_{iqs} - \lambda_{iqs})\, g(y)\, dy. \tag{21}$$

Note that, with homothetic preferences, demand is linear in $y$ such that profits merely scale with aggregate expenditures. It follows that, under homothetic preferences, the expenditure distribution would be entirely immaterial for the producers' profit maximization program.

**Notation.** To streamline notation, the sectoral expenditure share of a consumer of type $y$ on variety $(i, q, s)$ is denoted by

$$x_{iqs}(y, \boldsymbol{p}) \equiv \frac{p_{iqs} c_{iqs}(y, \boldsymbol{p})}{p_s(y, \boldsymbol{p})\, c_s(y, \boldsymbol{p})}. \tag{22}$$

Moreover, the consumption of $(i, q, s)$ of a household $y$ relative to the aggregate consumption of $(i, q, s)$ is

$$\tilde{c}_{iqs}(y, \boldsymbol{p}, g) \equiv \frac{c_{iqs}(y, \boldsymbol{p})}{\int c_{iqs}(y, \boldsymbol{p})\, g(y)\, dy}. \tag{23}$$

This expression provides us with a measure of the relative importance of consumers of type $y$ for the customer base of producer $(i, q, s)$. Finally, the price-elasticity of variety $(i, q, s)$ among consumers of type $y$ is denoted by

$$\varepsilon_{iqs}(y, \boldsymbol{p}) \equiv \left| \frac{\partial \log c_{iqs}(y, \boldsymbol{p})}{\partial \log p_{iqs}} \right|. \tag{24}$$

**Equilibrium**. In terms of primitives, the economy is represented by a marginal cost distribution $\{\lambda_{iqs}\}$, an exogenous expenditure distribution $g(y)$, as well as a parameterization of the preference structure in (1) and (2). Firms compete in prices. The Bertrand equilibrium is then defined as a price vector $\boldsymbol{p}^* = \big(p^*_{iqs}\big)$ such that consumption allocations are consistent with the Marshallian demand functions $\{c_{iqs}(y, \boldsymbol{p}^*)\}$ and firms' pricing decisions constitute a Nash equilibrium. That is, $\boldsymbol{p}^*$ solves

$$\int \left( \frac{\partial c_{iqs}(y, \boldsymbol{p})}{\partial p_{iqs}} \bigg|_{\boldsymbol{p}^*} \big(p^*_{iqs} - \lambda_{iqs}\big) + c_{iqs}(y, \boldsymbol{p}^*) \right) g(y)\, dy = 0 \quad \forall \quad (i, q, s). \tag{25}$$

Appendix B outlines an algorithm to compute this equilibrium numerically.

**Households' price-elasticities.** Under Bertrand competition the price-elasticity of variety $(i, q, s)$ for a consumer of type $y$ is given as

$$\varepsilon_{iqs}(y, \boldsymbol{p}) = \big(1 - x_{iqs}(y, \boldsymbol{p})\big)\, \sigma + x_{iqs}(y, \boldsymbol{p})\, \eta\, \zeta_{iqs}(y, \boldsymbol{p}). \tag{26}$$

In the above expression

$$\zeta_{iqs}(y, \boldsymbol{p}) \equiv \frac{\Big(\sigma\, \bar{\xi}(y, \boldsymbol{p}) + (1 - \sigma)\, \xi_q\Big)^2}{\sigma\, \eta\;\bar{\xi}(y, \boldsymbol{p})^2 + (1 - \sigma)\, \eta\;\bar{\xi^2}(y, \boldsymbol{p}) + (1 - \eta)\, \bar{\xi}(y, \boldsymbol{p})} \tag{27}$$

modulates across-sector substitutability due to the "nonlinearity" in sectoral prices. The derivation is relegated to Appendix B. When consumers shift spending towards a given variety $(i, q, s)$, they become less price-elastic vis-à-vis this particular variety. For instance, from (26) and (27) we can see that, in markets with a single low-quality option, poor consumers' price-elasticity for this variety approaches $\eta$. Since pricier high-quality alternatives are not affordable as substitutes, from the perspective of those consumers there is effectively no within-sector competition; there is only across-sector competition with other low-quality varieties in different sectors. Emphasizing the importance of competition within quality bins, the availability of multiple low-quality options weakens this lock-in effect.

It is worthwhile noting that the price-elasticity in (26) is a generalization of more familiar settings. With $\xi_q = 1$ for all $q$, preferences specialize to a nested homothetic CES structure. That is, expenditure shares are constant across the expenditure distribution and $\zeta(y, \boldsymbol{p})$ is identically equal to one. As a consequence, the price-elasticity in (26) collapses into the standard expression from Atkeson and Burstein (2008). That is,

$$\varepsilon_{iqs}(\boldsymbol{p}) = \big(1 - x_{iqs}(\boldsymbol{p})\big)\,\sigma + x_{iqs}(\boldsymbol{p})\,\eta.$$

Moreover, without a distinction between within- vs across-sector substitutability, such that $\sigma = \eta$, we effectively dispense with the effects of granularity. The price-elasticity of $(i, q, s)$ even further specializes to the standard expression obtained under monopolistic competition. That is, $\varepsilon_{iqs} = \sigma \ \forall \ (i, q, s)$.

**Markups**. Recessionary changes in demand patterns affect the strategic price-setting decisions of cheap vs premium producers differently. In general, firms set markups in reference to some concept of demand-elasticity. With nonhomothetic preferences, the relevant notion of demand-elasticity for producer $(i, q, s)$ is the cross-sectional average of consumer-specific price-elasticities weighted at the corresponding relative consumption shares. That is,

$$\int \varepsilon_{iqs}(y, \boldsymbol{p}^*)\,\tilde{c}_{iqs}(y, \boldsymbol{p}^*, g)\,g(y)\,dy. \tag{28}$$

Intuitively, producers consider price-elasticities throughout the entire cross-section, $\varepsilon_{iqs}(y, \boldsymbol{p}^*)$, but they also take into account which consumers ultimately matter for their customer base, $\tilde{c}_{iqs}(y, \boldsymbol{p}^*, g)$, as well as the mass of those consumers in the population, $g(y)$.

The gross markup is then defined as price over marginal cost, $\mu_{iqs} \equiv p_{iqs}/\lambda_{iqs}$. The first-order conditions in (25), therefore, dictate that profit maximizing markups are given by the following Lerner-type formula

$$\mu_{iqs}(\boldsymbol{p}^*, g) = \frac{\displaystyle\int \varepsilon_{iqs}(y, \boldsymbol{p}^*)\,\tilde{c}_{iqs}(y, \boldsymbol{p}^*, g)\,g(y)\,dy}{\displaystyle\int \varepsilon_{iqs}(y, \boldsymbol{p}^*)\,\tilde{c}_{iqs}(y, \boldsymbol{p}^*, g)\,g(y)\,dy - 1}. \tag{29}$$

When setting markups, firms trade off the loss of business from relatively elastic customers with the rents they could extract from the less elastic segment of their respective customer base. For tangibility, envision the problem of a producer marketing a particularly expensive, high-quality variety. The customer base for this variety is comprised of moderately price-elastic middl- class households as well as price-inelastic consumers populating the far-out right tail of $g(y)$. When contemplating a price increase, the producer weighs the loss of business from middle-class consumers who would substitute towards cheaper alternatives against the higher margin earned from the price-insensitive, affluent segment of their customer base. This trade-off takes into account the respective mass of each one of those consumer types in the population. Strategic price-setting, therefore, depends on the expenditure distribution.

# 3 Quantification

In this section I outline my calibration strategy. Specifically, I parameterize the nonhomothetic demand structure based on data moments from the NielsenIQ Homescan Consumer Panel. Additionally, I leverage expenditure data from the PSID to capture the distribution of household spending beyond fast-moving consumer goods.

**Quantitative model.** For parsimony, I make a binary quality distinction with $q \in \{\text{low}, \text{high}\}$. Firms' marginal costs $\lambda_q$ are quality-dependent. In my baseline model there are no differences in marginal cost within quality tiers. A sector is, therefore, fully characterized by the number of firms operating in each quality bin. I partition the continuum of sectors $\mathscr{S}$ into a finite number of uncountably infinite sets of identical sectors. Specifically, I consider 25 distinct sector compositions with $\left(N_{\text{low}}, N_{\text{high}}\right) \in \{1, \ldots, 5\}^2$. The measure of each one of these compositions is given by the corresponding fraction in the data. Similarly, I read the expenditure distribution directly off of the PSID. Note that, while entirely immaterial in a homothetic framework, under nonhomotheticities the expenditure distribution is a crucial determinant of consumption patterns. Robustness checks with a more granular segmentation of the quality spectrum as well as productivity differences within quality bins are relegated to Appendix D.

**Calibration**. I calibrate the firms' marginal costs $\lambda_q$ to align my model with empirical evidence on relative prices along the premium margin. To recover a suitable target from the data, I compute the sales-weighted average of below vs above median prices in each product module. I then average the resulting ratio across modules.

I calibrate the nonhomotheticity parameters $\left\{\xi_q\right\}$ to match the consumption of cheap vs expensive goods across the expenditure distribution. Since model-implied Engel curves are functions of nominal spending $y$, the parameterization of $\left\{\xi_q\right\}$ is inextricably linked with scale of the expenditure distribution. Therefore, let $\nu$ denote a scalar such that $y_{\text{data}} = \nu\, y$. Conditionally on having matched relative prices, I calibrate the parameters $\left(\{\xi_q\}, \nu\right)$ targeting household premium-indices and household premium-dispersion across the expenditure distribution.[4]

With exogenously given sector compositions, the taste-parameters $\left\{\varphi_q\right\}$ shift consumption across quality-tiers and therefore speak to measures of sectoral sales concentration.[5] Since most competition is inherently local, the relevant measure of concentration is that of local sales concentration.[6] I therefore calibrate my model to match moments of the distribution of local sales HHIs from Benkard, Yurukoglu, and Zhang (2023).

Lastly, I temporarily shut down nonhomotheticities in my model environment, and pin down the parameters governing within- and across-sector substitutability to match the model-implied markup distribution from Becker, Edmond, Midrigan, and Xu (2024).[7] Since their model implies a local sales HHI that is consistent

[4]As $\eta \to 1$, the scale of the nonhomotheticity parameters $\left\{\xi_q\right\}$ is increasingly less identified. Since, in my calibration $\eta = 1.025$, I normalize $\xi_{\text{low}} = 1$.

[5]With homothetic preferences $\varphi_q$ and $\lambda_q$ are not separately identified from revenue moments. Under nonhomothetic preferences, however, the distinction between $\varphi_q$ and $\lambda_q$ is meaningful, even if the calibration was confined to revenue data.

[6]See e.g. Rossi-Hansberg and Hsieh (2023) or Franco (2024).

[7]As pointed out by Bond *et al.* (2022) the measurement of markups based on revenue data is an

with my calibration target, I choose $\{\eta, \sigma\}$ to translate this HHI of 0.21 into an aggregate markup of 1.31. When reintroducing nonhomotheticicities, the model-implied aggregate markup increases from its calibration target of 1.31 to 1.41. Intuitively, for the same level of concentration, a quality distinction means that competition is diluted. Table 1 summarizes the model fit.

**Validation**. In Table 2 I also report some key moments that were not targeted in my calibration exercise. An untargeted moment that is crucial for the response of markups to changes in spending patterns, is that of relative price-elasticities for different-quality varieties. Computing the ratio of model-implied price-elasticities for poor vs rich consumers in each quality bin, I find that my model is perfectly in line with the evidence presented in Section 2.2.

Since production markups are not readily measured in the data, I compute retail markups from PriceTrak PromoData and correlate them with barcode-level premium scores.[8] I find that there is no particular correlation between markups and premium scores. The model-implied relative markup on high- vs low-quality goods aligns well with the data (on retail-markups) and is reported in Table 2.

# 4 Quantification of the Markup Channel

I feed observed changes in the expenditure distribution into my model and find an unequal markup response for low- vs high-quality goods during the Great Recession. Low-quality markups increase, whereas high-quality markups fall. As a result, recession-induced shifts in demand patterns make recessions even more burdensome for poor consumers. Providing direct evidence on this mechanism, I show that relative price movements in the data are consistent with my model predictions.

inherently bleak endeavor. I, therefore, target model-implied markups.

[8]The underlying assumption here is that retail and production markups are proportional in each quality bin.

## 4.1 An unequal markup response

In this subsection I isolate the response of different-quality markups to demand shifts during the Great Recession. I use my model to abstract away from the price impact of recessionary changes in the firms' marginal cost structure. Specifically, I feed observed changes in the expenditure distribution into my model, which is calibrated to match pre-crisis moments on the relative price of different-quality varieties.

**Changes in the expenditure distribution.** In a nutshell, the Great Recession led to a drop in overall spending alongside a slight narrowing of expenditure inequality. This observation emerges from a comparison of symmetrically PCE-deflated expenditures in PSID data for 2006 vs 2012. Given the biennial nature of the PSID, this choice of period accounts for the full impact of the crisis on consumer spending habits, thereby acknowledging scarring effects and longer-lasting changes in expenditure patterns. While expenditures decline at the outset of the recession, the most pronounced shifts are observed when comparing pre-crisis (2006) and post-crisis (2012) periods. Expenditure levels return to, and eventually exceed, pre-crisis levels in subsequent years. Figure 5 depicts a histogram comparing the expenditure distribution in 2006 with that of 2012. There is a notable influx of expenditure mass into the lower end of the support and a slight decrease in inequality. Specifically, average spending declines by 15.9% while the 75/25 percentile ratio of the distribution decreases from 3.02 to 2.89.

**Model-implied markup response.** On average, the Great Recession causes a 6.79 percentage point increase in model-implied markups for low-quality varieties. In contrast, markups for high-quality goods decline by an average of 1.82 percentage points. I refer to the economic forces underlying this unequal markup response as the *markup channel*. To isolate this markup channel in this exercise, the Great Recession manifests exclusively in terms of a change in the expenditure distribution. The firms' marginal cost structure is counterfactually fixed and conforms with the pre-crisis calibration of the environment.

Table 3 presents model-implied markup and price changes during the Great Recession. The results are stratified by within-sector competition levels. Naturally, there is a more pronounced markup response in markets with lower levels of competition where firms capitalize on the limited options available to consumers. Conversely, in markets with high competition, the availability of multiple options curtails market power. Intuitively, the ability to substitute within quality bins means that households remain more price-elastic even as they consume a less variegated mixture across quality tiers.

As the Great Recession causes households to spend less, there is a substantial shift of consumption towards relatively inexpensive, low-quality goods. Producers of those lower-quality varieties respond to this inflow of customers by charging higher markups.[9] Specifically, I find that markups for low-quality varieties increase by an average of 6.79 percentage points. With a fixed marginal cost structure, this corresponds to a 4.19% price increase. Since even wealthier households opt for less expensive alternatives, the corresponding shift in demand patters prompts producers of high-quality goods to reduce markups. During the Great Recession, the markup channel leads prices of high-quality goods to decrease by an average of 1.21%.

**Impact on consumers across the expenditure distribution.** In PSID data, the expenditure distribution narrows over the course of the Great Recession. This decrease in inequality, however, is reversed when accounting for the markup channel and deflating household expenditures accordingly. Table 4 presents results for quartiles of the expenditure distribution.

It is well-known, e.g. from Heathcote *et al.* (2020), that poor households are disproportionately hit by recessions. They are more likely to lose their jobs and experience an, on average, more substantive decrease in labor earnings compared to richer households. In PSID data, the income distribution's 75/25 percentile

[9] As I quantify the impact of shifts in the expenditure distribution at business cycle frequencies, I deliberately abstract away from entry and exit. The relative profitability of low-quality goods, therefore, does not precipitate a surge in competition in this market segment.

ratio rises from 4.48 to 5.61 during the Great Recession. From the first row of Table 4, at first glance, this does not seem to be true for spending. In percentage terms, the reduction in nominal expenditures among poor consumers is less pronounced than among richer households. This pattern is not implausible: affluent households are able to cut their spending by smoothing along the quality margin; a tool that is not available to poor households whose consumption baskets are largely comprised of low-quality options to begin with.[10] A conclusion to the effect that the Great Recession had a smaller impact on the consumption of poor households would, however, be incorrect. Since recessionary shifts in demand patterns also led to an increase in the relative price of low-quality goods, there is a force that exacerbates inequality in real terms. Accounting for the markup channel during the Great Recession, consumption among poor households actually decreases more than consumption for the rich. In real terms, consumption inequality, measured by the 75/25 percentile-ratio, rises from 3.02 to 3.11.

## 4.2 Inspecting the Mechanism

In this section I build intuition for the forces shaping the previously outlined markup response. Abstracting away from higher-order features of changes in the expenditure distribution, I use my model as a laboratory to examine the markup channel separately in two distinct scenarios: first, I entertain a drop in overall spending and, second, a narrowing of expenditure inequality.

**Aggregate spending.** As spending falls throughout the entire economy, markups along the quality margin respond asymmetrically. Model-implied markups for low-quality goods increase, while high-quality markups fall. The experiment here is what I call a dispersion-preserving shift. I vary aggregate spending while maintaining a fixed level of inequality. For clarity, I conduct this experiment in a stylized environment with a binary quality distinction and a single variety mar-

[10] Poor households' consumption is also closer to subsistence levels. As a consequence, there is not much scope to reduce spending substantialy.

keted in each quality bin. A drop in overall spending means that consumers across the expenditure distribution flock to more affordable, lower-quality options. Consequently, as aggregate spending shares on low-quality goods increase, producers of these varieties gain more market power and charge higher markups. Moreover, as richer households cut their spending, they substitute towards low-quality varieties. The corresponding loss of business prompts producers of high-quality varieties to reduce markups in order to remain competitive. The lefthandside panel of Figure 6 illustrates.

**Inequality.** In isolation, a narrowing expenditure distribution leads markups to decrease across all quality bins. The experiment here is a mean-preserving spread. I vary the standard deviation of $g(y)$ while maintaining a constant level of aggregate spending. As inequality declines, there is a shift of consumers from either tail into the middle of the distribution. Consequently, with a larger mass of middle-class consumers, there is a weaker segmentation of consumer base. As the disciplining influence of moderately price-elastic middle-class households strengthens, firms across different quality bins engage in fiercer competition and charge lower markups. At business cycle frequencies, narrowing inequality, therefore, mitigates the adverse consequences of a recession. The righthandside panel of Figure 6 illustrates.

A remark is in order: Aguiar and Bils (2015) document a secular trend of increasing expenditure inequality over the past couple of decades. So, with a correspondingly dwindling middle-class, firms grow less and less concerned about losing business from price-elastic middle class consumers. Producers at either end of the quality spectrum, in turn, focus on extracting rents and charge higher markups. That said, a proper examination of this possible link between increasing expenditure inequality and rising markups is beyond the scope of this paper. It would certainly require a model that endogenizes market structure and accommodates evidence on the evolution of entry barriers as discussed by Philippon and Gutiérrez (2019).

**A decomposition.** A typical recession unambiguously places downward pressure on high-quality markups. The equilibrium response of low-quality markups, on the other hand, is shaped by two diametrically opposed forces. Table 5 presents a decomposition of the overall markup response in Table 3, separating the impact of the drop in spending as well as the decrease in inequality during the Great Recession. Absent the narrowing of the expenditure distribution, markups for low-quality varieties would have increased by 7.13 percentage points.

## 4.3 Evidence on the Mechanism

In this subsection, I show that, in the data, relative price movements and shifts in spending patterns during the Great Recession are qualitatively consistent with my model predictions. Attributing quantitative discrepancies to other forces, such as recessionary changes in marginal costs, I assess the relative importance of the markup channel.

**Evidence on differences inflation rates.** In economic downturns, markups faced by poor consumers increase relative to those faced by the rich. This model prediction stems from isolating the markup response to shifts in demand patterns, while abstracting away from concurrent changes in firms' marginal cost structure. In the data, where price changes are also driven by marginal cost changes, relative prices for poor consumers are still countercyclical.

To establish this fact, I compute Törnqvist inflation-indeces separately for poor and rich households. That is, for $h \in \{\text{poor}, \text{rich}\}$, I define

$$\text{inflation}_{h,t} \equiv \exp\left(\sum_{i \in \mathscr{I}} \frac{\text{share}_{i,h,t} + \text{share}_{i,h,t-1}}{2} \log\left(\frac{\text{price}_{i,t}}{\text{price}_{i,t-1}}\right)\right) \tag{30}$$

where $\text{share}_{i,h,t}$ is the average expenditure share of consumer segment $h$ on barcode $i$. Crucially, in this definition barcode-level inflation rates are averaged across households and do not differ across consumer segments. As a consequence, any disparity in $\text{inflation}_{h,t}$ stems from differences in consumption choices rather than search behavior. In demarcating poor vs rich consumers, I present results for two different classification schemes. First, I identify as rich those households whose income surpasses their (region- and time-specific) median. Alternatively, I categorize as rich those consumers with above median total spending on NielsenIQ barcodes. Using income rather than expenditure as a proxy for economic status deals with the lack of data on substitutes outside of NielsenIQ (e.g. grocery vs restaurant spending, meaning a high grocery bill doesn't necessarily connote affluence). The focus on expenditures, however, is also sensible, as NielsenIQ lacks wealth data, and income alone might inadequately depict a household's financial situation. The inflation gap between poor and rich is defined as

$$\Delta\, \text{inflation}_{\text{cons.},t} \equiv \text{inflation}_{\text{poor},t} - \text{inflation}_{\text{rich},t}. \tag{31}$$

Figure 7 plots the time series of this inflation gap. Consistent with my model predictions, prices faced by poor consumers increase relative to those faced by the rich – both during as well as in the aftermath of recessions.[11]

In my model, this pattern emerges because cheaper, low-quality options become relatively more expensive in recessions. To confirm that this is also true in the data, I compute Törnqvist indices across the entire population but separately for a partition of NielsenIQ barcodes $\{\mathscr{I}_k\}$ where $k \in \{\text{cheap, premium}\}$. That is,

$$\text{inflation}_{k,t} \equiv \exp\left(\sum_{i\in\mathscr{I}_k} \frac{\text{share}_{i,t} + \text{share}_{i,t-1}}{2} \log\left(\frac{\text{price}_{i,t}}{\text{price}_{i,t-1}}\right)\right). \tag{32}$$

Here, cheap goods are those whose sales-weighted region- and time-average of $\text{premium}_{irt}$ is below zero – and vice versa for $\mathscr{I}_{\text{premium}}$. I average premium-scores over time to ensure that any correlation with inflation rates is not a mechanical

[11] In that sense recessions are a pivotal driver of inflation inequality as documented by e.g. Jaravel (2019). In the long-run disparities in inflation rates are due to a somewhat muted reversal in normal times.

artifact.[12] The inflation gap between cheap and expensive varieties is

$$\Delta \,\text{inflation}_{\text{goods},t} \equiv \text{inflation}_{\text{cheap},t} - \text{inflation}_{\text{premium},t}. \tag{33}$$

Figure 8 plots the time series of this inflation gap. Consistent with my model predictions, the relative price of cheaper, more basic varieties increases both during as well as in the aftermath of recessions.

**Evidence on price-elasticities during recessions.** Another key-prediction of my model is that wealthy households become less price-elastic towards cheaper goods as their consumption shifts towards these goods during recessions. To verify this prediction, I compute barcode-level price elasticities for consumers in $\mathscr{H}\big|^{mt}_{\text{premium}}$ both during and outside of the Great Recession. My estimation follows the same approach as outlined in regression equation (19). Figure 9 displays a binscatter plot of the ratio of price elasticities for a given barcode during the recession versus outside of it. The $x$-axis represents barcode-level premium scores. The results show that, during the recession, wealthy households become price-elastic towards cheaper goods and more price-elastic towards more expensive goods.

# 5 Redistribution in General Equilibrium

Since the markup channel amplifies real consumption inequality, policymakers who are concerned about inequality might naturally consider implementing redistributive interventions. In this section, I explore the impact of redistribution on product market competition within a Bewley-Aiyagari model. I find that redistributive stabilization policies worsen the effects of the markup channel.

[12]Specifically, this precludes a scenario where higher inflation on cheaper goods is not due to a mean-reverting component in marginal cost.

## 5.1 General equilibrium model

Since redistribution to the poor typically distorts incentives to save or work, policymakers face a trade-off between equity and efficiency. Consequently, assessing redistributive policies warrants a general equilibrium model. In this section, I embed the markup channel into a Bewley-Aiyagari model with elastic labor supply.

**Household behavior.** Time is discrete and the economy is populated by a continuum of infinitely-lived households. Each household consumes a bundle of different-quality varieties. The intratemporal consumption allocation decision is governed by the nonhomothetic preferences from equations (1) and (2). For tractability, I maintain that $|\mathscr{S}| = \mathfrak{c}$ but posit that sector compositions are perfectly symmetric. Households differ in their labor market ability $e$ and choose how many hours of labor to supply. Labor market ability follows a Markov chain $e' \sim H(e' \,|\, e)$. To insure against idiosyncratic income risk, households save in a single safe asset.

Households enter a period with endogenously chosen, yet pre-determined, asset holdings $a$ as well as an exogenously drawn idiosyncratic labor market ability $e$. Written recursively, the consumers' problem is to choose $\big(c, h, a'\big)$ in order to solve

$$V(a, e) = \max \left\{ u(c, h) + \beta \, \mathbb{E}\Big[ V(a', e') \,\Big|\, e \Big] \right\} \tag{34}$$

where optimization is subject to a budget constraint

$$p\big(c, \boldsymbol{p}\big)\, c + \bar{p}\, a' = \big(1 + r\big)\, \bar{p}\, a + (1 - \tau)\, w\, e\, h + \pi(a) + T \tag{35}$$

as well as no-borrowing condition $a' \geq 0$. Firm ownership is proportional to a strictly increasing function of asset holdings. That is, aggregate profits $\pi$ are are distributed according to

$$\pi(a) = \frac{f(a)}{\int f(a)\, \Gamma(da, de)}\, \pi \tag{36}$$

where $\Gamma$ is the endogenous stationary distribution of idiosyncratic consumer states. The model, therefore, features heterogeneity in returns to saving, which Benhabib, Bisin and Zhu (2011) argue are key determinants of top wealth inequality. The key departure from a standard incomplete market setting with elastic labor supply is that real consumption enters the budget constraint nonlinearly. Specifically, the nonhomothetic ideal price-index is given as

$$p(c, \boldsymbol{p}) = \left( \sum_{q=1}^{Q} \sum_{i=1}^{N} \varphi_q \, p_{iq}^{1-\sigma} c^{(1-\sigma)(\xi_q - 1)} \right)^{\frac{1}{1-\sigma}}. \tag{37}$$

This object succinctly encapsulates all the intricacies of intratemporal consumption allocation under nonhomothetic preferences.

The households' problem immediately yields policy functions for real consumption $c(a, e)$, hours worked $h(a, e)$, as well as savings $a'(a, e)$. Notably, the implied policy function for nominal spending is

$$y(a, e) = p\big(c(a, e), \boldsymbol{p}\big)\, c(a, e). \tag{38}$$

Since spending is now a choice variable, the expenditure distribution is endogenous and prescribed by the pushforward measure $G = \Gamma \circ y^{-1}$. Later on, this endogenous expenditure distribution is a crucial input for product market competition.

To appreciate how households trade off spending, leisure, and savings, I next present the first-order conditions that shape consumer decision making. To that end, I first define the marginal price of real consumption as

$$\tilde{p}(c, \boldsymbol{p}) \;\equiv\; p(c, \boldsymbol{p}) + \frac{\partial\, p(c, \boldsymbol{p})}{\partial\, c}\, c. \tag{39}$$

This object can be thought of as the partial derivative of nominal spending with respect to real consumption.[13] The consumers' intratemporal consumption leisure

[13]For a natural cardinalization of homothetic preferences with $\xi_q = 1$ for all $q$, the marginal price of real consumption is just the familiar constant homothetic CES price-index.

trade-off is then governed by

$$u_h(c,h) = -u_c(c,h)\,\frac{(1-\tau)\,w\,e}{\tilde{p}\big(c,\boldsymbol{p}\big)} \tag{40}$$

while the intertemporal consumption savings trade-off is given through

$$\mathbb{E}\left[\beta\,\frac{u_c(c',h')}{u_c(c,h)}\,\frac{\tilde{p}\big(c,\boldsymbol{p}\big)}{\tilde{p}\big(c',\boldsymbol{p}'\big)}\,\big(1+r\big)\,\middle|\,e\right] \leq 1. \tag{41}$$

**Firm behavior.** Firms maximize profits vis-à-vis the now-endogenous expenditure distribution $G$. They operate a constant returns to scale production technology such that

$$c_{iq} = z_q\,\ell_{iq}^{1-\alpha} k_{iq}^{\alpha}. \tag{42}$$

Cost-minimization, therefore, dictates that firms produce under constant marginal cost with

$$\lambda_q = \frac{1}{z_q}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}\left(\frac{r\,\bar{p}}{\alpha}\right)^{\alpha}. \tag{43}$$

The price setting protocol is precisely as beforehand. Given consumer policies, profit-maximizing prices are pinned down through a Lerner-type expression for markups

$$\mu_q(\boldsymbol{p}^*,g) \equiv \frac{p_q^*}{\lambda_q} = \frac{\displaystyle\int \varepsilon_q(y,\boldsymbol{p}^*)\,\tilde{c}_q(y,\boldsymbol{p}^*,g)\,g(y)\,dy}{\displaystyle\int \varepsilon_q(y,\boldsymbol{p}^*)\,\tilde{c}_q(y,\boldsymbol{p}^*,g)\,g(y)\,dy - 1}. \tag{44}$$

where $g(y)$ satisfies $\Gamma \circ y^{-1}(da,de) = g(y)\,dy$.

**Equilibrium.** The stationary equilibrium in this economy is characterized by a vector $\big(r,w,\boldsymbol{p},\pi,T\big)$ such that households optimize according to (34) and (35), different-quality prices are consistent with

$$p_q = \mu_q\big(\boldsymbol{p},g\big)\,\lambda_q \quad \forall \quad q=1,\ldots,Q, \tag{45}$$

market clear such that

$$r\,\bar{p}\int a\,\Gamma(da,de) = \alpha\sum_{q=1}^{Q}\sum_{i=1}^{N}\lambda_q\int c_q(a,e)\,\Gamma(da,de) \tag{46}$$

$$w\int e\,h(a,e)\,\Gamma(da,de) = (1-\alpha)\sum_{q=1}^{Q}\sum_{i=1}^{N}\lambda_q\int c_q(a,e)\,\Gamma(da,de) \tag{47}$$

and the government runs a balanced budget with

$$\tau\,w\int e\,h(a,e)\,\Gamma(da,de) = T. \tag{48}$$

The stationary distribution satisfies

$$\Gamma\big(\mathscr{A}\times\mathscr{E}\big) = \int \mathbb{1}\big\{a'(a,e)\in\mathscr{A}\big\}\sum_{e'\in\mathscr{E}} H(e'|e)\;\Gamma(da,ae) \tag{49}$$

for all Borel-sets $\mathscr{A}$ and $\mathscr{E}$ and $g(y)$ is the Radon-Nikodym derivative of the pushforward $\Gamma\circ y^{-1}$.

**Calibration.** I calibrate my general equilibrium model at the quarterly frequency to match data moments of the joint income and wealth distribution. The parameterization of the nonhomothetic ideal-price index follows the same strategy I adopted in Section 3. Parameter values, calibration targets, and model fit are reported in Table 6.

## 5.2 The markup channel and redistributive policy

In this section, I study how a recession affects relative prices, the cyclicality of different-quality goods, and real consumption inequality in this Bewley-Aiyagari setting. I find that redistributive policy increase the relative price of low-quality goods.

**The markup channel in general equilibrium.** I generate a recession through a persistent aggregate TFP shock $\Theta_t$ that symmetrically decreases productivity across all quality-tiers. That is, for each $q \in \{\text{low, high}\}$, productivity is given by

$$z_{q,t} = z_q \exp(\Theta_t).$$

For the following illustrations, $\{\Theta_t\}$ encodes a $-5\%$ MIT shock hitting the economy at time $t = 0$ and decaying exponentially with a persistence of 0.95. In order to isolate the effects of the markup channel, Figure 10 shows the time-paths of relative prices and consumption quantities in two distinct scenarios: without and with markup adjustments.[14]

First, I counterfactually prevent firms from reoptimizing markups by keeping $\mu_{q,t}$ fixed at its pre-recession value. Since marginal cost changes are identical across producers, this suppression of the markup channel eliminates changes in the relative price of different-quality goods. As the recession hits, households shift from more expensive, higher-quality goods to more affordable options. The red lines in the middle and right panel of Figure 10 illustrate that, without markup adjustments, high-quality consumption significantly declines, whereas consumption of lower-quality goods increases relative to its steady-state level.

Secondly, I allow producers to adjust their markups to maximize profits. Now, as households switch towards lower-quality consumption, lower-quality producers gain market share and charge higher markups. Consequently, the relative price of low-quality goods increases during the recession. This increase in relative price, in turn, moderates the shift towards low-quality varieties; so much so that the aggregate consumption of low-quality goods actually falls. The markup channel, therefore, dampens the cyclical fluctuations of high-quality consumption while amplifying those of low-quality consumption.

Since the markup channel raises the relative price of low-quality goods, it increases real consumption inequality. Figure 11 shows the appropriately deflated spending of households in the bottom half as well as the top decile of the ex-

[14] The computation of these time-paths follows the first-order approximation from Bhandari, Bourany, Evans, and Golosov (2023).

penditure distribution. The markup channel disproportionately harms poorer consumers while benefiting wealthier ones.

**Redistribution through automatic stabilization.** In order to assess the interaction of the markup channel with redistributive policy interventions, I study the implementation of an automatic stabilizer[15]

$$\psi\,\Theta_t. \tag{50}$$

Setting the policy parameter $\psi < 0$, a policymaker imposes extra taxes on labor income and redistributes the additional revenue through lump-sum rebates. The resulting budget constraint is given by

$$p\big(c_t, \boldsymbol{p}_t\big)\,c_t + \bar{p}_t\,a_{t+1} = \big(1 + r_t\big)\,\bar{p}_t\,a_t + \big(1 - \tau - \psi\,\Theta_t\big)\,w_t\,e_t\,h_t + \pi(a_t) + T_t + S_t \tag{51}$$

where the lump-sum transfer $S_t$ is such that

$$S_t = \psi\;\Theta_t \int h_t(a,e)\,e\;\Gamma_t(da,de). \tag{52}$$

Note that this policy intervention constitutes a redistribution towards households with lower labor-income. Evaluating the impact of this automatic stabilizer requires a general equilibrium framework, as an increase in labor taxes is bound to distort incentives for labor supply.

The dotted green line in leftmost panel of Figure 10 depicts the time-path of the relative price of low-quality goods for $\psi = -2$, meaning that a 1% drop in aggregate TFP results in a 2 percentage point increase in labor taxes. The relative price increase is more than twice as large as in the scenario without stabilization. Intuitively, when redistributing to the poor, the policymaker transfers funds that would have been spent on high-quality goods to those who instead spend

[15] While optimal policy design is beyond the scope of this paper, the presence of curvature in my model economy implies that, in the wake of a recession, a policy authority that is concerned with inequality finds it desirable to redistribute towards the poor.

on lower-quality goods. Consequently, lower-quality producers gain even more market share and charge even higher markups. While the markup channel itself increases inequality, redistribution actually amplifies the markup channel.

The green lines in Figure 11 show that while redistributive policy provides a limited amount of relief immediately after the shock, it leads to *cheapflation* that significantly harms poor consumers in the long run. As a result, redistribution ends up hurting the very population it was intended to help.

# 6 Conclusion

This paper shows that the well-documented shift in demand towards low-quality goods during recessions results in higher prices for poor consumers. The primary mechanism behind this phenomenon is the *markup channel*: as consumers switch to lower-quality goods, producers of these goods gain market power and increase their markups. This mechanism underscores recessions as a major driver of *cheapflation*.

Given that the markup channel increases real consumption inequality, policymakers might consider redistributing towards the poor during recessions. By incorporating the markup channel into a Bewley-Aiyagari setting, this paper shows that such redistribution actually increases the relative price of low-quality consumption even further, thereby worsening the very inequality it aims to address. Since the adverse impact on real consumption inequality stems from a disruption of product market competition, the insights from this paper call for product market interventions. Future research could explore quality-specific subsidies, such as those implemented through food stamps, as a potential solution.

## References


Aguiar, Mark and Mark Bils (2015). "Has Consumption Inequality Mirrored Income Inequality?" *American Economic Review*, 105, 2725-2756.

Aguiar, Mark and Erik Hurst (2005). "Consumption versus Expenditure." *Journal of Political Economy*, 113, 919-948.

Albrecht, James, Guido Menzio, and Susan Vroman (2023). "Vertical Differentiation in Frictional Product Markets." *Journal of Political Economy: Macroeconomics*, 1, 586-632.

Anderson, Eric, Sérgio Rebelo, and Arlene Wong (2020). "Markups Across Space and Time."

Argente, David and Munseob Lee (2021). "Cost of Living Inequality during the Great Recession." *Journal of the European Economic Association*, 19, 913-952.

Atkeson, Andrew and Ariel Burstein (2008), "Pricing-to-Market,Trade Costs, and International Relative Prices." *American Economic Review*, 98,1998-2031.

Becker, Jonathan, Chris Edmond, Virgiliu Midrigan, and Daniel Y. Xu (2024). "National Concentration, Local Concentration, and the Spatial Distribution of Markups."

Benkard, C. Lanier, Ali Yurukoglu, and Anthony Lee Zhang (2021). "Concentration in Product Markets." *National Bureau of Economic Research*.

Berry Steven, James Levinsohn, and Ariel Pakes (1995). "Automobile Prices in Market Equilibrium." *Econometrica*, 63.

Bils, Mark and Peter J. Klenow (2001). "Quantifying Quality Growth." *American Economic Review*, 91, 1006-1030.

Bisgaard-Larsen, Rasmus and Christoffer J. Weissert (2020). "Quality and Consumption Basket Heterogeneity."

Boar, Corina, and Virgiliu Midrigan (2023). "Markups and Inequality." *National Bureau of Economic Research.*

Bond, Steve, Arshia Hashemi, Greg Kaplan, and Piotr Zoch (2021). "Some Unpleasant Markup Arithmetic: Production Function Elasticities and their Estimation from Production Data." *Journal of Monetary Economics*, 121, 1-14.

Boppart, Timo (2014). "Structural Change and the Kaldor Facts in a Growth Model With Relative Price Effects and Non-Gorman Preferences." *Econometrica*, 82, 2167-2196.

Bornstein, Gideon and Alessandra Peter (2024), "IneQuality."

Buera, Fransisco J. and Joseph P. Kaboski (2009). "Can Traditional Theories of Structural Change Fit the Data?" *Journal of the European Economic Association*, 7, 469-477.

Burstein, Ariel, Martin Eichenbaum, and Sérgio Rebelo (2005). "Large Devaluations and the Real Exchange Rate." *Journal of Political Economy*, 113, 742-784.

Burstein, Ariel, Vasco M. Carvalho, and Basile Grassi (2020). "Bottom-up Markup Fluctuations." *National Bureau of Economic Research.*

Chetty, Raj, John N. Friedman, and Jonah E. Rockoff (2014). "Measuring the Impacts of Teachers II: Teacher Value-Added and Student Outcomes in Adulthood." *American Economic Review*, 104, 2633-2679.

Cirelli, Fernando (2022). "Bank-Dependent Households and the Unequal Costs of Inflation."

Comin, Diego, Danial Lashkari, and Martí Mestieri (2021). "Structural Change with Long-Run Income and Price Effects." *Econometrica*, 89, 311-374.

Deaton, Angus, and John Muellbauer (1980). "Economics and Consumer Behavior." *Cambridge University Press.*

DellaVigna, Stefano and Matthew Gentzkow (2019). "Uniform Pricing in US Retail Chains." *The Quarterly Journal of Economics*, 134, 2011-2084.

Edmond, Chris, Virgiliu Midrigan, and Daniel Yi Xu (2013). "How Costly are Markups?" *Journal of Political Economy* 131, 000-000.

Fajgelbaum, Pablo D., Gene M. Grossman, and Elhanan Helpman (2011). "Income Distribution, Product Quality, and International Trade." *Journal of Political Economy*, 119, 721-765.

Ferraro, Domenico and Vytautas Valaitis (2022). "Wealth and Hours."

Handbury, Jessie (2021). "Are Poor Cities Cheap for Everyone? Non-Homotheticity and the Cost of Living across US Cities." *Econometrica* 89, 2679-2715

Hanoch, Giora (1975). "Production and Demand Models With Direct or Indirect Implicit Additivity." *Econometrica*, 43, 395-419.

Hausman, Jerry A. (1996). "Valuation of New Goods under Perfect and Imperfect Competition." *The Economics of New Goods*.

Heathcote, Jonathan, Fabrizio Perri, and Giovanni L. Violante (2020). "The Rise of US Earnings Inequality: Does the Cycle drive the Trend?" *Review of Economic Dynamics*, 37, 181-204.

Herrendorf, Berthold, Richard Rogerson, and Akos Valentinyi (2014). "Growth and Structural Transformation." *Handbook of Economic Growth*, 2, 855-941.

Hitsch, Günter J., Ali Hortacsu, and Xiliang Lin (2019). "Prices and Promotions in US Retail Markets: Evidence from Big Data." *NBER Working Paper*.

Jaimovich, Nir, Sérgio Rebelo, and Arlene Wong (2019). "Trading down and the Business Cycle." *Journal of Monetary Economics*, 102, 96-12.

Jaravel, Xavier (2019). "The Unequal Gains from Product Innovations: Evidence from the US Retail Sector." *The Quarterly Journal of Economics*, 134, 715-783.

Jaravel, Xavier, and Danial Lashkari (2024). "Measuring Growth in Consumer Welfare with Income-Dependent Preferences: Nonparametric Methods and Estimates for the United States." *The Quarterly Journal of Economics*, 139, 477-532.

Jaravel, Xavier and Alan Olivi (2021). "Prices, Non-homotheticities, and Optimal Taxation."

Jørgensen, Casper N. and Leslie Shen (2022), "Consumption Quality and the Welfare Implications of Business Cycle Fluctuations."

Kaplan, Greg and Guido Menzio (2015). "The Morphology of Price Dispersion." *International Economic Review* 56, 1165-1206.

Kaplan, Greg and Guido Menzio (2016)."Shopping Externalities and Self-Fulfilling Unemployment Fluctuations." *Journal of Political Economy* 1243, 771-825.

Kongsamut, Piyabha, Sérgio Rebelo, and Danyang Xie (2001). "Beyond Balanced Growth." *Review of Economic Studies*, 68, 869-882.

Marto, Ricardo (2023). "Structural Change and the Rise in Markups."

Matsuyama, Kiminori (2023). "Non-CES Aggregators: A Guided Tour." *Annual Review of Economics*, 15, 235-265.

Nord, Lukas (2022). "Shopping, Demand Composition, and Equilibrium Prices." *SSRN.*

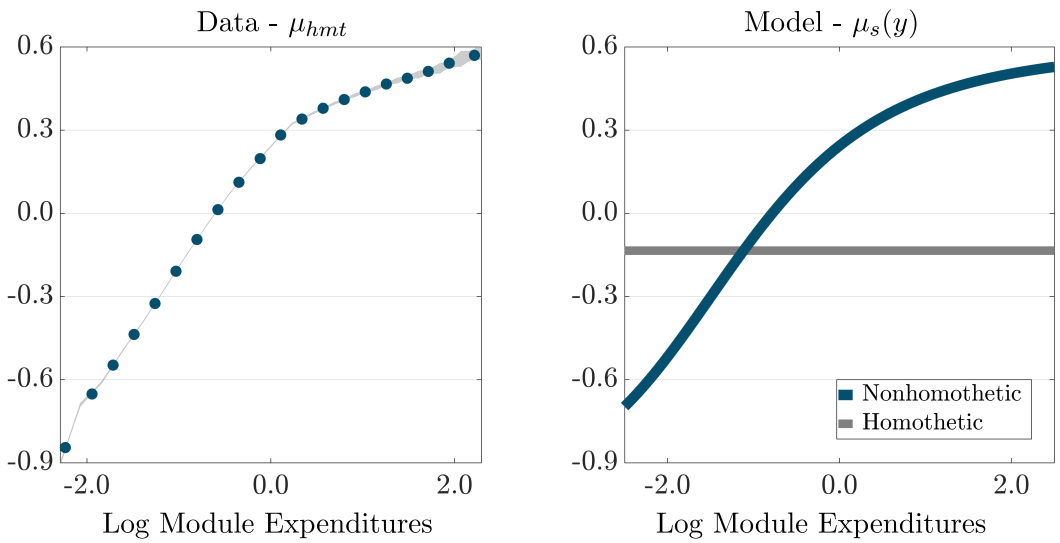
Sangani, Kunal (2023). "Markups Across the Income Distribution: Measurement and Implications."

Straub, Ludwig (2019). "Consumption, Savings, and the Distribution of Permanent Income."

Wachter, Jessica A. and Motohiro Yogo (2010). "Why Do Household Portfolio Shares Rise in Wealth?" *The Review of Financial Studies*, 23, 3929-3965.

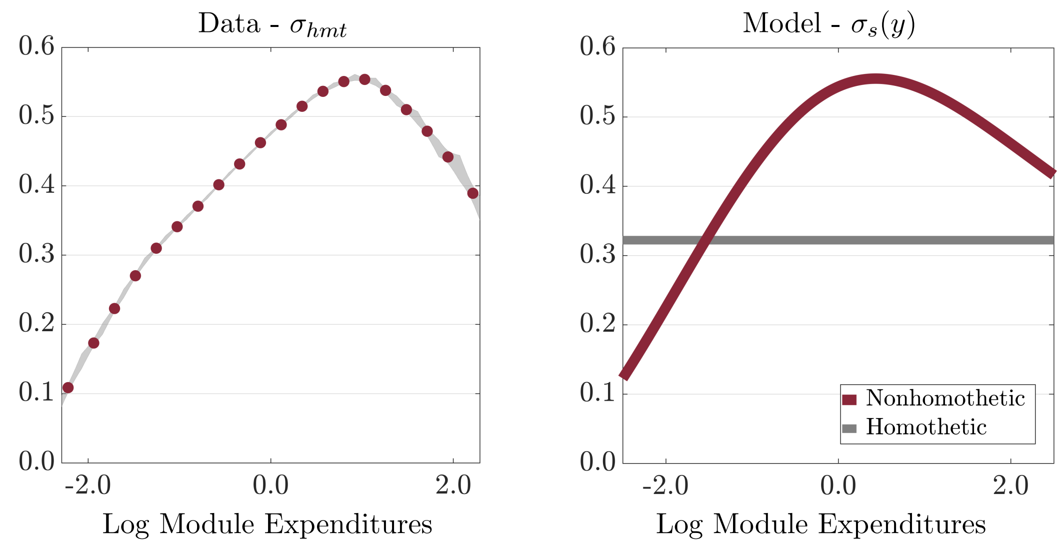
# Appendix A - Figures and Tables

Figure 1: Taste for Premium Goods Increases with Expenditures



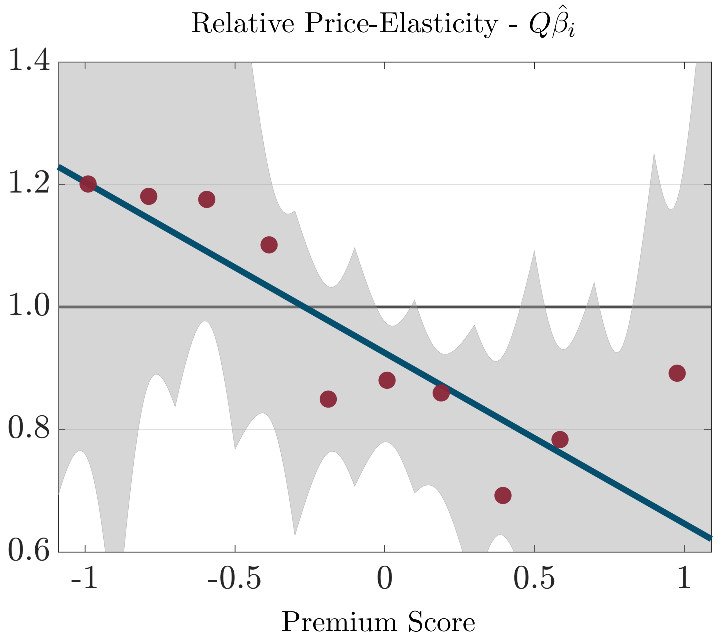

The lefthandside panel depicts a binscatter of the logarithm of region/time normalized household module-expenditures on the $x$-axis against household premium-indices $\mu_{hmt}$ on the $y$-axis. The construction of confidence band for this binscatter follows Cattaneo *et al.* (2023). The righthandside panel plots the model-implied relationship between expenditures and household premium-indices under homothetic as well as nonhomothetic preferences.

Figure 2: Polarization in Consumption Patterns



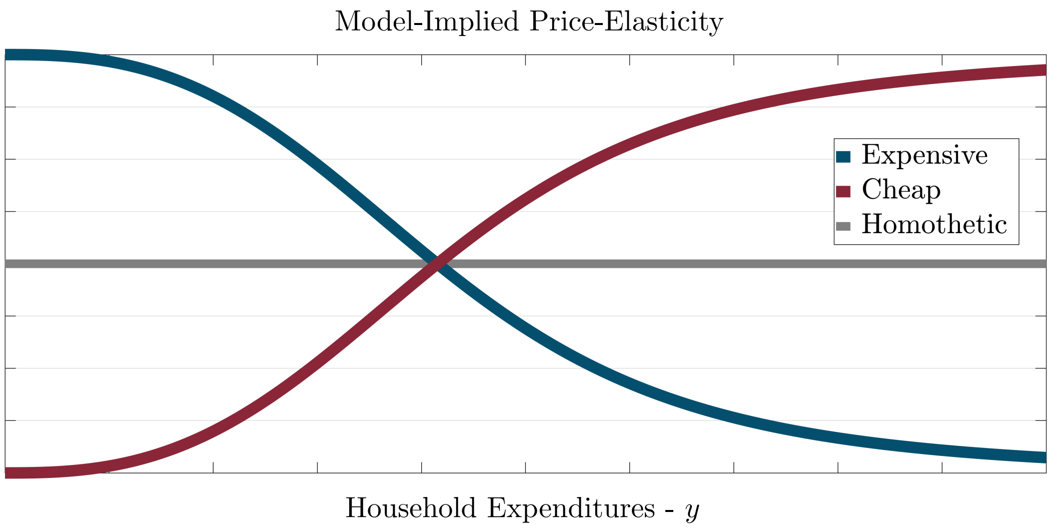

The lefthandside panel depicts a binscatter of the logarithm of region/time normalized household module-expenditures on the $x$-axis against household premium-dispersion $\sigma_{hmt}$ on the $y$-axis. The construction of confidence band for this binscatter follows Cattaneo *et al.* (2023). The righthandside panel plots the model-implied relationship between expenditures and household premium-dispersion under homothetic as well as nonhomothetic preferences.

Figure 3: Differential Price-Elasticities Across the Expenditure Distribution




This Figures depicts a binscatter of the barcode-level premium scores on the $x$-axis against the corresponding relative price-elasticities $Q\hat{\beta}_i$ for rich vs poor households. Confidence bands are constructed following Cattaneo, Crump, Farrell, and Feng (2023). For details see Section 2.2.

Figure 4: Model-Implied Price-Elasticities as a Function of Expenditures




This Figure plots model-implied price-elasticities for cheap and premium varieties as a function of households spending levels. For details see Section 2.2.

Table 1: Calibration and Model Fit

| Parameter | Value | Significance | Target | Data | Model |
|---|---|---|---|---|---|
| $\lambda_{\text{low}}$ | 0.80 | Marginal cost | Price (high/low) | 1.24 | 1.24 |
| $\lambda_{\text{high}}$ | 1.13 | | Premium-Index (mid/poor) | 1.10 | 1.09 |
| $\nu$ | 20,896 | Expenditure scale | Premium-Index (rich/poor) | 1.21 | 1.20 |
| $\xi_{\text{low}}$ | 1.00 | Nonhomotheticity | Normalization ($\eta \to 1$) | - | - |
| $\xi_{\text{high}}$ | 0.74 | | Polarization (mid/poor) | 6.18 | 6.93 |
| $\varphi_{\text{low}}$ | 0.86 | Demand shifter | Polarization (rich/poor) | 4.82 | 5.01 |
| $\varphi_{\text{high}}$ | 1.33 | | Sales HHI | 0.22 | 0.21 |
| $\sigma$ | 18 | Substitution with sector | Aggregate markup | 1.31 | 1.32 |
| $\eta$ | 1.02 | Substitution across sector | Markup dispersion | 0.23 | 0.19 |

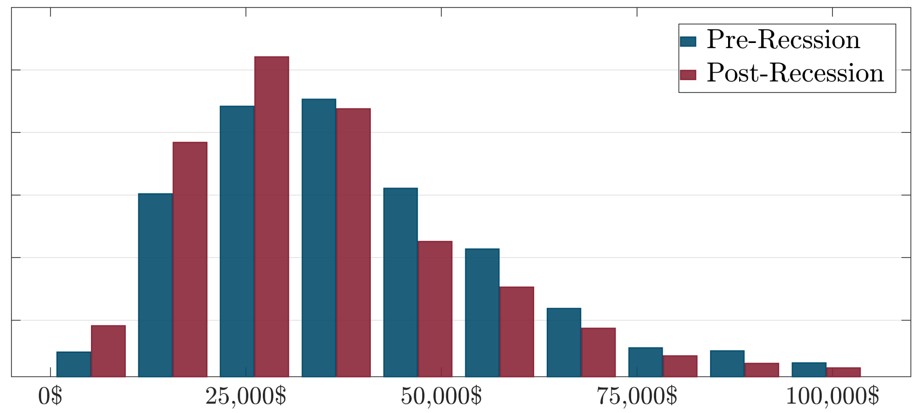
This Table reports the jointly calibrated parameters of my quantitative model. Specifically, I calibrate the firms' marginal cost $\lambda_q$, the scale of the empirical mass-function of PSID expenditures $\nu$, the nonhomotheticity parameters $\xi_q$, the taste parameters $\varphi_q$, as well as within- and across-sector substitutability $\sigma$ and $\eta$. Since $\eta \to 1$, the scale of $\xi_q$ is close to being unidentified. I, therefore, normalize $\xi_{\text{low}} = 1$. The price targets respectively refer to the relative price for cheap vs expensive varieties. The premium-index and premium-dispersion targets refer to the corresponding ratios for rich and middle-class vs poor consumers.

Table 2: Untargeted Moments

| Moments | Data | Model |
|---|---|---|
| Relative price-elasticity - low quality | 0.87 | 0.82 |
| Relative price-elasticity - high quality | 1.16 | 1.23 |
| Relative markups | 0.99 | 0.96 |

This Table reports untargeted moments. Relative price-elasticities are the quotient of barcode-specific price-elasticities for poor vs rich consumers. Relative retail-markups are computed from PriceTrak Promo-Data 2006-2012. For details see Section 2.2.

Figure 5: Expenditure Distribution - 2006 vs 2012




This Figure is a histogram of the symmetrically PCE-deflated expenditures in PSID data for 2006 as well as 2012. During this time period, i.e., during the Great Recession, average spending decreased by 15.9% while the 75/25 percentile ratio of the distribution decreased from 3.02 to 2.89.

Table 3: Price Impact of Markup Channel

| | | Non-homothetic | | Homothetic | |
|---|---|---|---|---|---|
| | | $\Delta\mu$ | $\Delta p$ | $\Delta\mu$ | $\Delta p$ |
| Overall | Low Quality | 6.79 pp | 4.19 % | 0 pp | 0 % |
| | High Quality | −1.82 pp | −1.21 % | 0 pp | 0 % |
| Low Competition | Low Quality | 8.43 pp | 3.97 % | 0 pp | 0 % |
| ($\text{HHI}_{2006} \approx 0.35$) | High Quality | −2.88 pp | −1.59 % | 0 pp | 0 % |
| High Competition | Low Quality | 2.57 pp | 1.97 % | 0 pp | 0 % |
| ($\text{HHI}_{2006} \approx 0.10$) | High Quality | −1.22 pp | −0.95 % | 0 pp | 0 % |

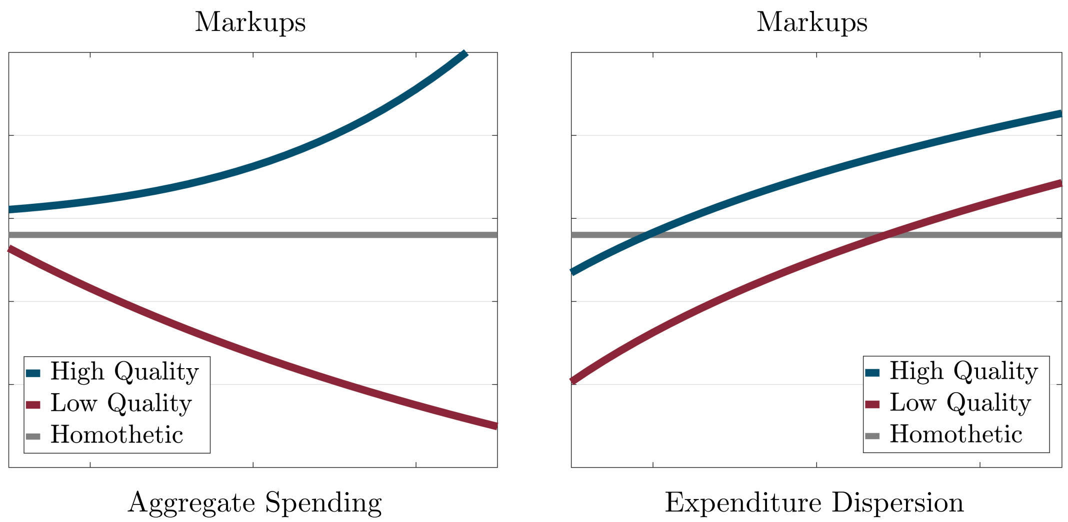
This Table presents the model-implied average markup and price response of low and high quality goods during the Great Recession. I report markup changes in terms of percentage points. Price changes are presented as percentages and can alternatively be read as percentage changes in gross markups. Results are stratified by competition levels according to pre-crisis sales HHIs. The latter columns show results for a homothetic baseline.

Table 4: Impact Across the Expenditure Distribution

| Quartile | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|
| Δ Nominal spending (data) | −13.5% | −12.9% | −13.7% | −16.3% |
| Δ Price (model) | 4.5% | 3.4% | 0.1% | −1.2% |
| Δ Real spending (model) | −18.05% | −16.28% | −13.81% | −15.09% |

This Table quantifies the unequal impact of the Great Recession across the expenditure distribution. Changes in "nominal" spending are directly computed from (symmetrically PCE-deflated) expenditures in the PSID. Prices changes are model-implied and take into account the composition of consumption baskets in different quartiles of the expenditure distribution. Changes in real spending are computed as the difference of rows one and two.

Figure 6: Isolated Markup Response to Aggregate Spending & Inequality



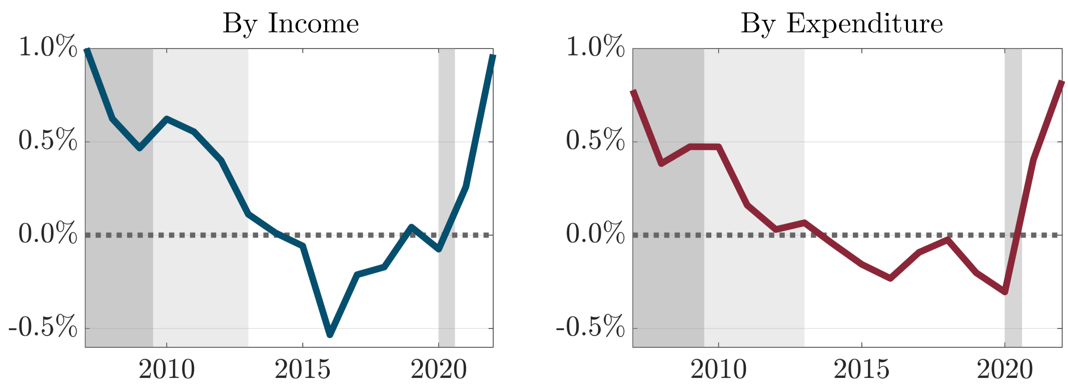

The lefthandside panel plots model-implied markups as a function average spending levels. Entertaining a dispersion-preserving shift, the standard deviation of the expenditure distribution is kept at a fixed level. Conversely, the righthandside panel illustrates the markup response to a change in expenditure inequality. That is, I graph markups as a function of the standard deviation of the expenditure distribution while maintaining a fixed level of aggregate spending. Under homothetic preferences markups are unresponsive to changes in the expenditure distribution.

Table 5: Decomposition of the Markup Response

| | Overall response | Drop in spending | Inequality | Higher moments |
|---|---|---|---|---|
| Low Quality | 6.79 pp | 7.13 pp | −2.95 pp | 2.61 pp |
| High Quality | −1.82 pp | −1.91 pp | −0.34 pp | 0.43 pp |

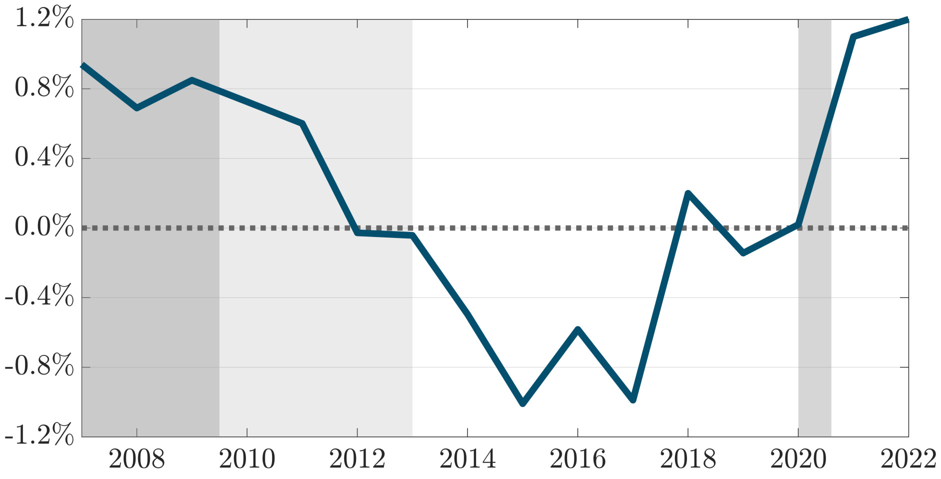
This Table presents results for a decomposition exercise. For the 2006 baseline I assume a log-linear expenditure distribution which is parameterized to match moments of the ($\nu$-scaled) empirical mass function. I then reparameterize to match the overall markup response from Table 3. For the decomposition exercise, I, separately, fix average spending and standard deviation while matching the respective other moment with its 2012 value. The effect of higher moments, interactions, as well as approximation error is reported in the last column.

Figure 7: Inflation for Poor Households is Higher in Recessions



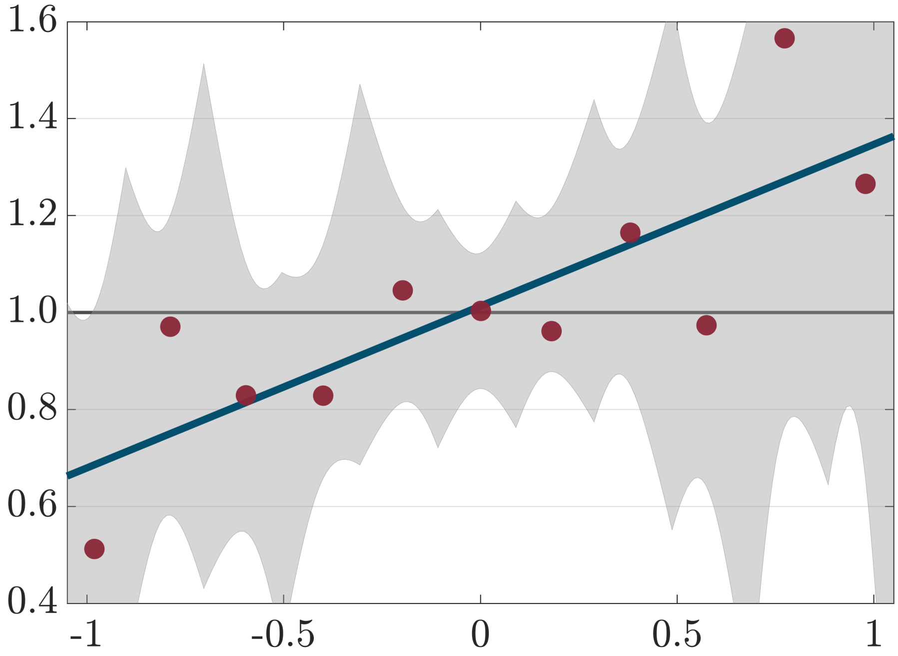

This Graph illustrates differences in Törnqvist inflation rates for poor vs rich households. The lefthandside panel plots a time series of the inflation gap $\text{inflation}_{\text{poor},t} - \text{inflation}_{\text{rich},t}$ with the distinction between poor and rich based on income levels. Similarly, the righthandside panel plots a time series for the same inflation gap distinguishing households based on expenditures. By construction, inflation rates are only reflective of product choice and abstract away from search behavior. For details see Section 4.3.

Figure 8: Inflation for Cheap Goods is Higher in Recessions




This Graph plots a time series of Törnqvist inflation rates for cheap vs premium goods. The distinction between cheap and premium goods is based on barcode-level premium scores. For details see Section 4.3.

Figure 9: The Rich become Less Elastic towards Cheap Goods in Recessions



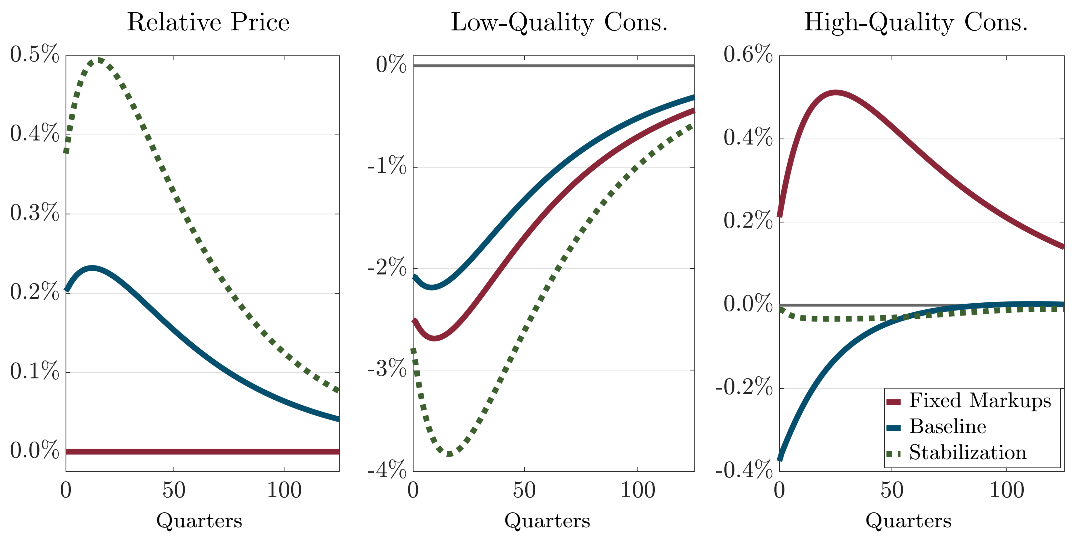

This Graph depicts a binscatter of barcode-level premium scores on the $x$-axis against the corresponding relative price-elasticity among wealthier households during and outside of the Great Recession. For details see Section 4.3.

Table 6: Dynamic GE Model – Calibration and Model Fit

| Parameter | Value | Significance | Target | Data | Model |
|---|---|---|---|---|---|
| $\alpha$ | 0.33 | Capital elasticity of output | Assigned | - | - |
| $\gamma$ | 2 | Inverse Frisch elasticity | Assigned | - | - |
| $\beta$ | 0.9572 | Discount rate | Average wealth to income | 16.4 | 16.9 |
| $\theta$ | 3.46 | Constant relative risk aversion | Top 10% wealth share | 0.49 | 0.46 |
| $\mu$ | 1.36 | Mean labor market ability | Gini income | 0.39 | 0.42 |
| $s$ | 0.045 | Dispersion labor market ability | Top 10% income share | 0.31 | 0.32 |
| $\rho$ | 0.968 | Persistence labor market ability | Persistence income | 0.98 | 0.97 |
| $\eta$ | 1.55 | Across-sector substitution | Aggregate markup | 1.43 | 1.40 |
| $\sigma$ | 12 | Within-sector substitution | Sales HHI | 0.22 | 0.25 |
| $\varphi_{\text{high}}/\varphi_{\text{low}}$ | 1.22 | Demand-shifters | Polarization (mid/poor) | 6.18 | 5.98 |
| $\xi_{\text{high}}/\xi_{\text{low}}$ | 0.523 | Nonhomotheticities | Premium index (rich/poor) | 1.21 | 1.17 |
| $z_{\text{high}}/z_{\text{low}}$ | 0.84 | Relative Productivity | Relative Price | 1.24 | 1.22 |

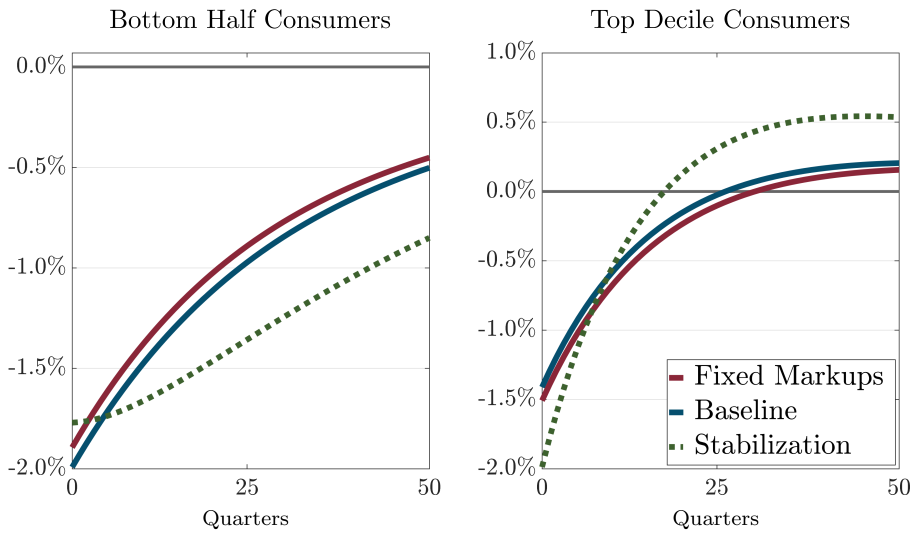
This Table reports the jointly calibrated parameters of my dynamic general equilibrium model. Specifically, I match various moments of the joint wealth and income distribution in PSID data. My calibration target for the aggregate markup is aligned with the model-implied markup from my partial equilibrium exercise. My calibration strategy for the parameters speaking to quality distinctions in production and consumption patterns follows my approach from Section 3.

Figure 10: Time Path of Aggregates in Response to MIT Shock to $\Theta$




This Figure depicts the time path of the relative price of low-quality goods, aggregate consumption of low-quality goods, and aggregate consumption of high-quality goods in response to a $-5\%$ TFP shock. The stabilization parameter is $\psi = -2$. For details see Section 5.2.

Figure 11: Time Path of Consumption Across the Expenditure Distribution




This Figure depicts the time path of appropriately deflated spending among consumers in the lower half as well as in the top decile of the expenditure distribution in response to a $-5\%$ TFP shock. The stabilization parameter is $\psi = -2$. For details see Section 5.2.

# Appendix B - Model and Derivations

**Households' program.** Consumers take as given the economy's price vector $\boldsymbol{p} = \left(\boldsymbol{p}_s : s \in \mathscr{S}\right)$ where $\boldsymbol{p}_s = \left(p_{iqs} : q \in \mathscr{Q} \text{ and } i \in \mathscr{I}_{qs}\right) \; \forall \; s \in \mathscr{S}$. They choose allocations $\{c_{iqs}\}$ to minimize the expenditure necessary to attain real consumption $c$. That is, they solve

$$\inf_{\{c_{iqs}, c_s\}} \int_{\mathscr{S}} \sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} p_{iqs} c_{iqs} \, ds \tag{53}$$

subject to

$$\int_{\mathscr{S}} \left(\frac{c_s}{c}\right)^{\frac{\eta-1}{\eta}} ds = 1 \tag{54}$$

and

$$\sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} \left(\frac{\varphi_q}{c_s^{(1-\sigma)(1-\xi_q)}}\right)^{\frac{1}{\sigma}} \left(\frac{c_{iqs}}{c_s}\right)^{\frac{\sigma-1}{\sigma}} = 1 \quad \forall \quad s \in \mathscr{S}. \tag{55}$$

**Intermediate Hicksian demand.** Invoking a standard separation theorem, the first step is to minimize within-sector expenditures to attain a given level of sectoral consumption $c_s$. To that end, households solve

$$\min_{\{c_{iqs}\}} \left\{ \sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} p_{iqs} c_{iqs} \;\middle|\; \sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} \varphi_q^{\frac{1}{\sigma}} \left(\frac{c_{iqs}}{c_s^{\xi_q}}\right)^{\frac{\sigma-1}{\sigma}} = 1 \right\}. \tag{56}$$

With $\lambda$ being the Lagrange-multiplier on the nonhomothetic CES aggregator, the first-order conditions with respect to $c_{iqs}$ are

$$p_{iqs} = \lambda \frac{\sigma - 1}{\sigma} \varphi_q^{\frac{1}{\sigma}} \left(\frac{c_{iqs}}{c_s^{\xi_q}}\right)^{\frac{\sigma-1}{\sigma}-1} \frac{1}{c_s^{\xi_q}}. \tag{57}$$

Multiplying by $c_{iqs}$ and summing over producers and quality-bins we obtain sectoral spending $y_s$ as

$$y_s \equiv \sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} p_{iqs} c_{iqs} = \lambda \frac{\sigma - 1}{\sigma} \tag{58}$$

where the latter equality follows from the definition of the nonhomothetic CES aggregator in (55). Sectoral expenditure shares are, thus, given as

$$x_{iqs} \equiv \frac{p_{iqs} c_{iqs}(c_s, \boldsymbol{p}_s)}{\sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} p_{iqs} c_{iqs}} = \varphi_q^{\frac{1}{\sigma}} \left( \frac{c_{iqs}}{c_s^{\xi_q}} \right)^{\frac{\sigma-1}{\sigma}}. \tag{59}$$

At this point, we can define nonhomothetic ideal price-index $p_s(c_s, \boldsymbol{p}_s)$ to satisfy

$$y_s = p_s(c_s, \boldsymbol{p}_s)\, c_s = \sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} p_{iqs} c_{iqs}. \tag{60}$$

It is instructive to use (58) and (60) and rearrange terms in (57) to obtain

$$c_{iqs} = \varphi_q \left( \frac{p_{iqs}}{p_s(c_s, \boldsymbol{p}_s)} \right)^{-\sigma} c_s^{\sigma + (1-\sigma)\, \xi_q}. \tag{61}$$

Defining the nonhomothetic taste-shifter $\psi_q(c_s)$ as

$$\psi_q(c_s) \equiv \varphi_q\, c_s^{(1-\sigma)(\xi_q - 1)} \tag{62}$$

intermediate Hicksian demand functions are, in turn, concisely written as

$$c_{iqs}(c_s, \boldsymbol{p}_s) = \psi_q(c_s) \left( \frac{p_{iqs}}{p_s(c_s, \boldsymbol{p}_s)} \right)^{-\sigma} c_s. \tag{63}$$

To obtain an expression for $p_s(c_s, \boldsymbol{p}_s)$, expenditure shares can be rewritten as

$$x_{iqs} = \varphi_q \left( \frac{p_{iqs}}{p_s(c_s, \boldsymbol{p}_s)} \right)^{1-\sigma} c_s^{(1-\sigma)(\xi_q - 1)} \tag{64}$$

Since $\sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} x_{iqs} = 1$, it then follows that

$$p_s(c_s, \boldsymbol{p}_s) = \left( \sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} \varphi_q\, p_{iqs}^{1-\sigma} c_s^{(1-\sigma)(\xi_q - 1)} \right)^{\frac{1}{1-\sigma}}. \tag{65}$$

**Intermediate Marshallian demand.** Marshallian demand is not available in closed-form. We can, however, recover the sectoral nonhomothetic ideal price-index $p_s(y_s, \boldsymbol{p}_s)$ as a function of sectoral spending $y_s$ in a single fixed-point problem. That is, in a slight abuse of notation,

$$p_s(y_s, \boldsymbol{p}_s) = \text{fix} \left\{ p \mapsto \left( \sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} \varphi_q \, p_{iqs}^{1-\sigma} \left( \frac{y_s}{p} \right)^{(1-\sigma)(\xi_q - 1)} \right)^{\frac{1}{1-\sigma}} \right\}. \tag{66}$$

This object, in turn, pins down intermediate Marshallian demand as

$$c_{iqs}(y_s, \boldsymbol{p}_s) = \varphi_q \left( \frac{p_{iqs}}{p_s(y_s, \boldsymbol{p}_s)} \right)^{-\sigma} \left( \frac{y_s}{p_s(y_s, \boldsymbol{p}_s)} \right)^{\sigma + (1-\sigma)\, \xi_q}. \tag{67}$$

**Demand for sectoral aggregates.** Conditional on the optimal within-sector allocation of consumption, we can next determine the expenditure-minimizing allocation of sectoral real consumption indices. Note that the nonhomothetic ideal price-index recovered in (65) encapsulates optimality of the consumers' within-sector decision problem. As a consequence, at the outer nest, we can think of the households' program as a homothetic expenditure minimization problem with a non-linear pricing structure. That is,

$$\inf_{\{c_s\}} \left\{ \int_{\mathscr{S}} p_s(c_s, \boldsymbol{p}_s)\, c_s \, ds \;\middle|\; \int_{\mathscr{S}} \left( \frac{c_s}{c} \right)^{\frac{\eta-1}{\eta}} ds = 1 \right\}. \tag{68}$$

With $\lambda$ being the Lagrange-multiplier on the across-sector CES aggregator, the first-order conditions with respect to $c_s$ are such that

$$\frac{\partial\, p_s(c_s, \boldsymbol{p}_s)}{\partial\, c_s}\, c_s + p_s(c_s, \boldsymbol{p}_s) = \lambda \, \frac{\eta - 1}{\eta} \left( \frac{c_s}{c} \right)^{\frac{\eta-1}{\eta} - 1} \frac{1}{c} \tag{69}$$

To arrive at the first-order condition from (6), first off, we recover the partial derivative of sectoral prices with respect to real consumption as

$$\frac{\partial\, p_s(c_s, \boldsymbol{p}_s)}{\partial\, c_s} = \frac{\partial}{\partial\, c_s}\left[\left(\sum_{q=1}^{Q}\sum_{i=1}^{N_{qs}} \varphi_q\, p_{iqs}^{1-\sigma}\, c_s^{(1-\sigma)(\xi_q-1)}\right)^{\frac{1}{1-\sigma}}\right] \tag{70}$$

$$= p_s(c_s, \boldsymbol{p}_s)^{\sigma}\sum_{q=1}^{Q}\sum_{i=1}^{N_{qs}} \varphi_q\, p_{iqs}^{1-\sigma}\, c_s^{(1-\sigma)(\xi_q-1)-1}(\xi_q - 1) \tag{71}$$

Using (64) and rewriting the derivative as an elasticity, the above expression simplifies to

$$\frac{\partial\, \log p_s(c_s, \boldsymbol{p}_s)}{\partial\, \log c_s} = \sum_{q=1}^{Q}\sum_{i=1}^{N_{qs}} x_{iqs}(c_s, \boldsymbol{p}_s)\, \xi_q - 1. \tag{72}$$

For notational compactness, I define

$$\bar{\xi}_s(c_s, \boldsymbol{p}_s) = \sum_{q=1}^{Q}\sum_{i=1}^{N_{qs}} x_{iqs}(c_s, \boldsymbol{p}_s)\, \xi_q. \tag{73}$$

Multiplying the first-order condition from (69) by $c_s$ we obtain

$$\left[\frac{\partial\, \log p_s(c_s, \boldsymbol{p}_s)}{\partial\, \log c_s} + 1\right] p_s(c_s, \boldsymbol{p}_s)\, c_s = \lambda\, \frac{\eta - 1}{\eta}\left(\frac{c_s}{c}\right)^{\frac{\eta-1}{\eta}}. \tag{74}$$

It, thus, follows that

$$p_s(c_s, \boldsymbol{p}_s)\, c_s\; \bar{\xi}_s(c_s, \boldsymbol{p}_s) = \lambda\, \frac{\eta - 1}{\eta}\left(\frac{c_s}{c}\right)^{\frac{\eta-1}{\eta}}. \tag{75}$$

We can now integrate over sectors and use the definition of across-sector aggregation from (54) to see that

$$\int_{\mathscr{S}} p_s(c_s, \boldsymbol{p}_s)\, c_s\; \bar{\xi}_s(c_s, \boldsymbol{p}_s)\, ds = \lambda\, \frac{\eta - 1}{\eta}. \tag{76}$$

It then immediately follows that

$$\frac{p_s(c_s, \boldsymbol{p}_s)\, c_s\; \bar{\xi}_s(c_s, \boldsymbol{p}_s)}{\int p_s(c_s, \boldsymbol{p}_s)\; c_s\; \bar{\xi}_s(c_s, \boldsymbol{p}_s)\, ds} = \left(\frac{c_s}{c}\right)^{\frac{\eta-1}{\eta}}. \tag{77}$$

Using the fact that $p_s(c_s,\boldsymbol{p}_s)\,c_s=\sum_q\sum_i p_{iqs}\,c_{iqs}(c_s,\boldsymbol{p}_s)$, this can be rewritten as

$$\frac{\sum_q\sum_i p_{iqs}\,c_{iqs}(c_s,\boldsymbol{p}_s)\,\xi_q}{\int\sum_q\sum_i p_{iqs}\,c_{iqs}(c_s,\boldsymbol{p}_s)\,\xi_q\,ds}=\left(\frac{c_s}{c}\right)^{\frac{\eta-1}{\eta}}. \tag{78}$$

**Bertrand competition.** To obtain an expression for the Bertrand price-elasticity of variety $(k,r,s)$, I, first off, take the logarithm of the intermediate Hicksian demand function from (63). That is,

$$\log c_{krs}(c_s,\boldsymbol{p}_s)=\log\varphi_r-\sigma\log p_{krs}+\sigma\log p_s(c_s,\boldsymbol{p}_s)+\big(\sigma+(1-\sigma)\,\xi_r\big)\,\log c_s. \tag{79}$$

The partial derivative with respect to log $p_{krs}$ is then given as

$$\frac{\partial\log c_{krs}(c_s,\boldsymbol{p}_s)}{\partial\log p_{krs}}=-\sigma+\sigma\frac{\partial\log p_s(c_s,\boldsymbol{p}_s)}{\partial\log p_{krs}}+\Big(\sigma+(1-\sigma)\,\xi_q\Big)\,\frac{\partial\log c_s}{\partial\log p_{krs}}. \tag{80}$$

In order to see how the nonhomothetic ideal price-index $p_s$ responds to a *ceteris paribus* change in $p_{krs}$, I compute

$$\begin{aligned}\frac{\partial p_s(c_s,\boldsymbol{p}_s)}{\partial p_{krs}}&=\frac{\partial}{\partial p_{krs}}\left[\left(\sum_{q=1}^{Q}\sum_{i=1}^{N_{qs}}\varphi_q\,p_{iqs}^{1-\sigma}\,c_s^{(1-\sigma)(\xi_q-1)}\right)^{\frac{1}{1-\sigma}}\right] \qquad (81)\\ &=\;p_s(c_s,\boldsymbol{p}_s)^{\sigma}\,\varphi_q\,p_{iqs}^{-\sigma}\,c_s^{(1-\sigma)(\xi_q-1)-1}\\ &\quad+\;p_s(c_s,\boldsymbol{p}_s)^{\sigma}\frac{\partial c_s}{\partial p_{krs}}\sum_{q=1}^{Q}\sum_{i=1}^{N_{qs}}\varphi_q\,p_{iqs}^{1-\sigma}\,c_s^{(1-\sigma)(\xi_q-1)-1}(\xi_q-1)\end{aligned}$$

Using (64) and writing the above derivative as an elasticity, we obtain

$$\frac{\partial\ \log p_s(c_s,\boldsymbol{p}_s)}{\partial\ \log p_{kqs}}=x_{kqs}(c_s,\boldsymbol{p}_s)+\frac{\partial\log c_s}{\partial\log p_{kqs}}\Big[\bar{\xi}_s(c_s,\boldsymbol{p}_s)-1\Big] \tag{82}$$

Next, $\partial\log c_s/\partial\log p_{kqs}$ is most conveniently recovered in an application of the implicit function theorem. Specifically, I define

$$F(c_s, p_{kqs}) \equiv \sum_{q=1}^{Q} \sum_{i=1}^{N_{qs}} p_{iqs} c_{iqs}(c_s, \boldsymbol{p}_s)\, \xi_q - A \left(\frac{c_s}{c}\right)^{\frac{\eta-1}{\eta}} \tag{83}$$

We can, therefore compute

$$\begin{aligned}\frac{\partial F(c_s, p_{kqs})}{\partial c_s} = \; & \sigma \sum_{q=1}^{Q} \varphi_q\, \xi_q \sum_{i=1}^{N_{qs}} \left(\frac{p_{iqs}}{p_s(c_s, \boldsymbol{p}_s)}\right)^{1-\sigma} \frac{\partial p_s(c_s, \boldsymbol{p}_s)}{\partial c_s}\, c_s^{\sigma+(1-\sigma)\,\xi_q} \\ & + \sum_{q=1}^{Q} \varphi_q\, \xi_q \left(\sigma + (1-\sigma)\,\xi_q\right) \sum_{i=1}^{N_{qs}} \left(\frac{p_{iqs}}{p_s(c_s, \boldsymbol{p}_s)}\right)^{1-\sigma} p_s(c_s, \boldsymbol{p}_s)\, c_s^{(1-\sigma)(\xi_q-1)} \\ & - A\, \frac{\eta-1}{\eta} \left(\frac{c_s}{c}\right)^{\frac{\eta-1}{\eta}-1}\end{aligned} \tag{84}$$

as well as

$$\begin{aligned}\frac{\partial F(c_s, p_{kqs})}{\partial p_{krs}} = & \varphi_r\, \xi_r\, (1-\sigma) \left(\frac{p_{krs}}{p_s(c_s, \boldsymbol{p}_s)}\right)^{-\sigma} c_s^{\sigma+(1-\sigma)\,\xi_r} \\ & + \sigma \sum_{q=1}^{Q} \varphi_q\, \xi_q \sum_{i=1}^{N_{qs}} \left(\frac{p_{iqs}}{p_s(c_s, \boldsymbol{p}_s)}\right)^{1-\sigma} \left.\frac{\partial p_s(c_s, \boldsymbol{p}_s)}{\partial p_{krs}}\right|_{c_s} c_s^{\sigma+(1-\sigma)\,\xi_q}\end{aligned} \tag{85}$$

Note that, in the partial derivative of $F$ with respect to $p_{krs}$ sectoral consumption $c_s$ is not responsive to price changes. That is,

$$\left.\frac{\partial p_s(c_s, \boldsymbol{p}_s)}{\partial p_{krs}}\right|_{c_s} \neq \frac{\partial p_s(c_s, \boldsymbol{p}_s)}{\partial p_{krs}} \tag{86}$$

and, specifically,

$$\left.\frac{\partial p_s(c_s, \boldsymbol{p}_s)}{\partial p_{krs}}\right|_{c_s} = x_{krs}(c_s, \boldsymbol{p}_s). \tag{87}$$

By the implicit function theorem (and a few straightforward algebraic manipulations), we then have

$$\frac{\partial \log c_s}{\partial \log p_{krs}} = -\frac{\dfrac{\partial F(c_s, p_{krs})}{\partial p_{krs}} \dfrac{p_{krs}}{p_s(c_s, \boldsymbol{p}_s)}}{\dfrac{\partial F(c_s, p_{krs})}{\partial p_{krs}} \dfrac{c_s}{p_s(c_s, \boldsymbol{p}_s)}} \tag{88}$$

Substituting in the results from above and simplifying the expression we find that

$$\frac{\partial \log c_s}{\partial \log p_{krs}} = -\frac{(1-\sigma)\, x_{krs}(c_s, \boldsymbol{p}_s)\, \xi_r + \sigma\, x_{krs}(c_s, \boldsymbol{p}_s)\, \bar{\xi}_s(c_s, \boldsymbol{p}_s)}{(1-\sigma)\, \bar{\xi}_s^2(c_s, \boldsymbol{p}_s) + \sigma\, \bar{\xi}_s(c_s, \boldsymbol{p}_s)^2 - \dfrac{\eta - 1}{\eta}\, \bar{\xi}_s(c_s, \boldsymbol{p}_s)}. \tag{89}$$

Finally, substituting (82) and (89) into (80) and by duality, the price-elasticity of variety $(k, r, s)$ is given as

$$\left| \frac{\partial \log c_{krs}(y, \boldsymbol{p})}{\partial \log p_{krs}} \right| = \big(1 - x_{krs}(y, \boldsymbol{p})\big)\, \sigma + x_{iqs}(y, \boldsymbol{p})\, \eta\, \zeta_{krs}(y, \boldsymbol{p}) \tag{90}$$

where

$$\zeta_{krs}(y, \boldsymbol{p}) \equiv \frac{\Big(\sigma\, \bar{\xi}(y, \boldsymbol{p}) + (1-\sigma)\, \xi_r\Big)^2}{\sigma\, \eta\, \bar{\xi}(y, \boldsymbol{p})^2 + (1-\sigma)\, \eta\, \bar{\xi}^2(y, \boldsymbol{p}) + (1-\eta)\, \bar{\xi}(y, \boldsymbol{p})}. \tag{91}$$