# Wealth and Hours*

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**Abstract**

In the United States, market hours worked are approximately flat across the wealth distribution. Accounting for this phenomenon is a standing challenge for standard heterogeneous-agent macro models. In these models, wealthier households consume more, enjoy more leisure, and work less. We propose a theory that generates the cross-sectional wealth-hours relation as in the data. We quantify this theory in the context of a new general-equilibrium heterogeneous-agent incomplete-markets model with three key features: a quality choice in consumption, non-homothetic preferences, and a multi-sector production structure. As external validation, we show that the model produces expenditure patterns that are consistent with the data, as well as realistic "quality Engel curves."

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# 1 Introduction

A large and important literature studies consumption and labor supply decisions in the context of heterogeneous-agent incomplete-markets models in which households face uninsurable wage shocks. In these models, endogenous labor supply acts as a "self-insurance" mechanism to smooth consumption, implying that work incentives taper off steeply with wealth: wealthier households consume more and work less. This prediction is at odds with micro data. In the United States, employment rates as well as hours worked are nearly flat or mildly increasing across the wealth distribution (see Figure 1).

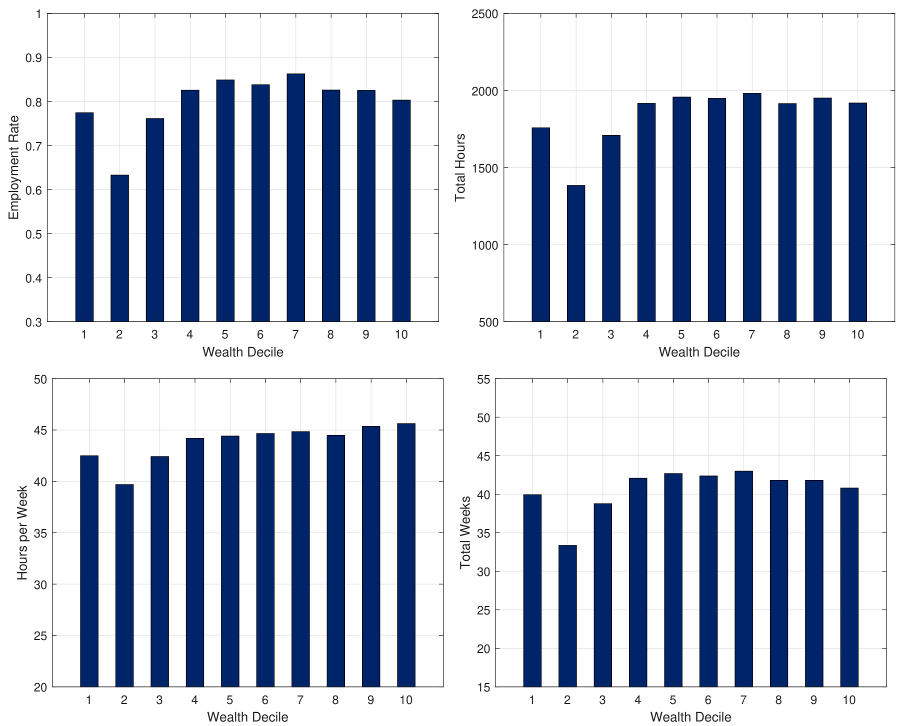


Figure 1: Employment and Hours by Wealth

*Notes*: The figure shows the employment rate (top left panel), total hours worked (top right panel), weekly hours worked (bottom left panel), and weeks worked (bottom right panel) by wealth deciles for household heads of 25-65 years old. Data are from the biannual 2001-2015 waves of the Panel Study of Income Dynamics (PSID). Wealth is total assets minus total liabilities at the household level. See Appendices A.1-A.2 for details on variables' construction and additional evidence based on gender, age, education, single household heads, spouses, and spouses of employed household heads.

Accounting for these cross-sectional facts is a challenge for complete- and incomplete-markets models alike. The intuition is fairly simple. In the equilibrium of these models, wealthier households have higher consumption, and thereby a lower marginal utility of consumption. To the extent that leisure is a normal good, wealthier households enjoy more leisure and work fewer hours. These basic predictions hold under "balanced growth preferences" in which income and substitution effects on labor supply offset each other (King, Plosser and Rebelo, 1988), and even more so for preferences in which the income effect dominates the substitution effect.[1]

The maintained assumption in these models is that households can only choose the *quantity* of consumption, abstracting from the *quality* of the consumption basket they buy. There is, however, a growing body of empirical work based on micro data suggesting that this assumption is strongly counterfactual as higher-income, wealthier households consume not only more goods but better goods (Bils and Klenow, 2001; Aguiar and Bils, 2015; Jaimovich, Rebelo and Wong, 2019; Jaimovich et al., 2019b; Faber and Fally, 2020).

The purpose of this paper is to study how "quality choice" affects labor supply and thereby the cross-sectional distributions of consumption expenditures, employment rates, earnings, and wealth. While quality choice has a long tradition in consumer theory (Deaton and Muellbauer, 1980), its general-equilibrium implications for labor allocations across the distribution of earnings and wealth have been unexplored. To the best of our knowledge, this is the first paper that tackles this question.

We argue that embedding quality choice into a consumption-leisure choice problem goes a long way in reconciling theory with the *cross-sectional* relation between hours and wealth in micro data. Further, in the presence of uninsurable wage shocks, quality choice serves as a self-insurance mechanism: in bad times, households cut back on consumption expenditures by buying cheaper lower-quality goods, with little sacrifice of the quantity of consumption. For example, think of the choice between calories intake, i.e., quantity of consumption, and the quality grades of a commodity like meat (see Deaton, 1988, for a similar analogy). We conclude then, that quality choice changes standard incomplete-markets model's predictions in crucial ways. In a nutshell, abstracting from quality choice is neither empirically plausible nor theoretically innocuous.

Our contribution to the literature is twofold. First, we propose a simple theory based on quality choice that reconciles macro models with salient micro observations on hours and wealth. Second, we embed it in a quantitative general-equilibrium model that allows

[1] Balanced growth preferences guarantee that household-level hours, and so aggregate hours per capita, are constant along a balanced growth path. Yet, wealthier households with a larger *share* of aggregate wealth work fewer hours/exhibit lower employment rates.

us to gauge the role of quality choice for labor allocations across the wealth distribution. In doing so, we develop a new heterogeneous-agent, incomplete-markets model that is well suited for policy analysis.

To build intuition, our analysis begins by studying the implications of quality choice in the context of a partial-equilibrium model of labor supply, and of a simple one-period, as well as an infinite-horizon general-equilibrium model with wealth heterogeneity. The main idea in these models is that households choose labor supply along the extensive margin, as well as the quantity and the level of quality of consumption.[2]

We derive theoretical restrictions on the class of admissible utility functions consistent with upward-sloping "quality Engel curves," that rule out preferences of the homothetic type.[3] In addition, we show that a form of *non-separability* between the quantity and the quality of consumption is needed to preserve work incentives for the wealth rich. To the extent that the optimal choice of quality increases with income, and the marginal utility of consumption depends positively on quality, wealthy households *may* decide to work to afford high quality goods. In general equilibrium, however, prices of different qualities are determined to clear product markets. Ultimately, whether employment rates decrease, increase, or are constant across households with different wealth depends not only on their preferences for quality, but also on the *relative prices* of different qualities that prevail in equilibrium. In this sense, a flat relation between hours and wealth is *not* hard-wired into the theory.

To quantify these mechanisms, we build a heterogeneous-agent, incomplete-markets model in which households face uninsurable idiosyncratic wage shocks, as in Bewley (1983), Imrohoroğlu (1989), Huggett (1993), and Aiyagari (1994). Novel features of the model are a *quality choice* in consumption, *non-homothetic* preferences, and a *multi-sector* production structure. The incomplete-market structure allows for an endogenous wealth distribution, in which households' choices in response to idiosyncratic shocks determine their rankings in the distribution.

We show that the model, calibrated to match salient features of the distribution of

[2]We focus on the extensive margin of labor supply for two reasons. First, employment rates display the same pattern of hours worked, suggesting that the variation (or the lack thereof) in hours worked by wealth deciles is to a large extent accounted for labor supply along the extensive margin. Second, while there might be concerns about measurement error in self-reported hours worked, such concerns are much alleviated or non-existent for employment rates, that are measured uncontroversially.

[3]A quality Engel curve traces out unit prices against income or expenditure (see Bils and Klenow, 2001).

earnings and wealth, yields the near-zero, cross-sectional correlation between wealth and hours in the data.In the model, the distribution of consumption expenditure is highly concentrated and skewed to the right. Using household-level data from the Panel Study of Income Dynamics (PSID), we find that this prediction lines up well with the empirical distributions of expenditure on food away from home, education, clothing, childcare, and entertainment – five good categories that are typically associated with "luxuries" (Aguiar and Bils, 2015; Chang, Hornstein and Karabarbounis, 2019). We find that the quality Engel curves generated by the calibrated model are in line with those estimated in the literature.

In the model, households face a menu of quality-price bundles from which to choose. Notably, higher-quality versions cost more. With non-homothetic preferences, the level of quality increases with income and wealth: higher-income and/or wealthier households consume not only more goods, but also more expensive higher-quality versions (see Bils and Klenow, 2001; Jaimovich et al., 2019b; Faber and Fally, 2020, for evidence supporting this mechanism). Working long hours allows wealthy households to keep up with their preferred, high-quality consumption basket.

On the production side, there is a continuum of sectors producing versions of the consumption good that differ by quality, and an investment sector producing a capital good, that adds to the capital stock of the economy. Production functions in both sectors are of the constant elasticity of substitution (CES) form. We allow for factor intensities to vary by quality, encompassing the case where higher-quality goods are more intensive in labor as in Jaimovich, Rebelo and Wong (2019).

In our model, quality choice acts as a self-insurance mechanism, in addition to the well-known precautionary work motive in incomplete-markets models with endogenous labor supply. In the face of uninsurable, negative wage shocks, households can cut back on the quality of their consumption basket, which allows them to maintain a relatively stable quantity of consumption. This mechanism naturally interacts with labor supply decisions: wealth-poor households trade off the quality of consumption with the value of leisure. This mechanism is absent in standard incomplete-markets models.

To further highlight the role of quality choice, we revisit a classic question related to the distortionary effects of proportional labor taxes. We find that quality choice with non-homothetic preferences changes the predictions of the incomplete-markets model in important ways. Notably, in response to a tax rate hike, households cut back on quality, leaving the quantity of consumption virtually unchanged. As lower-quality goods are less intensive in labor, the standard work disincentive effects of distortionary labor taxation are magnified by a decrease in the demand for labor. Comparing two economies with and without quality, calibrated to match the same targets, a flat-rate tax hike provides a considerably larger fall in aggregate employment in the model with quality.

Our paper is organized as follows. Section 2 highlights the paper's contribution to the literature. Section 3 derives theoretical results that provide intuition into the role of quality choice for labor allocations. In Sections 4 and 5, we present the heterogeneous-agent model with quality choice and incomplete markets, parametrize it, and study its quantitative properties. Section 6 validates the model's predictions via independent evidence and our own estimates based on micro data from three different sources. Section 7 discusses the implications of the model for tax policy. Finally, Section 8 concludes. Appendices A-D contain details on data sources, variables' construction, proofs, model derivations and extensions, and additional results.

## 2 Related Literature

This paper adds to the important literature studying labor supply decisions in the context of heterogeneous-agent macro models with uninsurable idiosyncratic wage risk (Chang and Kim, 2006, 2007; Chang et al., 2019; Heathcote, Storesletten and Violante, 2008, 2014; Pijoan-Mas, 2006). When markets are incomplete, and wage shocks are persistent, labor supply acts as a self-insurance mechanism to smooth consumption. In the equilibrium of these models, individuals with low productivity turn out to be wealth poor. However, in spite of being of low productivity, they work long hours as their marginal utility of consumption is high. At the same time, individuals with high productivity are wealth rich; they do not supply nearly as many hours of work as the wealth poor because their marginal utility of consumption is low. This mechanism implies that work incentives taper off steeply with wealth, generating a counterfactual negative relationship between wealth and hours.

Mustre-del-Río (2015) shows that heterogeneity in preferences for leisure brings the standard incomplete-markets model closer to the data. In the equilibrium of his model, wealthier households have weaker preferences for leisure. Yum (2018) argues that means-tested transfers and capital taxation play an important role in reconciling the model with the data. Means-tested transfers mitigate the self-insurance motive of labor supply for wealth-poor households, whereas capital income taxation generates a negative income effect, pushing wealth-rich households to work.

In this paper, we propose a new mechanism, develop a model of this mechanism, and assess its ability to reproduce the evidence on employment rates by wealth deciles and expenditure patterns. In the equilibrium of our model, wealth-rich individuals work long hours to purchase expensive, high quality versions of the consumption good. On the opposite end of the wealth distribution, quality choice act as an additional self-insurance mechanism. In the face of negative wage shocks, wealth-poor individuals cut back not only on the quantity, but also on the quality of consumption. Our contribution to this strand of the literature is to propose a new theory based on quality choice and quantify its importance for labor allocations in the context of a heterogeneous-agent, incomplete-markets model. To the best of our knowledge, our paper is the first to do so.

Our paper is also closely related to a recent body of work studying how average hours worked vary over time and across countries. Boppart and Krusell (2020) provide a new class of utility functions in which the income effect outweighs the substitution effect, that admits falling hours along a balanced growth path, consistently with the historical, time-series evidence for several OECD countries, excluding the United States. In the postwar period, U.S. hours worked show no secular trend, consistently with the assumption of balanced growth preferences.[4] Similarly, Restuccia and Vandenbroucke (2013) leverage the income effects on labor supply from Stone-Geary preferences to explain the decline in U.S. hours worked over the last century. Bick et al. (2019) argue that income effects in preferences are the main driving force behind the decline of average hours worked with GDP per capita.

What distinguishes our work is the focus on the *cross-sectional* distribution of hours over wealth. In other words, given a total number of hours worked in the economy, here we study how those hours are distributed across households with different wealth. Notably, we propose a theory that can reconcile the highly concentrated distribution of wealth with the observation that hours worked are typically more evenly distributed than wealth. It is important to stress that the implications of our theory for the cross-sectional distribution of hours do *not* readily apply to cross-country comparisons of average hours worked, or to comparisons of per capita hours worked over time within a country. To

[4]See also Cociuba, Prescott and Ueberfeldt (2018) for the U.S., and Bick, Fuchs-Schündeln and Lagakos (2018) and Bridgman, Duernecker and Herrendorf (2018) for cross-country evidence on hours worked.

see this clearly, consider a standard neoclassical growth model with balanced growth preferences and wealth heterogeneity. Along the balanced growth path of that model, per capita hours worked are *constant*, consistently with postwar U.S. evidence, yet, wealthier households, with a larger *share* of total wealth, work less than poorer households with a smaller share of total wealth. In other words, the relation between wealth and hours in the cross-section, does not necessarily hold in the aggregate. Similarly, one can specify preferences such that per capita total hours are constant in the model with quality choice as well, preserving consistency with micro data that the distribution of hours over wealth is nearly flat.

Another closely related paper is Jaimovich, Rebelo and Wong (2019). They study the implications of quality choice for business cycle analysis in the context of a representative-agent model, and of a model in which heterogeneous agents achieve full insurance within a family that pools income and shares wealth across its members. Naturally, given their model setup, they do not examine the cross-sectional distribution of hours over wealth, which is one of the equilibrium objects of interest generated by our model. They show that higher-quality versions of consumption goods are more intensive in labor, which greatly magnifies the impact of cyclical shocks on hours worked and output. Here, we ask a different question, and we learn a new mechanism. In the presence of *uninsurable* wage risk, a quality choice with non-homothetic preferences has important implications for the cross-sectional distribution of hours, too, something that previous work has not addressed. Further, we argue that with incomplete markets, quality choice acts as a self-insurance mechanism against negative productivity shocks.

# 3 Preferences, Quality Choice, and Labor Supply

The objective of this section is to provide insight into how a quality choice in consumption affects labor supply across the wealth distribution. We first derive theoretical restrictions on the class of admissible utility functions consistent with upward-sloping quality Engel curves. Then, through the lens of a simple general-equilibrium model, we highlight the role of capital-labor substitutability and relative prices.

Here we take wealth as given. In Section 4, we embed quality choice into an infinite-horizon model with uninsurable wage shocks, in which precautionary savings fuel wealth accumulation, giving rise to an *endogenous* wealth distribution.

### 3.1 A Standard Model of Labor Supply

An individual has preferences $u(c) - Bh$, where $u$ is strictly increasing, concave, and twice continuously differentiable, $c \geq 0$ is consumption, $B$ is the disutility of work, and $h \in \{0, 1\}$ is indivisible labor supply as in Rogerson (1988). The individual's problem is to maximize $u(c) - Bh$, by choosing whether to work ($h = 1$), or not to work ($h = 0$), subject to the budget constraint $c = wh + a$, where $w$ is the wage and $a$ is wealth.[5]

The value of working is $V^E = u(w + a) - B$, whereas the value of not working is $V^U = u(a)$. Comparing the value of working with that of not working, it follows that the individual's decision is to work if and only if $V^E > V^U$. The labor supply choice follows a reservation wage rule: for a given level of wealth $a$, there is a unique cutoff on the wage $w_R$, such that if $w \leq w_R$, the individual does not work, otherwise if $w > w_R$, the individual works. Such cutoff is implicitly determined by the indifference condition between working and not working:

$$u(w_R + a) - B = u(a). \tag{1}$$

Total differentiation of equation (1) gives that the reservation wage is monotonically increasing in wealth,

$$\frac{dw_R}{da} = \frac{u'(a) - u'(w_R + a)}{u'(w_R + a)} \geq 0, \tag{2}$$

since $u'(a) \geq u'(w_R + a)$ from the concavity of the utility function. Thus, everything else equal, the larger the endowment of wealth, the higher the reservation wage, the weaker the incentives to work.[6]

As shown in Figure 1, employment rates are nearly flat across wealth deciles. There are two aspects of this observation that are worth stressing. First, in the data, household heads with nearly zero wealth work "too little" compared to what the model predicts. This happens because in the model individuals that are out of work have no income

[5]Here we assume that individuals differ solely in terms of their wealth. If we introduced heterogeneity in, say, efficiency units of labor ("skills"), as well as idiosyncratic shocks to skills, the reservation wage would be unambiguously decreasing in skills for any given level of wealth.

[6]In Appendices B.1-B.3, we show that the same prediction remains true in the context of (i) a model with capital income taxes, (ii) a neoclassical growth model with wealth heterogeneity, and (iii) a version of the neoclassical growth model with idiosyncratic wage shocks, wealth heterogeneity, and complete markets.

to fund consumption, which is clearly unrealistic. Allowing for government transfers targeted to the wealth poor has been the common approach in the literature to overcome this counterfactual model prediction.

Second, the standard labor supply model predicts that work incentives taper off as wealth increases. What is needed is then, a mechanism that flattens the cross-sectional relation between reservation wages and wealth. Next, we show that a "quality choice" in consumption can account under some conditions for the cross-sectional relation between hours worked and wealth in the data.

## 3.2 A Labor Supply Model with Quality Choice

We modify the individual's labor supply problem by allowing for a quality choice in consumption.[7] Preferences are $u(c, q) - Bh$ where $q$ denotes the quality of consumption. The individual's problem is to maximize $u(c, q) - Bh$, subject to the budget constraint $p(q)c = wh + a$. To capture the idea that higher-quality versions are more expensive, we assume that $p'(q) \equiv \partial p(q)/\partial q \geq 0$.

**Restrictions on preferences** The first-order conditions (FOCs) for quality and quantity give the intratemporal condition

$$\frac{u_2(c,q)}{u_1(c,q)} = \frac{p'(q)c}{p(q)}, \tag{3}$$

where $u_1$ denotes the derivative of the utility function with respect to consumption, the marginal utility of consumption. Similarly, $u_2$ is the marginal utility of quality.

Total differentiation of equation (3) yields

$$\frac{dq}{dc} = \left[\frac{1}{c} - \left(\frac{u_{21}(c,q)}{u_2(c,q)} - \frac{u_{11}(c,q)}{u_1(c,q)}\right)\right] \Big/ \left[\frac{u_{22}(c,q)}{u_2(c,q)} - \frac{u_{12}(c,q)}{u_1(c,q)} - \left(\frac{p''(q)}{p'(q)} - \frac{p'(q)}{p(q)}\right)\right], \tag{4}$$

[7] More formally, "quality" is an attribute of the good that is valued by consumers. For example, consider meat and the quality grades assigned by the U.S. Department of Agriculture, ranging from the "prime" cut, i.e. the highest quality available, to lower quality, ungraded cuts.

so that $dq/dc = 0$ if and only if

$$\frac{1}{c} - \frac{u_{21}(c,q)}{u_2(c,q)} + \frac{u_{11}(c,q)}{u_1(c,q)} = 0. \tag{5}$$

Condition (5) defines the class of admissible utility functions consistent with quality being invariant to the quantity of consumption.

**Proposition 1 (Separable preferences)** *Assume that preferences are separable in the quantity and quality of consumption, such that $u(c,q) = f(c) + g(q)$, where $f$ and $g$ are strictly increasing and concave, and twice continuously differentiable. Quality choice is invariant to the quantity of consumption, i.e., $dq/dc = 0$, if and only if the utility function is logarithmic in consumption:*

$$f(c) = \alpha \log(c),$$

*where $\alpha > 0$ is an arbitrary constant.*

**Proof.** See Appendix B.4. ■

**Proposition 2 (Non-separable preferences)** *Assume that preferences are non-separable in the quantity and quality of consumption, such that $u(c,q) = f(c)g(q)$, where $f$ and $g$ are strictly increasing and concave, and twice continuously differentiable. Quality choice is invariant to the quantity of consumption, i.e., $dq/dc = 0$, if and only if the marginal rate of substitution is proportional to consumption:*

$$MRS \equiv \frac{u_2(c,q)}{u_1(c,q)} \propto c.$$

**Proof.** See Appendix B.4. ■

To sum, the requirement of quality be a normal good, i.e., $dq/dc > 0$, so that higher-income individuals choose higher-quality goods, imposes restrictions on preferences. That is, preferences are to be of the *non-homothetic* type.

**Quality choice and labor supply** The reservation wage is implicitly determined by the indifference condition

$$u\left(\frac{w_R + a}{p(q_e)}, q_e\right) - B = u\left(\frac{a}{p(q_u)}, q_u\right), \tag{6}$$

where $q_e$ and $q_u$ indicate the quality choice if working, and not working, respectively.

Total differentiation of equation (6) gives

$$\left[\frac{u_1(c_e, q_e)}{p(q_e)}\right] dw_R = \left[\frac{u_1(c_u, q_u)}{p(q_u)} - \frac{u_1(c_e, q_e)}{p(q_e)}\right] da$$
$$+ \left[u_2(c_u, q_u) - \frac{p'(q_u)c_u}{p(q_u)} u_1(c_u, q_u)\right] dq$$
$$- \left[u_2(c_e, q_e) - \frac{p'(q_e)c_e}{p(q_e)} u_1(c_e, q_e)\right] dq, \tag{7}$$

where $c_e = (w_R + a)/p(q_e)$ and $c_u = a/p(q_u)$ indicate consumption if working, and not working, respectively. The intratemporal condition (3) implies that the last two terms on the right-hand side of equation (7) are equal to zero, such that

$$\frac{dw_R}{da} = \frac{p(q_e)}{p(q_u)} \cdot \frac{u_1(c_u, q_u)}{u_1(c_e, q_e)} - 1 \lesseqqgtr 0. \tag{8}$$

The key insight from equation (8) is that the sign of the comparative statics depends on two distinct channels. The first pertains to the available menu of price-quality bundles, as captured by the relative price term $p(q_e)/p(q_u)$. The second measures the extent to which the marginal utility of consumption changes based on the decision to work or not, as captured by the ratio of marginal utilities term $u_1(c_u, q_u)/u_1(c_e, q_e)$. In general, then, the reservation wage can be increasing or decreasing in wealth, or even invariant to wealth if the knife-edge condition $p(q_e)u_1(c_u, q_u) = p(q_u)u_1(c_e, q_e)$ holds.

There are, however, two cases in which we can provide a definite answer.

**Proposition 3 (Irrelevance of quality choice #1)** *If the utility function $u(c, q)$ defined over the quantity $c$ and quality $q$ of consumption is strictly increasing and concave, twice continuously differentiable, and it satisfies the restriction that*

$$\frac{1}{c} - \frac{u_{21}(c, q)}{u_2(c, q)} + \frac{u_{11}(c, q)}{u_1(c, q)} = 0,$$

*then the reservation wage is monotonically increasing in wealth.*

**Proof.** If $q_e = q_u = \bar{q}$, then $p(q_e) = p(q_u) = p(\bar{q})$, implying that $p(q_e)/p(q_u) = 1$. Since $u_1(a/p(\bar{q}), \bar{q}) \geq u_1((w_R + a)/p(\bar{q}), \bar{q})$ from the concavity of the utility function, equation

(8) implies that $dw_R/da \geq 0$ for all $a \geq 0$. ■

Proposition 3 provides an important benchmark. In the case of homothetic preferences in which quality choice does not depend on the employment status, the reservation wage is always increasing in wealth, as in the standard labor supply model without a quality choice. In this sense, a quality choice is a necessary, not sufficient, condition to offset the standard negative wealth effect on labor supply.

**Proposition 4 (Irrelevance of quality choice #2)** *If the utility function $u(c, q)$ is separable in the quantity $c$ and quality $q$ of consumption (i.e., the marginal utility of consumption is invariant to quality) and prices are (weakly) increasing in quality, then the reservation wage is monotonically increasing in wealth.*

**Proof.** With a separable utility function, equation (8) becomes

$$\frac{dw_R}{da} = \frac{p(q_e)}{p(q_u)} \cdot \frac{u_1\left(c_u\right)}{u_1\left(c_e\right)} - 1 \geq 0. \tag{9}$$

If $p'(q) \geq 0$, then $p(q_e)/p(q_u) \geq 1$. With $c_e \geq c_u$, $u_1\left(c_u\right) \geq u_1\left(c_e\right)$ from the concavity of the utility function, such that $dw_R/da \geq 0$ for all $a \geq 0$. ■

Proposition 4 provides another important benchmark result. Insofar as consumption is a normal good, a form of non-separability between quality and quantity is needed in order to overturn the standard result of the reservation wage rising with wealth. That is, a higher quality must imply not only a higher utility, but also a higher marginal utility of consumption, i.e., $u_{12}(c, q) > 0$. Note, however, that non-separability is only a necessary condition; the positive effect of quality on the marginal utility of consumption has to be strong enough to offset the relative price effect.

## 3.3 A Simple General-Equilibrium Model with Quality Choice

A key theoretical insight from the previous subsection is that a quality choice with non-homothetic preferences is necessary, yet not sufficient, condition to reproduce the nearly flat relationship between employment rates and wealth in the data. Crucially, functional form assumptions for utility and production functions, as well as the general equilibrium that determines the menu of quality-price bundles are critical factors in determining the sign of the comparative statics of the reservation wage to wealth. To clarify some of these issues, and build intuition, in this section we study a *one-period* general-equilibrium (GE) model that features a quality choice with non-homothetic preferences and Cobb-Douglas production functions. (In Appendix B.5, we present an infinite-horizon version of the model with labor-augmenting technical change and a utility function specification that is consistent with a balanced growth path with constant per capita hours.)

On the consumption side, we amend the utility function in Jaimovich, Rebelo and Wong (2019) to allow for indivisible labor:

$$\frac{q^{1-\theta}}{1-\theta}\log(c) - Bh, \quad 0 < \theta < 1. \tag{10}$$

The FOCs for the quantity and quality of consumption give the intratemporal condition:

$$\frac{p'(q)q}{p(q)} = (1-\theta)\log(c) = (1-\theta)\log\left(\frac{wh+a}{p(q)}\right). \tag{11}$$

On the production side, there are sectors producing consumption goods that differ by quality. Within each sector, perfectly competitive firms produce $Y_q$ units of the final good of quality $q$ using a Cobb-Douglas production function,

$$Y_q = K_q^{\alpha}\left(\frac{N_q}{q}\right)^{1-\alpha}, \quad 0 < \alpha < 1, \tag{12}$$

where $K_q$ and $N_q$ are capital and labor services, respectively. Standard Cobb-Douglas algebra gives that the capital-labor ratio is independent of quality:

$$\frac{K_q}{N_q} = \left(\frac{\alpha}{1-\alpha}\right)\frac{w}{R}, \tag{13}$$

where $w$ and $R$ are the wage and rental rate of capital, respectively. Using equation (13) and the FOC for labor, after rearranging terms, we obtain

$$p(q) = q^{1-\alpha}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}\left(\frac{R}{\alpha}\right)^{\alpha} = Gq^{1-\alpha}, \tag{14}$$

where for notational convenience we let $G \equiv [w/(1-\alpha)]^{1-\alpha}(R/\alpha)^{\alpha}$. Note that equation (14) implies that prices are increasing in quality and that the price elasticity to quality

$p'(q)q/p(q)$ is constant and equal to $1-\alpha$.

Using equations (11) and (14), we obtain that the level of quality and unit prices are increasing in earnings and wealth, and that the quantity of consumption is a constant:

$$q = (wh+a)^{\frac{1}{1-\alpha}} / (e^{\frac{1}{1-\theta}} G^{\frac{1}{1-\alpha}}), \tag{15}$$

$$p(q) = (wh+a) / e^{\frac{1-\alpha}{1-\theta}}, \tag{16}$$

$$c = e^{\frac{1-\alpha}{1-\theta}}. \tag{17}$$

This simple GE model yields sharp predictions on quantity and quality Engel curves.[8] Specifically, the quantity Engel curve is a flat horizontal line, whereas the quality Engel curve is linear, implying an elasticity of the unit price to income of one. Furthermore, the elasticity of quality with respect to income is constant and larger than one, that is, $1/(1-\alpha) > 1$.

Finally, the individual's indifference condition between working and not-working gives the reservation wage,

$$w_R = \left[ a^{\frac{1-\theta}{1-\alpha}} + \frac{(1-\theta)^2}{1-\alpha} G^{\frac{1-\theta}{1-\alpha}} eB \right]^{\frac{1-\alpha}{1-\theta}} - a. \tag{18}$$

First, if the elasticity of utility with respect to quality equals the price elasticity to quality ($\theta = \alpha$), the reservation wage is independent of wealth. Note that while in the Cobb-Douglas case this result is based on a knife-edge condition on parameters, in the case of CES production functions this is no longer true. In general, the price elasticity to quality is an endogenous object determined alongside equilibrium allocations and prices. This comparative statics result thus provides a useful benchmark. Insofar as utility and (equilibrium) price elasticities to quality are roughly the same, the reservation wage is insensitive to changes in wealth, implying that employment rates, too, do not fall steeply with wealth.

Second, if the elasticity of utility to quality is larger than the price elasticity to quality ($\theta < \alpha$), the reservation wage is monotonically decreasing in wealth. That is, the higher the wealth, the lower the reservation wage, the higher the likelihood of working. Such negative relationship between reservation wages and wealth implies that employment

[8] A quantity Engel curve traces out the number of units purchased against income or wealth, whereas a quality Engel curve traces out the unit price against income or wealth.

rates are increasing in wealth. If instead the elasticity of utility to quality is smaller than the price elasticity ($\theta > \alpha$), the reservation wage is monotonically increasing in wealth. The larger the wealth, the higher the reservation wage, implying that employment rates are decreasing in wealth. Again, something we do not see in the data.

While valuable for analytical insight, the Cobb-Douglas structure puts restrictions on the shape of quality Engel curves that are not borne out in the data, such as a unitary price elasticity with respect to income. In Section 4, we assume a CES production structure, in which the price elasticity to quality becomes an equilibrium object determined alongside wages, rental rate, and the level of quality itself.

# 4 Incomplete-Markets Model with Quality Choice

We now study quality choice in a heterogeneous-agent, incomplete-markets model à la Bewley (1983), Imrohoroğlu (1989), Huggett (1993), and Aiyagari (1994). The objective is to develop a quantitative model of how households make consumption expenditures and labor supply decisions and how these decisions impact wealth accumulation and thereby the relation between wealth and hours worked across households. In doing so, we lay the ground for the counterfactual and policy analysis.

## 4.1 Environment

Time is discrete and continues forever, indexed by $t = 0, 1, \ldots, \infty$. The model economy is inhabited by a continuum of measure one of infinitely-lived households. Differently from the stylized settings in the previous section, the model we develop here is dynamic. Households choose the quantity and quality of consumption, whether to work or not, and how much to save in the face of idiosyncratic shocks. More precisely, households differ in terms of efficiency units of labor. Each household has one unit of time per period, which yields $z_t$ units of labor input, where $z_t$ is independent and identically distributed (i.i.d.) across households and follows an AR(1) process in logs:

$$\log(z_{t+1}) = \rho_z \log(z_t) + \sigma_z \epsilon_{t+1}, \tag{19}$$

where the parameters $\rho_z \in (0,1)$ and $\sigma_z > 0$ govern the persistence and the volatility of idiosyncratic productivity shocks, respectively. As is common in the heterogeneous-agent macro literature, we assume that asset markets are incomplete, so that households cannot fully insure against idiosyncratic risk.

On the production side, there is a continuum of sectors producing versions of the consumption good $Y_q$ of quality $q$. In the investment sector, a continuum of firms produce a capital good, $X$, that adds to the capital stock of the economy, $K$. The capital stock depreciates at the constant rate $\delta \in (0,1)$. Both consumption and investment goods are produced with a CES technology that uses capital and labor services (i.e., hours times efficiency units of labor) as inputs. Importantly, consumption goods of different quality are produced with different capital-labor ratios, encompassing the case of higher-quality goods being more intensive in labor.

**Preferences and budget constraints** Before describing preferences and budget sets, it is useful to discuss the choice problem of the household. At any point in time, households face a *menu* of quality-price bundles $\{q_t, p_t(q_t)\}$ from which to choose, where unit prices $p_t(q_t)$ are functions of quality levels $q_t$. Households can choose only *one* bundle from those available, whereas they can consume any quantity $c_{q,t}$ of the consumption good of quality $q_t$. Henceforth, abusing notation slightly, we use $p_t$ to denote the price function $p_t(q_t)$ and $c_t$ to denote the quantity $c_{q,t}$.

Household's preferences are described by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[ u(c_t, q_t) - v(h_t) \right], \tag{20}$$

where $\mathbb{E}_0$ is the expectation operator conditional on the information available at $t = 0$ and $0 < \beta < 1$ is the time discount factor. We assume that $u$ is strictly increasing, concave, and twice continuously differentiable in both arguments and $v$ satisfies $v\left(\bar{h}\right) = B\bar{h}$ when $h_t = \bar{h}$ and $v(0) = 0$ when $h_t = 0$.

Household's expenditures are purchases of consumption goods, $p_t c_t$, and of a one-period risk-free bond, $a_{t+1}$, that earns the real interest rate $r_t$. Household's income comes from three sources: (i) after-tax earnings, $(1 - \tau_t) z_t w_t h_t$, where $w_t$ is the hourly wage per efficiency units of labor, $z_t$, and $\tau_t$ is a flat-rate tax on labor income; (ii) asset income, $r_t a_t$; and (iii) government transfers, $T_t \geq 0$.

The household's budget constraint is given by

$$a_{t+1} = (1 + r_t)a_t + (1 - \tau_t)z_t w_t h_t - p_t c_t + T_t, \tag{21}$$

and we impose a no borrowing constraint such that $a_t \geq 0$ for all $t \geq 0$.

**Technology** Consumption goods of quality $q$ are produced by a continuum of measure one of competitive firms with a CES production function

$$Y_{q,t} = \left[\alpha K_{q,t}^{\rho} + (1 - \alpha)\left(N_{q,t}/q\right)^{\rho}\right]^{1/\rho}, \tag{22}$$

where $K_{q,t}$ and $N_{q,t}$ denote capital and labor inputs in the consumption sector, industry $q$, respectively. The parameter $\rho \leq 1$ governs the degree of substitutability between capital and labor. If $\rho = 0$, the production function (22) reduces to a Cobb-Douglas and if $\rho < 0$ there is less substitution between capital and labor than in the Cobb-Douglas case. For future reference, we note that when $\rho < 0$, labor intensity increases in quality, i.e., the production of higher-quality goods displays lower capital-labor ratios.

Investment goods are produced by a continuum of measure one of competitive firms with a CES production function

$$X_t = \left[\alpha K_{I,t}^{\rho} + (1 - \alpha)(N_{I,t}/q_I)^{\rho}\right]^{1/\rho}, \tag{23}$$

where $q_I$ is the quality of the investment good and $K_{I,t}$ and $N_{I,t}$ denote capital and labor inputs in the investment sector, respectively.

**Government** The government runs a means-tested transfer program which guarantees a minimum consumption level $\bar{c}$ to nonemployed households. Transfers $T_t \geq 0$ are tested by household's wealth as well as after-tax earnings. Absent these transfers, households with zero wealth would decide to work regardless of how low their productivity is.

According to this transfer program, nonemployed households receive $\bar{c}$ net of what they could afford by selling off their wealth and of their potential after-tax earnings:

$$T(a_t, z_t) = \max\{0, \bar{c} - a_t(1 + r_t) \perp (a_t > 0) - (1 - \tau_t)z_t w_t h_t\}, \tag{24}$$

where we make explicit that the transfers are targeted to an household with assets $a_t$ and productivity $z_t$.

The government balances the budget on a period-by-period basis. Hence, transfers must equal tax revenues at all times:

$$\int T(a_t, z_t) d\lambda(a_t, z_t) = \int \tau_t z_t w_t h_t(a_t, z_t) d\lambda(a_t, z_t), \tag{25}$$

where $\lambda(a_t, z_t)$ is the endogenous distribution of households over assets and productivity, an equilibrium object generated by the model.

## 4.2 Household Problem

A household's decision problem is to choose contingency plans for the quantity, $\{c_t\}_{t=0}^{\infty}$, and quality, $\{q_t\}_{t=0}^{\infty}$, of consumption, labor supply, $\{h_t\}_{t=0}^{\infty}$, and bond holdings, $\{a_t\}_{t=1}^{\infty}$, taking prices $\{r_t, w_t, p_t\}_{t=0}^{\infty}$ as given, in order to maximize lifetime utility (20), subject to the budget constraint (21) and the stochastic process for the idiosyncratic productivity shock (19) with the initial condition $(a_0, z_0)$.

We formulate the problem of the household in recursive form. To this goal, henceforth, we omit time subscripts and use primes to denote next period variables. All information necessary for optimal decision making at a particular point in time is summarized by the state vector $(a, z)$, where $a$ and $z$ are the individual state variables. We omit the aggregate state variables – prices and the balanced-budget tax rate – from the state vector as we focus on the stationary equilibrium of the model, in which aggregate state variables are constant.

**Bellman equations** Let $V(a, z)$ denote the maximum utility attainable by the household that begins the period with the state vector $(a, z)$ and subsequently behaves optimally. At the beginning of each period, the household has to choose between working ($E$) and not-working ($U$):

$$V(a, z) = \max_{h \in \{0, \bar{h}\}} \left[ V^E(a, z), V^U(a, z) \right]. \tag{26}$$

Let $V^E(a, z)$ be the value function of a working household. This function satisfies the

Bellman equation

$$V^E(a,z) = \max_{c,\,q,\,a'} u(c,q) - B\bar{h} + \beta \mathbb{E}\left[V(a',z')|z\right], \tag{27}$$

subject to the budget constraint

$$a' = a(1+r) + (1-\tau)zw\bar{h} - p(q)c. \tag{28}$$

Let $V^U(a,z)$ be the value function of a not-working household. This function satisfies the Bellman equation

$$V^U(a,z) = \max_{c,\,q,\,a'} u(c,q) + \beta \mathbb{E}\left[V(a',z')|z\right], \tag{29}$$

subject to the budget constraint

$$a' = a(1+r) - p(q)c + T. \tag{30}$$

**Quality-quantity trade-off** As in the static model in Section 3, the household's decision problem involves a trade-off between the quality and quantity of consumption. Higher-quality versions of consumption goods provide higher utility than lower-quality versions, but they are more expensive. For a given a menu of quality-price bundles, $\{q, p(q)\}$, households trade off the utility derived from quality versus the cost of purchasing the preferred basket.

The FOCs with respect to the quantity and quality of consumption are, respectively,

$$\frac{u_1(c,q)}{p(q)} = \beta \mathbb{E}\left[V_1(a',z')|z\right], \tag{31}$$

$$\frac{u_2(c,q)}{p'(q)c} = \beta \mathbb{E}\left[V_1(a',z')|z\right], \tag{32}$$

where $p'(q) \equiv \partial p(q)/\partial q$. Combining equations (31) and (32) gives the intratemporal condition that captures the quality-quantity trade-off faced by the household,

$$\frac{u_2(c,q)}{u_1(c,q)} = \frac{p'(q)c}{p(q)}. \tag{33}$$

### 4.3 Firm Problem

Production of consumption and investment goods takes place in perfectly competitive markets. We assume that capital and labor can freely move across sectors, such that wages and capital rental rates are equalized across sectors. We begin by describing the firm problem in the consumption sector, we then turn to the investment sector. Also, since the firm's problem is static, henceforth, we omit time subscripts.

**Consumption sector** Firms in the consumption sector maximize profits taking the wage, capital rental rate, and output price as given:

$$\max_{K_q, N_q} \Pi_q \equiv p(q)Y_q - RK_q - wN_q, \tag{34}$$

subject to the production technology (22). FOCs with respect to capital and labor services are

$$R = p(q)\left[\alpha K_q^{\rho} + (1-\alpha)\left(N_q/q\right)^{\rho}\right]^{\frac{1-\rho}{\rho}} \alpha K_q^{\rho-1}, \tag{35}$$

$$w = p(q)\left[\alpha K_q^{\rho} + (1-\alpha)\left(N_q/q\right)^{\rho}\right]^{\frac{1-\rho}{\rho}} (1-\alpha)q^{-\rho}N_q^{\rho-1}. \tag{36}$$

Combining equations (35) and (36) yields the capital-labor ratio in the industry that produces the consumption good of quality $q$:

$$\frac{K_q}{N_q} = \left[\left(\frac{\alpha}{1-\alpha}\right)\frac{w}{R}\right]^{\frac{1}{1-\rho}} q^{\frac{\rho}{1-\rho}}. \tag{37}$$

In the Cobb-Douglas case of $\rho = 0$, the capital-labor ratio is independent of quality:

$$\frac{K_q}{N_q} = \left(\frac{\alpha}{1-\alpha}\right)\frac{w}{R}. \tag{38}$$

If $0 < \rho < 1$, the capital-labor ratio is increasing in quality and the industry is capital intensive. Finally, if $\rho < 0$, the capital-labor ratio is decreasing in quality and the industry is labor intensive.

Using the expression for the capital-labor ratio (37), after rearranging terms, the price of the consumption good of quality $q$ is

$$p(q) = \left[(1-\alpha)^{1/(1-\rho)} (wq)^{\frac{\rho}{\rho-1}} + \alpha^{1/(1-\rho)} R^{\frac{\rho}{\rho-1}}\right]^{\frac{\rho-1}{\rho}}. \tag{39}$$

Equation (39) gives that prices are increasing in quality,

$$p'(q) = \frac{(1-\alpha)^{1/(1-\rho)} w^{\frac{\rho}{\rho-1}} q^{\frac{1}{\rho-1}}}{\left[(1-\alpha)^{1/(1-\rho)} (wq)^{\frac{\rho}{\rho-1}} + \alpha^{1/(1-\rho)} R^{\frac{\rho}{\rho-1}}\right]^{\frac{1}{\rho}}} > 0. \tag{40}$$

Further, the price elasticity to quality is

$$e_q^p \equiv \frac{p'(q)q}{p(q)} = \frac{(1-\alpha)^{1/(1-\rho)} (wq)^{\frac{\rho}{\rho-1}}}{(1-\alpha)^{1/(1-\rho)} (wq)^{\frac{\rho}{\rho-1}} + \alpha^{1/(1-\rho)} R^{\frac{\rho}{\rho-1}}}. \tag{41}$$

From expression (41) it is evident that $e_q^p$ is generally a function of the equilibrium wage, $w$, and rental rate, $R$. Moreover, if $0 < \rho < 1$, $e_q^p$ is decreasing in quality, whereas, if $\rho < 0$, $e_q^p$ is increasing in quality. And in the Cobb-Douglas case of $\rho = 0$, the price elasticity to quality is constant, that is, $e_q^p = 1 - \alpha$.

**Investment sector** We choose the investment good to be the numéraire, so its price is normalized to one. Firms in the investment sector maximize profits taking the wage and capital rental rate as given:

$$\max_{K_I, N_I} \Pi_I \equiv X - RK_I - wN_I, \tag{42}$$

subject to the production technology (23). FOCs with respect to capital and labor services are

$$R = p(q) \left[\alpha K_I^\rho + (1-\alpha) (N_I/q_I)^\rho\right]^{\frac{1-\rho}{\rho}} \alpha K_I^{\rho-1}, \tag{43}$$

$$w = p(q) \left[\alpha K_I^\rho + (1-\alpha) (N_I/q_I)^\rho\right]^{\frac{1-\rho}{\rho}} (1-\alpha) q_I^{-\rho} N_I^{\rho-1}. \tag{44}$$

Combining equations (43) and (44) yields the capital-labor ratio in the investment sector:

$$\frac{K_I}{N_I} = \left[ \left( \frac{\alpha}{1-\alpha} \right) \frac{w}{R} \right]^{\frac{1}{1-\rho}} q_I^{\frac{\rho}{1-\rho}}. \tag{45}$$

## 4.4 Stationary Competitive Equilibrium

We consider a stationary equilibrium in which aggregate variables are constant.

**Equilibrium definition** A Recursive Competitive Equilibrium (RCE) consists of a set of value functions, $\{V(a,z), V^E(a,z), V^U(a,z)\}$, a set of decision rules for the quantity and quality of consumption, asset holdings, and labor supply, $\{c_q(a,z), q(a,z), a'(a,z), h(a,z)\}$, aggregate inputs in the consumption sector, $\{K_C, N_C\}$, inputs in the investment sector, $\{K_I, N_I\}$, factor prices, $\{w, R\}$, unit prices of different qualities, $\{p(q(a,z))\}$, government policy, $\{T(a,z), \tau\}$, and a stationary distribution $\lambda(a,z)$ induced by the AR(1) process for $z$ and the decision rule for asset holdings $a'(a,z)$, such that:

1. Individual decision rules solve Bellman equations.

2. Firms maximize profits.

3. The asset market clears:

$$\int a \, d\lambda = K, \tag{46}$$

   where $K = K_C + K_I$ is the aggregate capital stock, and $K_C$ and $K_I$ are the capital stocks in the consumption and investment sector, respectively.

4. The labor market clears:

$$\int zh(a,z) \, d\lambda = N, \tag{47}$$

   where $N = N_C + N_I$ is aggregate labor services, and $N_C$ and $N_I$ are labor services in the consumption and investment sector, respectively. Note that $N$ is aggregate efficiency-weighted hours. Aggregate hours are

$$H = \int h(a,z) \, d\lambda. \tag{48}$$

5. The government budget constraint is balanced:

$$\int T(a,z)\,d\lambda = \tau w \int zh(a,z)\,d\lambda = \tau w N. \tag{49}$$

6. The market for each quality level $q$ clears:

$$\int c_q(a,z)\,d\lambda = Y_q. \tag{50}$$

7. The goods market clears:

$$\int \left[p(q(a,z))c_q(a,z) + a'(a,z)\right] d\lambda$$
$$= \int p(q(a,z)) \left[F_1\left(K_q, \frac{N_q}{q}\right) a + F_2\left(K_q, \frac{N_q}{q}\right) zh(a,z)\right] d\lambda + (1-\delta)K, \tag{51}$$

where $F_1\left(K_q, N_q/q\right) = \partial Y_q/\partial K_q$ and $F_2\left(K_q, N_q/q\right) = \partial Y_q/\partial N_q$.

8. The stock of capital evolves according to

$$K' = (1-\delta)K + X, \tag{52}$$

where $X = \delta K$.

# 5 Quantitative Analysis

In this section, we study the quantitative properties of the model. We refer the reader to Appendix C for the solution method used to compute the equilibrium of the model, and for a plot of the value function and decision rules.

## 5.1 Functional Form for Utility Function

In Section 3 we derived theoretical results that rule out utility function specifications of the homothetic type. Further, we established that a form of *non-separability* in quality is necessary to restore work incentives for wealthy individuals. Given these requirements, we adopt the utility function in Jaimovich, Rebelo and Wong (2019), amended to allow for a labor supply choice along the extensive margin:

$$\frac{q^{1-\theta}}{1-\theta}\log(c) - Bh. \tag{53}$$

This utility function specification has several appealing properties. First, the marginal utility of consumption is increasing in quality. This property is key for the model to generate work incentives that are strong enough to offset the negative wealth effect on labor supply. To see this, consider again the basic insight from standard labor supply theory. In deciding whether to work or not, an individual trades off the utility gain from working, due to the additional consumption one can afford, with the disutility of work. As consumption increases with wealth and the marginal utility of consumption instead decreases with consumption, it follows that the utility gain from working for a wealth-rich individual is necessarily smaller than that for a wealth-poor individual. As a result, the willingness to supply labor decreases with wealth.

Second, note that if we set $q = 1$, then preferences above nest the utility function $\log(c) - Bh$, which is one of the most widely used specification in macroeconomics. In Appendix D, we provide results for a calibrated version of the model without a quality choice and logarithmic preferences in consumption.

## 5.2 Parametrization

We now turn to discuss the calibration of the model parameters describing preferences, technology, and government policy. As standard in dynamic general equilibrium models, none of the parameters has a one-to-one relationship to a specific moment. Nonetheless, it is useful to describe the calibration procedure as a few distinct steps. Overall, we are to assign values to 13 parameters, $\left(\beta, \alpha, \delta, \rho, \theta, \rho_z, \sigma_z, \bar{h}, B, \bar{c}, z^{\max}, \pi^{\text{up}}, \pi^{\text{stay}}\right)$.

**Externally calibrated parameters** We externally calibrate a subset of eight parameters, $(\beta, \alpha, \delta, \rho, \theta, \rho_z, \sigma_z, \bar{h})$, directly from the data or based on common values in the literature. Panel A of Table 1 shows parameter values and their sources.

A model period is taken to be a quarter. The discount factor $\beta$ is set equal to 0.99. The physical depreciation rate of the capital stock $\delta$ is 2.5% per quarter, which yields a depreciation rate of 10% a year. The capital income share $\alpha$ is 36%. Based on Chang and

Kim (2007), we set the persistence of the productivity shock $\rho_z$ to 0.929, and the standard deviation of the innovation to the productivity shock $\sigma_z$ to 0.227. (See Appendix C for the grid and the matrix of transition probabilities of the discretized productivity process.)

There are two parameters that are important for our analysis whose calibration is not standard: (i) the utility parameter $\theta$ which determines the curvature of the utility function with respect to quality; (ii) the technology parameter $\rho$ which determines the elasticity of capital and labor in production, $1/(1-\rho)$. In the baseline calibration, $\theta = 0.5$, as in Jaimovich, Rebelo and Wong (2019), such that the elasticity of utility to quality is 0.5. In Appendix D, we provide results for four different values of the utility parameter: $\theta = 0.1$, $\theta = 0.3$, $\theta = 0.7$, and $\theta = 0.9$.

Table 1: Baseline Parametrization

| Parameter | Description | Value | Source/Target |
|---|---|---|---|
| Panel A. Externally calibrated parameters | | | |
| $\beta$ | Discount factor | 0.99 | Literature |
| $\alpha$ | Capital income share | 0.36 | Literature |
| $\delta$ | Depreciation rate | 0.025 | Literature |
| $\rho$ | Capital/labor substitutability | $-0.5$ | Jaimovich, Rebelo and Wong (2019) |
| $\theta$ | Elasticity of utility to quality | 0.5 | Jaimovich, Rebelo and Wong (2019) |
| $\rho_z$ | Persistence productivity shock | 0.929 | Chang and Kim (2007) |
| $\sigma_z$ | St. dev. productivity innovations | 0.227 | Chang and Kim (2007) |
| $\bar{h}$ | Labor supply if working | 1 | Normalization |
| Panel B. Internally calibrated parameters | | | |
| $B$ | Disutility of work | 0.86 | Emp. rate (80.23%) |
| $\bar{c}$ | Subsistence consumption | 2.02 | Emp. rate, lowest wealth quintile (71.32%) |
| $z^{\max}$ | Highest productivity shock | 13.34 | Wealth share, top decile (65.53%) |
| $\pi^{\text{up}}$ | Prob. of transitioning to $z^{\max}$ | 0.13 | Earnings share, top decile (35.87%) |
| $\pi^{\text{stay}}$ | Prob. of remaining at $z^{\max}$ | 0.94 | Earnings share, top 1% (11.76%) |

We set $\rho = -0.5$, as in Jaimovich, Rebelo and Wong (2019), such that the capital-labor elasticity is 0.67, implying that capital and labor are complements. This value for the elasticity is in line with the range of empirical estimates 0.5-0.7 in the literature (see, e.g., Oberfield and Raval, 2014). In Appendix D, we re-calibrate the model and provide results for the Cobb-Douglas case ($\rho = 0$), too.

**Internally calibrated parameters** Given the externally calibrated parameters, we jointly calibrate the remaining five parameters, $(B, \bar{c}, z^{\max}, \pi^{\text{up}}, \pi^{\text{stay}})$, so that five moments in the model match their corresponding empirical targets. Panel B of Table 1 shows the targets we use for the method-of-moments procedure, and their values in the model and data.

According to this procedure, the value of the disutility of work is set to $B = 0.86$, implying an aggregate employment rate of 80%. We normalize labor supply to $\bar{h} = 1$. Alternatively, one could set $\bar{h} = 1/3$, so that a working household spends one-third of available time at work, as in the data, and then multiply the value of the disutility of work $B$ by three.

We set the value of the subsistence consumption parameter to $\bar{c} = 2.02$, such that the model matches the average employment rate by the lowest wealth quintile of roughly 71%. This parametrization implies that total means-tested transfers are equal to 6% of average earnings. As a comparison, in the calibrated version of the model without quality, $\bar{c} = 1.05$, implying total transfers that are nearly 9% of average earnings. As we use $\bar{c}$ to match the same empirical target in both models, such a difference in the ratio of transfers to earnings highlights an important difference between the two models with and without quality. Everything else equal, in the model without quality, wealth-poor households have stronger incentives to work. This in turn implies that government transfers need to be relatively more generous for the model to hit the same 71% employment rate target for households in the lowest wealth quintile.

Based on Castañeda, Díaz-Giménez and Ríos-Rull (2003), we allow for the realization of an extreme productivity outcome, and that from that extreme productivity outcome, there is a nontrivial probability of a large fall in productivity. The combination of these features makes the highest earners have a significant demand for precautionary saving. Operationally, we introduce an additional productivity state, $z^{\max}$, that can be reached only from the second highest state. This gives 3 additional parameters: $z^{\max}$, $\pi^{\text{up}}$, and $\pi^{\text{stay}}$, where $\pi^{\text{up}}$ is the probability that $z$ moves to $z^{\max}$, and $\pi^{\text{stay}}$ is the probability that $z$ remains at $z^{\max}$. We calibrate these three parameters for the model to match three data moments: (i) the wealth share of the top wealth decile (65.53%); (ii) the earnings share of the top earnings decile (35.87%); (iii) the earnings share of the top 1% of the earnings distribution (11.76%). This procedure gives $z^{\max} = 13.34$, $\pi^{\text{up}} = 0.13$, and $\pi^{\text{stay}} = 0.94$. By heightening the precautionary saving motive of high earners, this parametrization generates an equilibrium wealth dispersion of a magnitude similar to that in U.S. data.

## 5.3 Properties of the Calibrated Economy

We now turn to discuss the main quantitative properties of the calibrated model. To clarify the role of quality choice, we contrast its predictions against those of the standard model without quality.[9]

### 5.3.1 Cross-Sectional Distributions of Hours, Earnings, and Wealth

As it is well known, in the United States, the distribution of earnings and, especially, that of household wealth are very concentrated and skewed to the right (see Castañeda, Díaz-Giménez and Ríos-Rull, 2003; Díaz-Giménez, Glover and Ríos-Rull, 2011; Kuhn and Ríos-Rull, 2016). Figure 2 shows that the model does a good job of accounting for these phenomena.

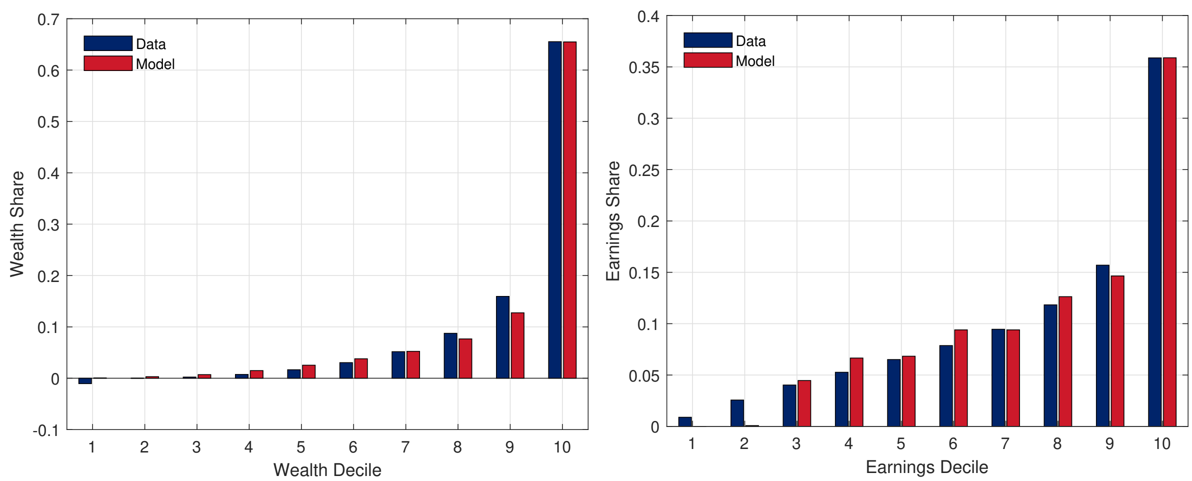


Figure 2: Earnings and Wealth Distributions – Model vs. Data

*Notes*: The figure shows the distributions of earnings and wealth in the model and the data. Data are from the PSID based on the biannual 2001-2015 waves for household heads of 25-65 years old. Wealth is total assets minus total liabilities at the household level. See Appendix A for details on data sources and variables' construction.

Figure 3 shows that the equilibrium distribution of employment rates by wealth deciles implied by the model lines up very well with its empirical counterpart in the data. This

[9] In Appendix D, we provide additional quantitative results for (i) a calibrated version of the standard model without a quality choice, and (ii) a calibrated version of the model with a quality choice and Cobb-Douglas production functions.Table D.1 shows the new re-calibrated parameter values. Figures D.1 and D.2 show the distribution of employment rates by wealth deciles in the two models, respectively.

is remarkable since all but the lowest quintile are un-targeted moments.[10]

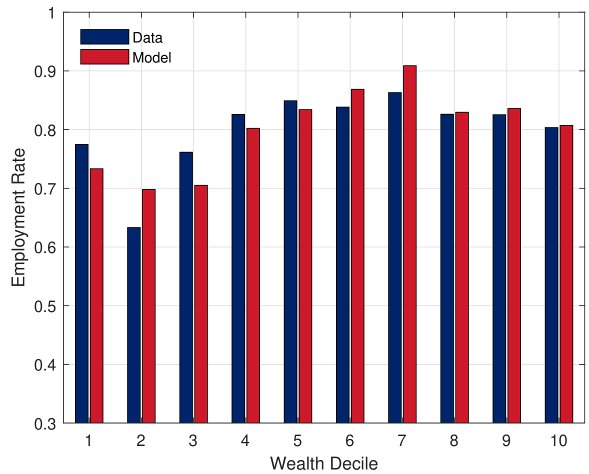


Figure 3: Employment by Wealth – Model vs. Data

*Notes*: The figure shows the distribution of employment rates by wealth deciles in the model and the data. Data are from the PSID based on the biannual 2001-2015 waves for household heads of 25-65 years old. Wealth is total assets minus total liabilities at the household level. See Appendix A for details on data sources and variables' construction.

Importantly, the model is able to account for the fact that wealth-rich households work nearly as much as wealth-poor households. In a version of the model without quality, these households would work considerably less. The wealth effect on labor supply is too strong in standard models. In the model with the quality choice, and non-homothetic preferences, instead, a large fraction of wealthy households keep on working in order to purchase expensive, high-quality versions of the consumption good.

At the lower end of the wealth distribution, in the model, as in the data, households have zero or near-zero wealth. For these households, the model implies an employment rate of one. The intuition for this prediction is straightforward. If an household has no wealth, and so no asset income, the only available option is to work at the ongoing wage in order to finance consumption. Notice that this mechanism is at play in models with and without a quality choice alike. In the data, however, we see that households with roughly zero wealth do not work nearly as much as the amount predicted by the model. To tackle this issue, a standard approach in the literature is to introduce government transfers that allow for a minimum level of consumption. These transfers go naturally to the wealth

[10] In Appendix D, Figure D.3 shows the distribution of employment rates by wealth deciles for versions of the model in which we keep the same baseline parameter values and change the utility parameter in turn to $\theta = 0.1$, $\theta = 0.3$, $\theta = 0.7$, and $\theta = 0.9$.

poor in the model, thus capturing the number of transfer programs that direct resources to needy U.S. households (e.g., Medicare, Medicaid, TANF, Unemployment Insurance, and so on).

In equilibrium, such means-tested transfers greatly mitigate the precautionary motive of labor supply, implying that some households do not work in spite of having no wealth, consistently with the data. Interestingly, though, we find that the extent to which transfers impact the equilibrium labor allocations of wealth-poor households differs significantly in the model with and without a quality choice.

**Role of transfers** To further highlight the role of government transfers, Figure 4 shows the equilibrium distributions from two versions of the model without quality (left panel) and with quality (right panel) in which transfers are not allowed. Two main results emerge.

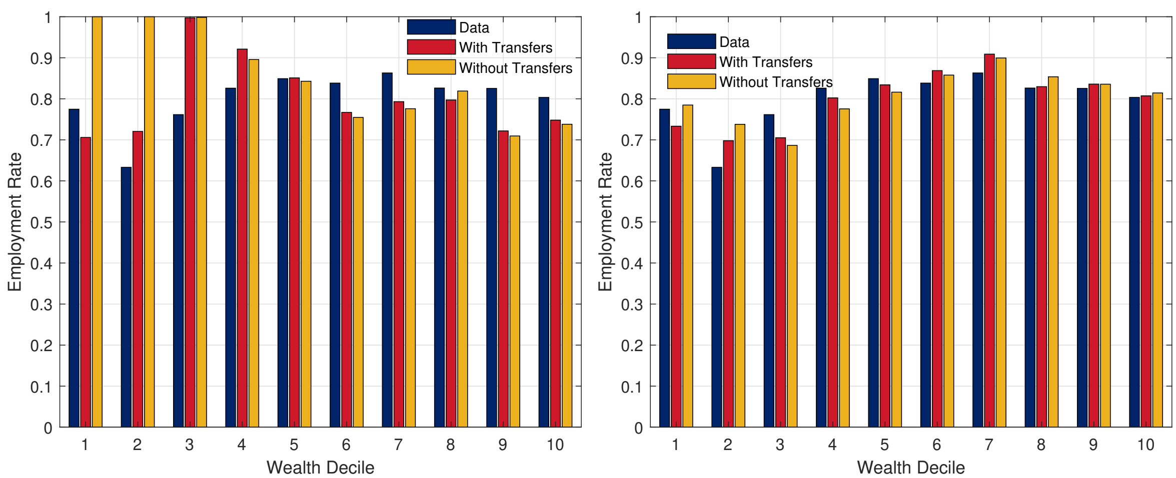


Figure 4: Employment by Wealth – Role of Transfers

(Left panel: Model without quality. Right panel: Model with quality.)

*Notes*: The figure shows the distribution of employment rates by wealth deciles in a version of the model without a quality choice (left panel) and with a quality choice (right panel) in which transfers are not allowed and in the data. Data are from the PSID based on the biannual 2001-2015 waves for household heads of 25-65 years old. Wealth is total assets minus total liabilities at the household level. See Appendix A for details on data sources and variables' construction.

First, in the standard model without quality, the employment rates for the first three deciles of the wealth distribution are equal to one. This comes at no surprise given

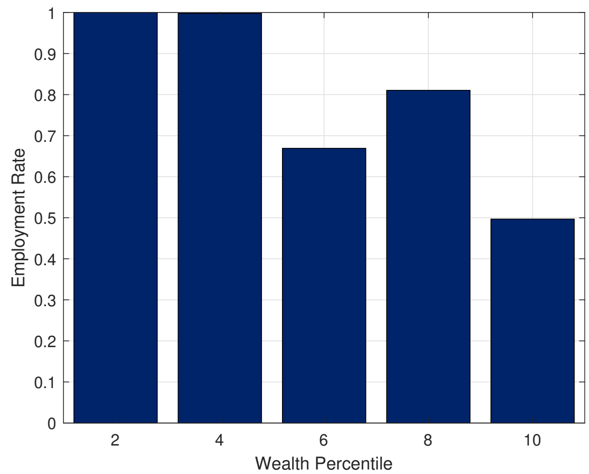


Figure 5: Employment by Wealth – First Wealth Decile

(Model with Quality and No Transfers)

*Notes*: The figure shows the distribution of employment rates within the first wealth decile of the model with a quality choice and no transfers. Data are from the PSID based on the biannual 2001-2015 waves for household heads of 25-65 years old. Wealth is total assets minus total liabilities at the household level. See Appendix A for details on data sources and variables' construction.

the discussion above. Second, the properties of the model with a quality choice do not seem to change in a significant way. However, if we zoom in the first wealth decile, the model predicts employment rates of one, but exclusively for the poorest 4% percent in the wealth distribution (see Figure 5). This arguably surprising result comes from the fact that wealth-poor households can cut back not only on the the quantity, but also on the quality of consumption. In this sense, quality choice acts as an additional self-insurance mechanism against negative wage shocks.

### 5.3.2 Consumption Versus Expenditures

**Unit prices, quantity, and quality of consumption** Figure 6 shows the relation between unit prices and quality implied by the equilibrium of the model. Not surprisingly, prices are increasing in quality: households are willing to pay more for higher-quality versions of the consumption good. As it turns out, the price-quality relation is approximately linear with a slope slightly less than one. We stress that the magnitude of this slope is an equilibrium object, which depends on the technological parameters $(\alpha, \rho)$ as well as the equilibrium wage and capital rental rate, as determined to clear the labor and asset markets alongside markets of different qualities. By virtue of this property, any change in the environment, for example, an unexpected change in tax policy, that causes a new equilibrium level of $w$ and $R$ necessarily implies a shift in the price function, and thereby a change in the relative prices of different qualities.

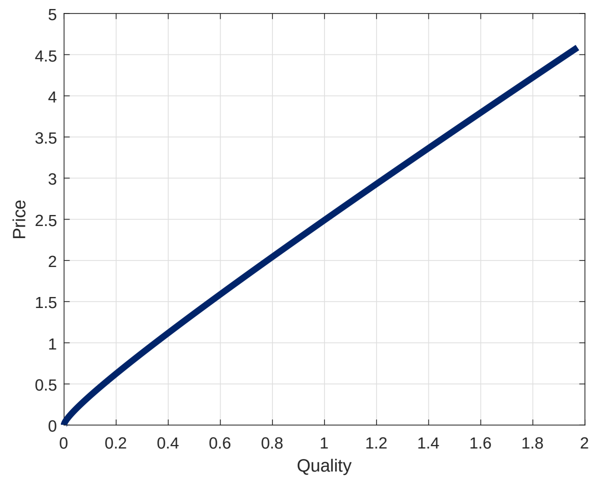


Figure 6: Price Function

*Notes*: The figure shows the relationship between prices and quality in the calibrated model.

Figure 7 shows (the quantity of) consumption and consumption expenditure by wealth deciles (left panel), and unit prices paid by wealth deciles (right panel). A striking result emerges. While consumption increases with wealth, it does not increase by nearly as much as expenditures. Most of the inequality in consumption expenditure generated by the model comes from differences in the quality of consumption, and so from the higher unit prices paid by wealthy households.[11]

Figure 8 shows the shares of total consumption (left panel) and of total expenditures (right panel) by earnings deciles, as implied by the calibrated models with and without quality choice. (Note that in the model without quality, consumption and expenditure are the same.) In the model with quality, consumption shares are nearly flat across the earnings distribution. By contrast, expenditure shares are highly concentrated with the top decile accounting for more than 25% of total expenditures. Again, such inequality in expenditures comes from the fact that richer households consume roughly the same

[11]In Appendix D, Figure D.4 shows quantity and quality Engel curves for a calibrated version of the model with quality and Cobb-Douglas production functions. In the Cobb-Douglas case, consumption is virtually flat across wealth deciles, so that differences in consumption expenditures by wealth come entirely from the different unit prices paid.

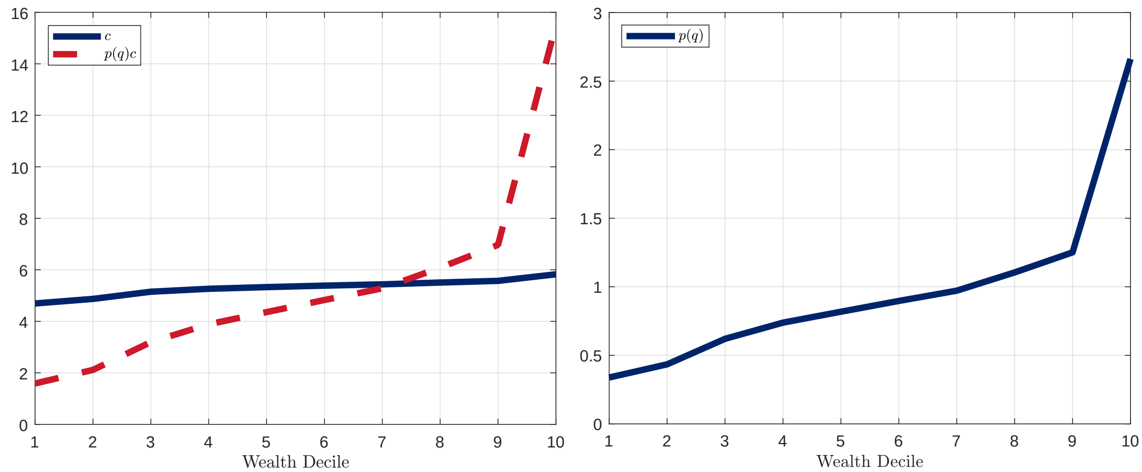


Figure 7: Quantity and Quality Engel Curves

*Notes*: The figure shows consumption and expenditures (left panel) and prices (right panel) by wealth deciles in the calibrated model.

quantity of consumption, but they purchase more expensive, higher-quality versions.

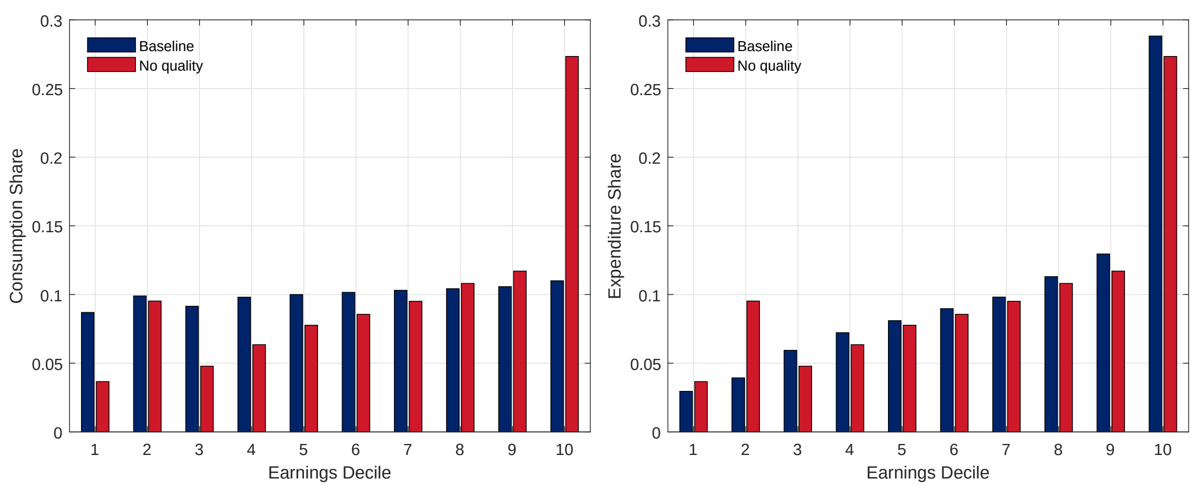


Figure 8: Consumption Expenditure Shares in the Model

(Left panel: Consumption. Right panel: Expenditure.)

*Notes*: The figure shows consumption share (left panel) and expenditure share (right panel) by earnings decile in the calibrated models with and without quality.

In the standard model without quality, instead, the quantity of consumption rises across the earnings distribution. Notably, the first decile of the distribution of earnings accounts for nearly 3% of total consumption, whereas the top decile accounts for nearly

28% of the total. This is indeed the property that makes the standard model at odds with the cross-sectional empirical evidence on employment rates and wealth. A pattern of increasing consumption across the earnings and wealth distribution implies a pattern of decreasing marginal utilities of consumption, which in turn implies that employment rates fall sharply with wealth.

Two important insights emerge from these results. First, the calibrated versions of the two models with and without a quality choice have rather different implications for how the quantity of consumption varies across the wealth distribution. In the standard model, consumption rises with wealth, whereas in the model with quality, it is virtually flat in wealth. Such a difference in consumption allocations is the reason why the model with quality accounts for the nearly flat distribution of employment rates across wealth deciles, whereas the standard model without quality cannot.

Second, the two calibrated models have instead remarkably similar implications for consumption expenditures, even though for radically different reasons. In the standard model, expenditures move one-to-one with the quantity of consumption. In the model with quality, instead, expenditures track closely unit prices, while consumption changes little across households. An immediate implication of these results is that one cannot readily use expenditure data to discriminate *between* the two models. Yet, one can still use expenditure data to assess (i) the extent to which the expenditure patterns in the model with quality are borne out in the data, and (ii) whether expenditure shares in the data vary across good categories in a way that can be associated with the quality margin of consumption.

To be sure, mapping the consumption good in the model to a specific good category in the data is problematic and to a large extent unwarranted. In addition, it is well known that quality measurement remains an empirical challenge, even if one has access to data on unit prices. To bypass these issues, our underlying idea here is that luxury goods are arguably goods for which quality differentiation is pervasive. And that, to the extent that this is the case, one would expect the distribution of expenditures on luxuries to be highly dispersed and *more* concentrated at the top of the earnings distribution relative to expenditures on necessity goods. Reassuringly, we find that this conjecture stands true in the data.

**Expenditure patterns in PSID data** We consider data on expenditures per person from the PSID for six good categories: "food at home," "food away from home," "clothing," "entertainment," "education," and "childcare."[12] The literature typically associates food at home with "necessities," and the other five categories with "luxuries" (see Aguiar and Bils, 2015; Chang, Hornstein and Karabarbounis, 2019).

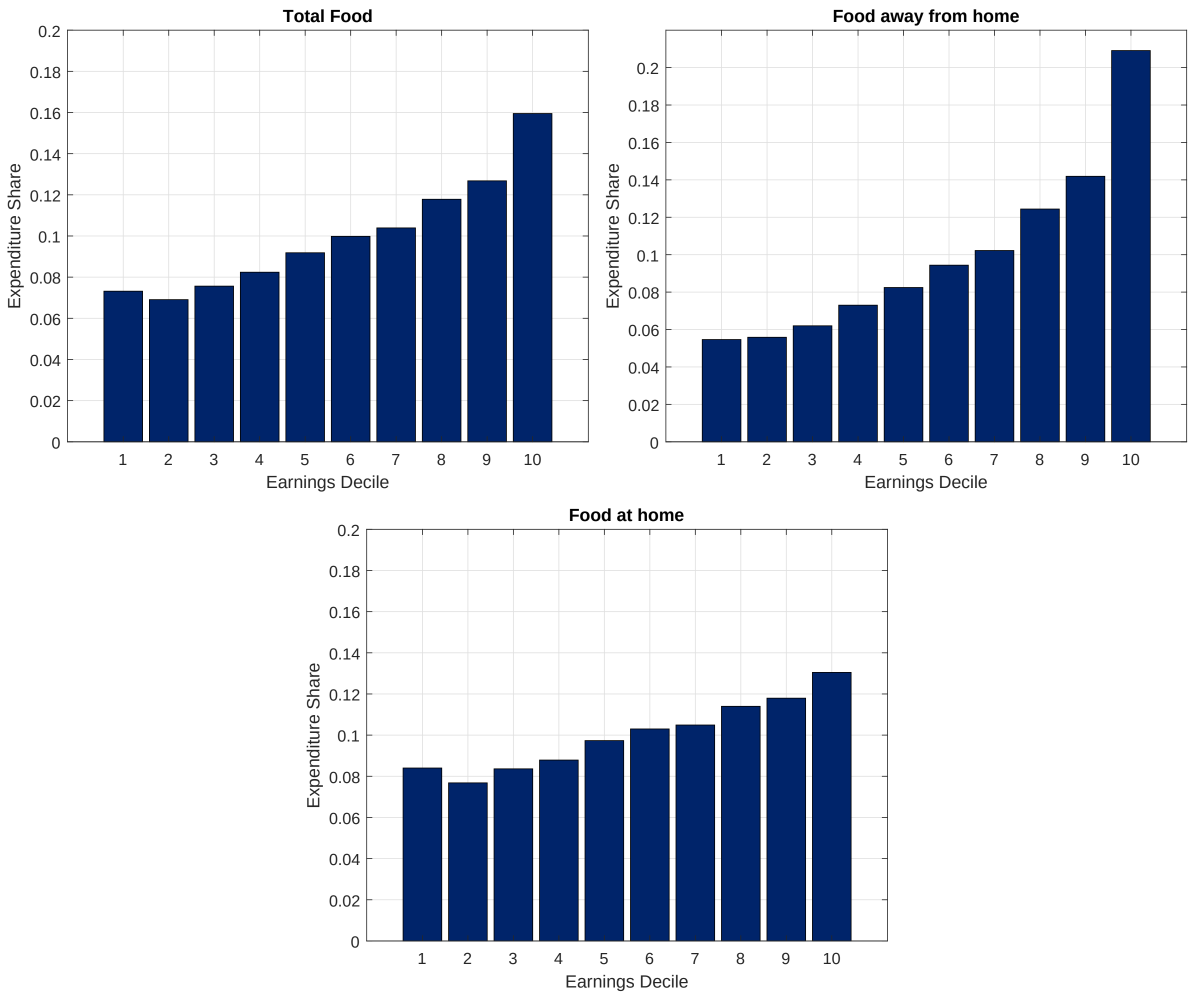


Figure 9: Food Expenditure Shares in the Data

*Notes*: The figure shows the distribution of total food expenditure (top left panel), expenditure on food away from home (top right panel), expenditure on food at home (bottom panel). Data are from the PSID based on the biannual 2005-2015 waves for households heads of 25-65 years old. See Appendix A for details on data sources and variables' construction.

We consider food expenditures first. Food is an appealing good category for at least

[12]For broad good categories, PSID expenditure data are largely consistent with Consumer Expenditure Surveys (CEX) data (see, e.g., Li et al., 2010; Andreski et al., 2014).

two reasons. First, it is an essential good, required to sustain life, implying that it must belong to the consumption basket of all households. Second, given its physical nature, it would seem natural to think that differences in the *quantity* consumed by households with different incomes are plausibly "small," relative to those in the quality of the food consumed. The advantage of using the food category then, is that we can view differences in food expenditures across households as mostly coming from differences in the unit prices paid.

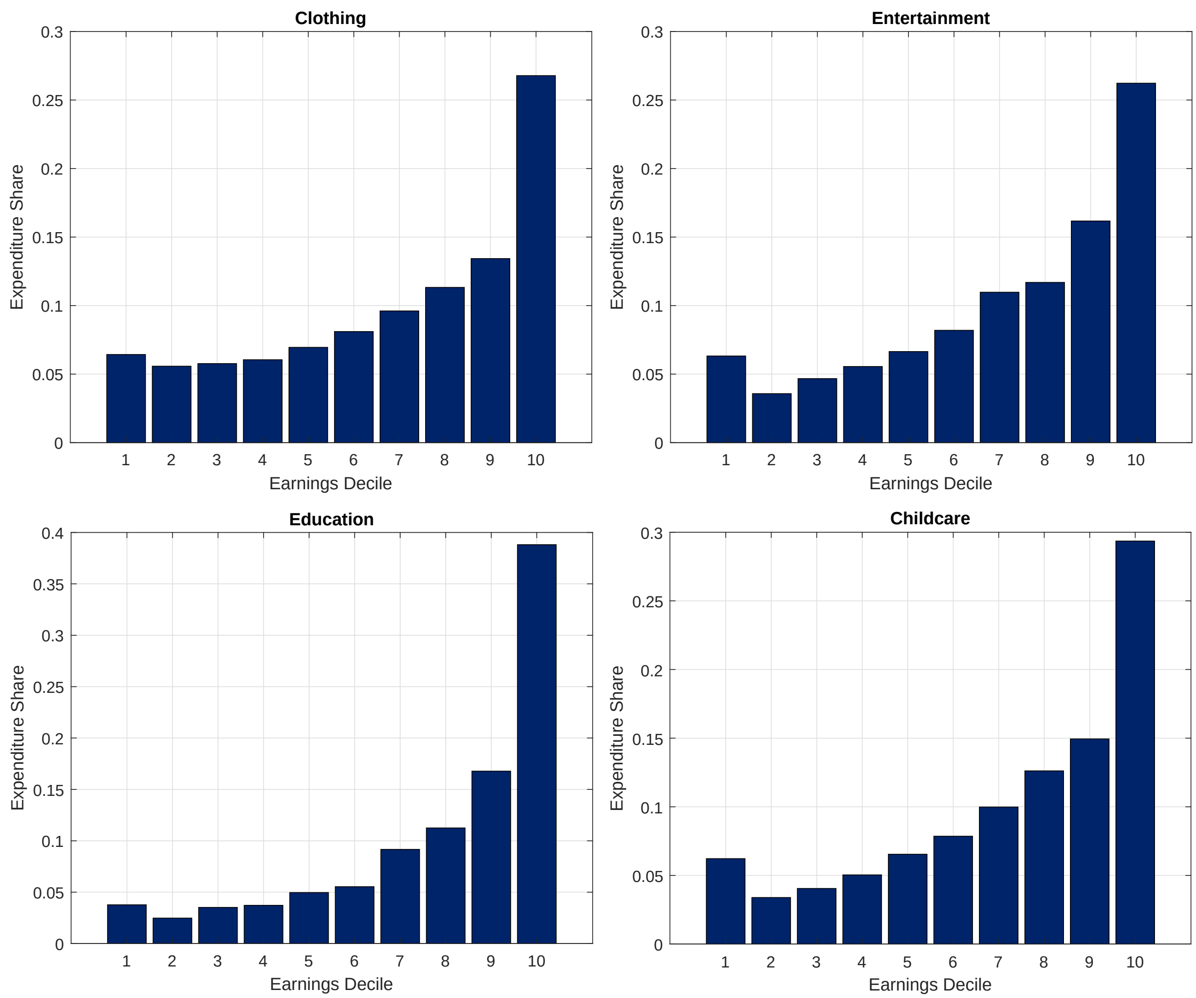


Figure 10: Other Expenditure Shares in the Data

*Notes*: The figure shows the distribution of expenditure shares on clothing (top left panel), expenditure shares on entertainment (top right panel), expenditure shares on education (bottom left panel), and expenditure shares on childcare (bottom right panel) by earnings deciles. Data are from the PSID based on the biannual 2005-2015 waves for households heads of 25-65 years old. See Appendix A for details on data sources and variables' construction.

Figure 9 shows the shares of total food expenditure (top left panel), food expenditure away from home (top right panel), and food expenditure at home (bottom panel), by earnings deciles. (To be precise, the shares are calculated relative to the total expenditures on food, food away from home, and food at home, respectively.) Expenditure on food away from home – a "luxury" – is highly concentrated. Households in the top decile of the earnings distribution account for more than 20% of total expenditure on food away from home, whereas households in the bottom decile account for slightly more than 5%.[13]

In contrast, expenditure on food at home – a "necessity" – is more evenly distributed across the earnings distribution. The first earnings decile accounts for slightly more than 8% of total expenditure on food at home, whereas the last earnings decile accounts for 13%. Hence, while there is variation in expenditure shares, it is not nearly as big as that for food away from home.

Figure 10 shows shares of expenditures on clothing, entertainment, education, and childcare by earnings deciles. Similarly to food away from home, expenditure shares rise with earnings. Indeed, the inequality in consumption expenditures for these luxuries is more pronounced than that for food away from home. For example, the top decile of the earnings distribution accounts for nearly 27% of total expenditures on clothing, as opposed to the 20% figure for food away from home.

To sum, household-level data from the PSID provide ample support to the predictions of the calibrated model with a quality choice. In the model, as in the data, consumption expenditures are unevenly distributed across the income distribution.

## 6 Validation of the Mechanism

In this section, we show that our model is qualitatively and quantitatively consistent with data from three different sources: (i) the Consumer Expenditure Survey (CEX); (ii) the Nielsen Consumer Panel; and (iii) the Continuing Survey of Food Intake of Individuals (CSFII). By and large, the evidence supports the model's prediction that unit prices and available measures of quality of consumption are greatly sensitive to household's income.

[13] In Appendix A, Figure A.13 shows data on the shares of food expenditure on food away from home by earnings decile. The higher the earnings, the higher the share of food expenditures that goes to food away from home. The dispersion is sizable going from nearly 27% at the bottom decile to 48% at the top decile.

A summary is as follows:

1. **Quality Engel curves** Using data on consumer durables' expenditures from the CEX and scanner data from the Nielsen Consumer Panel, we estimate quality Engel curves relating unit prices to income. We show that the model produces artificial data that are consistent with such estimates. See subsection 6.1 and Appendices A.5-A.7 for details on variables' construction and additional results.

2. **Food consumption** Using CSFII data, we find that the quantity of consumption as measured by total calories is virtually insensitive to household income. In contrast, regressions based on measures of food content such as vitamin A, C, E, calcium, cholesterol, saturated, and unsaturated fats, reveal a positive relationship between food quality and income. For instance, higher-income households consume less saturated fats and cholesterol, which is typically associated with healthier or higher-quality food consumption. See subsection 6.2 and Appendices A.3-A.4 for details on variables' construction and additional results.

## 6.1 Quality Engel Curves

In this subsection, we study the relationship between unit prices and income and how it varies across the income distribution using data from both the CEX and Nielsen.[14] We partition the income variable in quartiles and define a set of dummies $\mathbb{1}_{ih}$ which equal one if the household $i$'s income lies in quartile $h$, and zero otherwise. We consider the following regression:

$$\log\left(p_{it}\right) = \alpha + \sum_{h=1}^{4} \beta_h \mathbb{1}_{ih} + \gamma X_{it} + \epsilon_{it}, \tag{54}$$

where the subscript $i$ identifies the household, $p_{it}$ is the average unit price by product category for the regression based on Nielsen, e.g., grocery, and expenditures on durables for the regressions based on the CEX, and $X_{it}$ is a vector of controls including demographic variables, such as age, education, marital and employment status, household composition, race/ethnicity, occupation, state of residence, as well as time fixed effects, and $\epsilon_{it}$

[14]The Nielsen Consumer Panel dataset includes data on food and non-food items' purchases by a panel of households in the United States. Each purchase in the dataset records the actual price paid by the household at the level of the Universal Product Code (UPC). The dataset has detailed demographics about the shopper making the purchases, and it tracks the household purchases across multiple retail outlets.

denotes the residual from the regression. The exact definition of the variables changes depending on whether we use data from the CEX or Nielsen, and some variables can be found in one dataset but the the other.

The coefficients of interest are the $\beta_h$, which describe how unit prices vary across the income distribution. We take the first quartile as the reference point so that all estimates are relative to the first quartile. We emphasize that we do not attach any causal interpretation to these estimates. Rather, we use them as a test of the plausibility of the quality Engel curves generated by the model. As explained above, we use the estimated $\beta_h$ as moments to be matched by the model. Table 2 reports the data estimates and the implied coefficients from a regression run on artificial data from the model.

Table 2: Quality Engel Curves – Prices vs. Income

| | CEX | Nielsen | Model |
|---|---|---|---|
| Relative to income quartile 1 | | | |
| Income quartile 2 | | $0.095^{***}$ | |
| | | (0.00368) | |
| Income quartile 3 | | $0.162^{***}$ | |
| | | (0.00423) | |
| Income quartile 4 | | $0.241^{***}$ | |
| | | (0.00484) | |

*Notes*: The table reports the log-differences in unit prices paid by each income quartile relative to the first income quartile in the data and the model. Results in the column labeled "CEX" are based on... Results in the column "Nielsen" are based on 1,952,202 observations for 2010-2019 (5 percent random sample). Robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

In Nielsen, highest-income households in the top income quartile pay on average 24% more than households in the lowest income quartile. This figures is broadly consistent with estimates in Jaimovich et al. (2019b), which much smaller than their estimates bases on durables in CEX. This is perhaps not surprising since Nielsen data is on retail sales, such as grocery products. The unit-price differences implied by our model lie between those in the two datasets, and they are somewhat closer to those estimated from the CEX data.

For durable expenditures from the CEX, Jaimovich et al. (2019b) find a difference in prices between the top and bottom income quintile of 83%. For non-durable expenditures from the Nielsen Homescan, they find a much smaller difference in prices of nearly 23%. This is perhaps not surprising since Nielsen data is on retail sales, such as grocery products. The unit-price differences implied by our model lie between those in the two datasets, and they are somewhat closer to those estimated from the CEX data.

To summarize, the model generates a reasonable quality Engel curve.

**Unit prices vs. income** As in Jaimovich et al. (2019b), we consider quality Engel curves relating unit prices to household income. Using the cross-sectional variation in unit prices and income generated by the calibrated model with a quality choice, we estimate that a 1% increase in income is associated with about a 0.14% increase in unit prices:

$$\log(p_i) = -0.2841 + 0.1423 \log(income_i) + u_i, \tag{55}$$

where the subscript $i$ identifies the household, $p_i$ is the unit price paid by household $i$, the right-hand side variable $income_i$ is the sum of labor plus asset income, $wh_i + ra_i$, and $u_i$ denotes the residual from the regression.

## 6.2 Food Consumption

The appealing feature of the CSFII, that makes it uniquely tailored to the measurement of quality choices, is that it contains measures of *food intake* at the individual level using detailed food diaries including the quantity and the quality of food consumption.[15] As in Aguiar and Hurst (2005), we focus on household heads; unlike them, we consider prime-age individuals of 25-55 years old, thus extending their results on retirees and household heads of 45-55 years old. The two waves of the CSFII include diaries from 1989-91 and 1994-96, which we pool as a single cross section and include year dummies in the regressions.

[15] The CSFII has also been used by early studies of food expenditures over the life cycle (Aguiar and Hurst, 2005, 2013).

Our estimating regression model is

$$\log(intake_{i,t}) = \alpha_0 + \alpha_1 \log(income_{i,t}) + \alpha_2 X_{i,t} + u_{i,t}, \tag{56}$$

where the dependent variable $intake_{i,t}$ is calories, vitamin A, C, E, calcium, cholesterol, saturated and unsaturated fats, and proteins, all measured in grams, for household head $i$ in survey year $t$, $income_{i,t}$ is total household income, and $X_{i,t}$ is a vector of covariates that includes standard demographic characteristics (age, gender, and race), household size, and dummies for survey years, region and metropolitan area of residence, height, and a number of health variables.

Table 3 reports estimates of the income elasticity of food intake from ordinary least squares (OLS) and instrumental variable (IV) regressions. To deal with the problem of measurement error in income and unmeasured omitted variables, we follow Aguiar and Hurst (2005) and instrument household income with occupation, education, education and occupation interactions, and gender and race interactions. Aside from the log calories regression, all other regressions include log calories as an additional control. Also, for the log fat regressions, the log of total fats is included as an additional control.

Perhaps not surprisingly, calories vary slightly with income within the cross section of prime-age individuals. However, other food intake components are strongly correlated with income. Specifically, the income elasticities of vitamins and polyunsaturated fat, a "good fat," are positive and statistically significant at the 1% level in both OLS and IV regressions. In contrast, income elasticities of cholesterol and saturated fat, "a bad fat," are negative, but similarly, statistically significant at the 1% level.

Overall, the results provide evidence that the nutritional quality of food consumption deteriorates at the lower end of the household's income distribution. Notably, individuals consume inexpensive calories by switching their food consumption toward saturated fats and cholesterol and away from vitamins, calcium, and unsaturated fats. Such results are consistent with the idea that "healthy diets" are expensive and cannot be afforded by poor households.

Table 3: Income Elasticity of Food Intake

| | OLS | IV |
|---|---|---|
| Calories (log) | −0.000 | −0.014 |
| | (0.0101) | (0.0276) |
| Vitamin A (log) | 0.121*** | 0.479*** |
| | (0.0240) | (0.0688) |
| Vitamin C (log) | 0.139*** | 0.399*** |
| | (0.0252) | (0.0723) |
| Vitamin E (log) | 0.066*** | 0.182*** |
| | (0.0119) | (0.0345) |
| Calcium (log) | 0.016 | 0.071** |
| | (0.0113) | (0.0328) |
| Cholesterol (log) | −0.071*** | −0.217*** |
| | (0.0172) | (0.0458) |
| Saturated fat (log) | −0.020*** | −0.062*** |
| | (0.0054) | (0.0144) |
| Polyunsaturated fat (log) | 0.036*** | 0.148*** |
| | (0.0094) | (0.0256) |
| Monounsaturated fat (log) | −0.000 | −0.019** |
| | (0.0034) | (0.0090) |
| Protein (log) | 0.007 | −0.003 |
| | (0.0075) | (0.0217) |

*Notes*: Data is from the 1989-91 and 1994-96 waves of the CSFII for household heads of 25-55 years old. The table reports the coefficient on the log of income estimated from OLS and IV regressions of the food intake variable (in logs) on the log of income and a list of control variables, that includes age, gender, race, the highest grade of formal schooling completed, household size, and dummies for survey years, region and metropolitan area of residence, height, and health-related variables (weight, HEALTH, DOCTOR1, DOCTOR2, DOCTOR3, DOCTOR4, DOCTOR5, DOCTOR6, and DOCTOR7). For IV regressions, we instrument the log of income with occupation, education, education-occupation interactions, and sex-race interactions. Regressions include a constant. Aside from the log calories regression, all other regressions include log calories as an additional control. For the log fat regressions, the log of total fats is included as an additional control. First-stage F statistics: 57.35 (calories), 56.13 (vitamin A), 55.77 (vitamin C), 55.99 (vitamin E), 56 (calcium), 55.75 (cholesterol), 54.67 (fats), and 55.99 (protein). Robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. See Appendix A.3 for details on variables' definitions.

# 7 Implications for Labor Taxation

The objective of this section is to assess whether and to what extent a quality choice with non-homothetic preferences changes some basic implications related to tax policy. To this goal, we use the calibrated model with a quality choice as the benchmark economy and compare its predictions with those from the standard model without quality.

Before proceeding, it is useful to point out that one could in principle conduct the same analysis in the context of a model with a quality choice and non-homothetic preferences in which markets are complete, so that households achieve perfect insurance against shocks. For example, a viable approach would be to feed into a complete-markets version of the model the wealth distribution from the data, and look at the model implications for hours worked before and after a change in tax policy. In our view, there are at least two caveats to this approach.

First, a large literature emphasizes "self-insurance" against idiosyncratic shocks as a quantitatively important mechanism to understand the cross-sectional distributions of consumption, saving, and hours (see Blundell, Pistaferri and Preston, 2008; Heathcote, Storesletten and Violante, 2008; Kaplan and Violante, 2010; Jappelli and Pistaferri, 2010; Heathcote, Storesletten and Violante, 2014). An incomplete-markets model with a realistic precautionary saving motive would seem then the natural framework for counterfactual and policy analysis. Second, in the equilibrium of the model, the precautionary saving motive interacts with the quality choice in consumption. In our view, quantifying such interaction is of interest in itself, let alone its potential implications for tax policy.

**The experiment** We envision a large-scale transfer program that amounts to 5% of GDP, which adds to the preexisting means-tested transfers. The new transfers are not means-tested, but rather they are distributed to the households proportionally to their wealth, implying no additional redistribution of resources on top of that already in place in the benchmark calibrated model. Everything else equal, such transfer program leaves the wealth distribution unchanged. We use labor taxes to balance the government budget.

We run the same experiment in the model with and without quality. Balancing the government budget in the two models gives virtually the same tax rate on labor income. To the extent possible, this experiment is designed to downplay the redistributive role of arbitrary allocations of tax revenues across households with different wealth, and to highlight the effect of labor tax rates on work incentives.

## 7.1 Aggregate Implications

In a dynamic environment like ours, changes in the flat-rate tax on labor income distort not only work incentives, but also households' incentives to save and accumulate assets, implying that the economy's capital stock is affected, too. The magnitude of these effects critically depends on the strength of the precautionary saving motive embodied in the model, as well as the implied "aggregate labor supply elasticity."[16]

Table 4 shows the results for the labor tax experiment.[17] In the model with quality, the financing of the transfer program implies that the tax rate that clears the government budget goes from 0.36% to 5.99%. In the model without quality, the labor tax rate that clears the government budget goes from 0.93% to 6.07%.

Table 4: Aggregate Implications of Flat-Rate Labor Taxes

| | GDP | $E$ | $K$ | $C$ | $EXP$ | $R$ | $w$ |
|---|---|---|---|---|---|---|---|
| Panel A. Model with quality | | | | | | | |
| before | 6.27 | 0.80 | 34.17 | 5.30 | 5.42 | 0.0262 | 4.27 |
| after | 6.64 | 0.78 | 43.82 | 5.46 | 5.55 | 0.0198 | 4.67 |
| Panel B. Model without quality | | | | | | | |
| before | 2.64 | 0.80 | 16.41 | 2.23 | 2.23 | 0.0214 | 1.88 |
| after | 2.56 | 0.81 | 18.20 | 2.11 | 2.11 | 0.0172 | 2.00 |

*Notes*: The experiment consists of using labor taxes to finance a transfer program equivalent to 5% of GDP, in addition to the preexisting means-tested transfers. The new transfers are not means-tested, rather they are distributed across households as proportional to their wealth. In the model with quality (panel A), this implies that the labor tax rate that clears the government budget goes from 0.36% to 5.99%. In the model without quality (panel B), the labor tax rate that clears the government budget goes from 0.93% to 6.07%.

[16] In Appendix D, Figure D.5 shows the cumulative distribution function of reservation wages implied by the calibrated model with and without quality. Based on Chang and Kim (2006), and using the implied distributions of reservation wages, we calculate an approximate aggregate labor supply elasticity of 0.9 for the baseline model with quality, and an elasticity of 1.3 for the model without quality.

[17] In Appendix D, Table D.2 shows results from a larger scale experiment in which the government uses labor taxes to finance transfers that equal 20% of GDP.

In the calibrated model with quality, the aggregate employment rate falls from 80% to 78%, which amounts to a 2.5% drop in employment. GDP rises by nearly 6%. Such an increase in GDP materializes through a sizable increase in investment, such that in the new steady state, the capital stock is more than 25% higher. To accommodate the higher capital stock, the rental rate falls from 2.62% to 1.98%. In the new steady state, the before-tax wage is 9% higher. However, the after-tax wage rises by only 3%, since the labor tax rate increases from 0.36% to 5.99% in order to clear the government budget.[18]

In contrast, in the model without quality, aggregate employment increases by one percentage point, going from 80% to 81%. GDP falls by 3%. The capital stock rises by 10%, which is associated to a drop in the rental rate from 2.14% to 1.72%. In the new steady state, the before-tax wage is 6% higher, whereas the after-tax wage remains virtually unchanged. Note also that consumption drops by about 5.5%, which is in sharp contrast with the positive consumption response (about a 3% increase) that takes place in the model with a quality choice.

To sum, our results indicate that the presence of a quality choice in consumption changes the aggregate implications of labor taxes, both qualitatively and quantitatively. In the next subsection, we argue that the distributional implications of labor taxation change in crucial ways, too.

## 7.2 Distributional Implications

Figure 11 shows the distribution of employment rates implied by the equilibrium of the model with quality (left panel) and without quality (right panel), before and after the change in policy.

The main difference between the model with and without quality is the employment rate response in the left tail of the wealth distribution. Specifically, in the model without quality, wealth-poor households work more, whereas in the model with quality wealth-poor households work less after the increase in the labor tax rate. Such a fundamental difference in labor allocations comes from the different work incentives at play in the two models. In the model with quality, households with low wealth cut back on the quality of the goods consumed to maintain a fairly stable consumption. This additional margin

[18] In Appendix D, Figure D.6 shows the price function before and after the policy change. After the policy change, the price function rotates counterclockwise, implying higher unit prices for each level of quality.

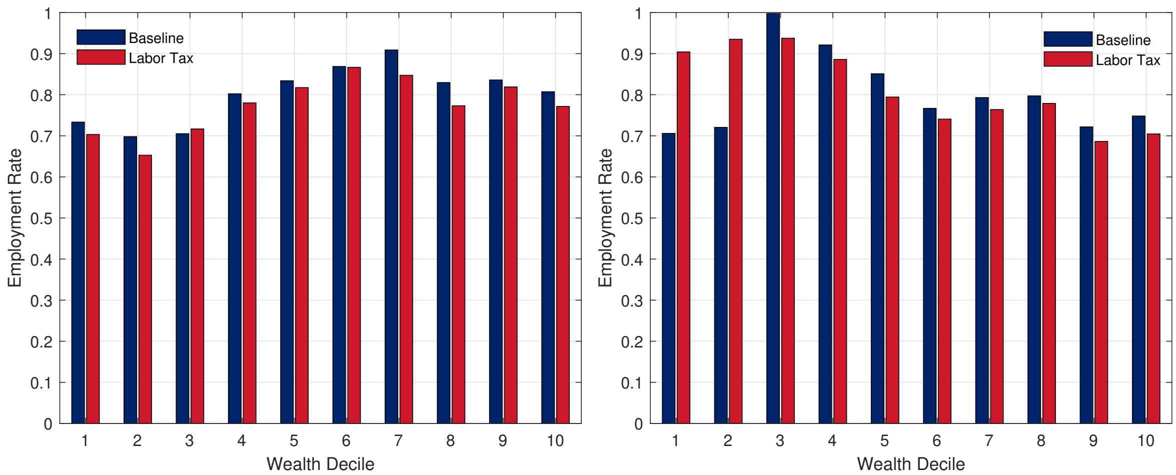


Figure 11: Employment by Wealth – Labor Tax Experiment

(Left panel: Model with quality. Right panel: Model without quality.)

*Notes*: The figure shows the distribution of employment rates by wealth deciles in the model with quality (left panel) and without quality (right panel) before and after the labor tax change. The experiment consists of using labor taxes to finance a transfer program equivalent to 5% of GDP, in addition to the preexisting means-tested transfers. The new transfers are not means-tested, rather they are distributed across households as proportional to their wealth. In the model with quality, this implies that the labor tax rate that clears the government budget goes from 0.36% to 5.99%. In the model without quality, the labor tax rate that clears the government budget goes from 0.93% to 6.07%.

of adjustment is absent in the standard model without quality, in which households cut back on consumption and at the same time work more as a self-insurance mechanism.[19]

The models with and without a quality choice also differ in terms of their implications for the wealth distribution (see Figure D.8, in Appendix D). In the model with quality, the distribution of wealth remains largely unchanged. In the model without quality, instead, the wealth share of the top wealth decile drops by about 5 percentage points.[20]

[19]In Appendix D, Figure D.7 shows average quality and average unit prices by wealth deciles before and after the policy change.

[20]In Appendix D, Figures D.9, D.10, and D.11 show the distributions of earnings, consumption, and consumption expenditure by wealth deciles before and after the policy change, respectively.

# 8 Conclusion

We develop a heterogeneous-agent incomplete-markets model with a quality choice in consumption and multi-sector production. The main idea is that "quality" is an attribute of the consumption good that is valued by households, and that higher-quality versions of the same good have higher unit prices. With non-homothetic preferences, the household's quality choice increases with income: higher-income, wealthier households consume not only more goods but better goods. Furthermore, to the extent that the marginal utility of consumption depends positively on quality, wealthy households may choose to work long hours to afford an expensive, high-quality consumption basket.

To quantify these mechanisms, we calibrate the model and find that it accounts well for the near-zero correlation between wealth and hours worked in U.S. data. Also, in the model, as in the data, consumption expenditures are not evenly distributed across the income and wealth distribution. Such inequality in consumption does not come from differences in the quantity, but rather from differences in the quality of consumption, thus from the higher unit prices paid by richer households. As external validation, we show that the model generates quality Engel curves comparable to those estimated in empirical studies based on micro data on prices and consumption expenditures.

Altogether, the results in this paper point to the importance of quality choice to study salient features of labor allocations at the individual and aggregate level. A natural next step would seem to assess the extent to which the cross-sectional distributions of market hours worked vary systematically across countries with different per capita income levels. And the extent to which such cross-countries differences can be accounted for quality choices as opposed to different level of distortionary taxation. While we view these issues of first-order importance, we leave them for future research.

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# Appendix

## A Data and Additional Evidence

Appendices A.1-A.7 contain details on data and variables' construction and additional evidence based on the PSID (A.1-A.2), the CSFII (A.3-A.4), the CEX (A.5-A.6), and the Nielsen Consumer Panel (A.7).

### A.1 PSID - Data and Variables' Construction

Our main variables of interest are a measure of net wealth and labor market indicators such as employment, hours worked, weekly hours worked, and weeks worked. The baseline sample includes households from the 2001-2015 waves.

Table A.1: Assets and Liabilities in the PSID

| Assets | Liabilities |
|---|---|
| *Home* | *Mortgage* |
| *Value of farm/business* | *Farm/business debt* |
| *Other real estate assets* | *Other real estate debt* |
| *Value of checking/saving account* | *Credit card debt* |
| *Stock holdings* | *Student loan Debt* |
| *Vehicles* | *Medical debt* |
| *Other assets* | *Other debt* |
| *Annuity IRA account* | *Family loan debt* |
| | *Legal debt* |

**Net Worth: Household Assets Minus Liabilities**

Wealth deciles are calculated at each wave for the sample of households whose heads are 25-65 years old. Wealth distribution is calculated using the household net wealth, which is the difference between household assets and liabilities. Table A.1 lists the components of assets and liabilities included in the PSID.

Relevant wealth statistics are observed in the wave prior to the wave used for the labor market statistics. As an example, the 2013 wave records household wealth at the time of the interview, which is the year 2013. The 2015 wave records the labor market variables for the year 2014. The baseline sample pools the observations of the labor market statistics from waves 2003 to 2015. Thus, while employment and hours data are taken from the 2003-2015 waves, net wealth data from the 2001-2013 waves.

**Employment and Hours Worked**

- *Employment:* Variable assigning 1 if the person is working, 0 if the labor force status is other. Separate variables for the head and the spouse: "BC1 EMPLOYMENT STATUS-1ST MENTION," and "DE1 EMPLOYMENT STATUS-1ST MENTION."
- *Total weeks:* Total weeks worked on all jobs, 0 if did not work for money in that year. Separate variables for the head and spouse: "HEAD WORK WEEKS," and "SPOUSE WORK WEEKS."
- *Total hours:* Annual work hours on all jobs including overtime. Separate variables for the head and spouse: "HEAD TOTAL HOURS OF WORK," and "SPOUSE TOTAL HOURS OF WORK."
- *Hours per week:* Total weekly work hours on all jobs. Separate variables for the head and spouse: "HEAD WEEKLY WORK HOURS," and "SPOUSE WEEKLY WORK HOURS." In the original PSID variable 0 stands for households who do not work. Such observations here are excluded, so the variable measures labor adjustment at the intensive margin.

All the numbers reported are obtained after applying cross-sectional individual weights at each wave to make the sample representative of the U.S. population in each year.

**Sub-Samples**

- *Male heads:* Male household heads, 25-65 years old. Used only heads because the information whether the spouse is male is not available. The sex variable for spouse only identifies whether the spouse is female.
- *Females:* Either heads or spouses, 25-65 years old. The variable spouse's gender is only available for the 2015 wave, so the samples restricted to females only use the

2015 wave data for the labor market variables and wave 2013 data for the household wealth.

- *Females without children:* Either heads or spouse in households without children, 25-65 years old.
- *Females with children:* Either heads or spouse in households with at least one child, 25-65 years old.

**Expenditure Data**

Expenditure categories, namely, food, clothing, entertainment, education and childcare are readily available in the PSID household panel starting from the 2005 wave. Data in Figures 9, 10, and A.13 is at the household level. The sample is restricted to households where the head is 25-65 years old. For earnings distribution, we use the sum of head and spouse labor income as recorded in the variables "LABOR INCOME OF HEAD" and "LABOR INCOME OF SPOUSE," divided by the household size. Expenditure is the total household expenditure on a given category divided by the household size.

## A.2 PSID - Additional Evidence

This appendix contains additional evidence on the cross-sectional relationship between employment rates and wealth. Again, our main sample consists of household heads of 25-65 years old from the biannual 2001-2015 waves of the PSID, and wealth is total assets minus total liabilities at the household level. We first report correlations for the whole sample and by age groups, and estimates from regressions of employment on wealth that allow us to control for demographic variables (see Appendix A.2.1), then we comment on a number of histograms of employment rates by wealth deciles for different subsamples grouped by age, education, marital status, and the presence of children in the household (see Appendix A.2.2).

### A.2.1 Regression Analysis

Our estimating model is

$$e_{i,t} = \alpha_0 + \alpha_1 W_{i,t} + \alpha_2 X_{i,t} + \epsilon_{i,t}, \tag{A.1}$$

where $e_{i,t}$ is a dichotomous employment variable $\{0 = \text{nonemployed}, 1 = \text{employed}\}$ for household head $i$ in survey year $t$, $W_{i,t}$ is a wealth variable, about which we say more below, and $X_{i,t}$ is a vector of covariates chosen to control for demographic characteristics (age, age-squared, gender, and race), education, number of children, a dummy variable on whether there is a spouse in the household, occupation and industry dummies, and dummies for survey years and state of residence. We consider three wealth variables: (i) raw wealth data (in millions); (ii) the logarithm of wealth for positive values of wealth only; and (iii) the logarithm of a transformed wealth variable. To bypass the issue of using the logarithm in the presence of negative values of wealth, the transformed wealth variable we use in (A.1) is the value of wealth minus the minimum wealth in the sample plus one.

Table A.2: Employment-Wealth Correlation

| Age | All wealth | Positive wealth (log) | Transformed wealth (log) |
|---|---|---|---|
| 25-65 | 0.012** | −0.001 | 0.023*** |
| 25-34 | 0.048*** | 0.052*** | 0.082*** |
| 35-44 | 0.050** | 0.085*** | 0.077** |
| 45-54 | 0.049*** | 0.074*** | 0.103*** |
| 55-65 | 0.034*** | 0.038*** | 0.054*** |

*Notes*: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Data are from the 2001-2015 waves of the PSID for household heads.

The sample correlation between employment and wealth is 0.012 for the raw wealth variable, −0.001 for the log of positive wealth, and 0.023 for the log of the transformed wealth variable. See Table A.2 for correlation coefficients by age groups.

As the correlation coefficients in Table A.2 are naturally affected by other demographic characteristics beyond age, Tables A.3-A.5 present regression estimates conditioning on a host of standard covariates. Across all specifications the coefficient on wealth is either small and positive or virtually zero.

Table A.3: Employment and Wealth – All Wealth

| | | | | |
|---|---|---|---|---|
| Wealth | 0.00307** | 0.00254 | 0.000786 | 0.000924 |
| | (0.00142) | (0.00155) | (0.00112) | (0.00113) |
| Gender | −0.0314*** | −0.0335*** | −0.0288*** | −0.0291*** |
| | (0.00825) | (0.00824) | (0.00680) | (0.00673) |
| Age | 0.0410*** | 0.0410*** | 0.0165*** | 0.0162*** |
| | (0.00178) | (0.00178) | (0.00145) | (0.00144) |
| $Age^2$ | −0.000545*** | −0.000545*** | −0.000205*** | −0.000202*** |
| | (0.0000207) | (0.0000207) | (0.0000166) | (0.0000165) |
| Education | 0.0233*** | 0.0220*** | 0.000879 | 0.000362 |
| | (0.000932) | (0.000944) | (0.000871) | (0.000873) |
| Children | ✓ | ✓ | ✓ | ✓ |
| Spouse | ✓ | ✓ | ✓ | ✓ |
| Race | ✓ | ✓ | ✓ | ✓ |
| Year | ✓ | ✓ | ✓ | ✓ |
| State | ✗ | ✓ | ✓ | ✓ |
| Occupation | ✗ | ✗ | ✓ | ✓ |
| Industry | ✗ | ✗ | ✗ | ✓ |
| Observations | 50,516 | 50,284 | 44,635 | 44,550 |

*Notes*: Robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Data are from the 2001-2015 waves of the PSID for household heads. All regressions include a constant.

### A.2.2 Employment Rates by Wealth

**Single household heads and heads' spouses** Figures A.1-A.2 show the distributions of employment rates by wealth deciles for *single* household heads, and for household heads' *spouses*, respectively. For the sample of single household heads, employment rates are remarkably constant from the fifth to the tenth wealth decile. Perhaps not surprisingly, the shape of the distribution of employment rates for single household heads corroborates the main empirical regularities in the main sample of household heads.

Importantly, the distribution of employment rates for the spouses of household heads confirms the empirical observation on employment rates and wealth for the main sample of household heads. Specifically, besides a difference in levels, spouses' employment rates are virtually flat from the fourth to the eighth wealth decile. Perhaps the only noticeable difference between the main sample of household heads and household heads' spouses is the drop in the employment rate at the highest wealth decile, which is bigger for spouses than for households' heads.

Table A.4: Employment and Wealth – Positive Wealth

| | | | | |
|---|---|---|---|---|
| Wealth (log) | 0.0153 | 0.00910 | −0.00979 | −0.00694 |
| | (0.0121) | (0.0123) | (0.00907) | (0.00914) |
| Gender | −0.0281*** | −0.0302*** | −0.0184** | −0.0181** |
| | (0.00949) | (0.00950) | (0.00745) | (0.00728) |
| Age | 0.0424*** | 0.0422*** | 0.0158*** | 0.0156*** |
| | (0.00193) | (0.00192) | (0.00154) | (0.00153) |
| Age$^2$ | −0.000566*** | −0.000563*** | −0.000201*** | −0.000199*** |
| | (0.0000223) | (0.0000223) | (0.0000177) | (0.0000175) |
| Education | 0.0187*** | 0.0177*** | −0.000133 | −0.000323 |
| | (0.00103) | (0.00104) | (0.000912) | (0.000911) |
| Children | ✓ | ✓ | ✓ | ✓ |
| Spouse | ✓ | ✓ | ✓ | ✓ |
| Race | ✓ | ✓ | ✓ | ✓ |
| Year | ✓ | ✓ | ✓ | ✓ |
| State | ✗ | ✓ | ✓ | ✓ |
| Occupation | ✗ | ✗ | ✓ | ✓ |
| Industry | ✗ | ✗ | ✗ | ✓ |
| Observations | 39,196 | 38,992 | 34,251 | 34,187 |

*Notes*: Robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Data are from the 2001-2015 waves of the PSID for household heads. All regressions include a constant.

Figure A.3 shows the distribution of employment rates by wealth deciles for *employed heads' spouses*. Specifically, we restrict the sample to households in which the household head is employed and has a spouse. Again, as for the main sample of household heads, employment rates are flat across the wealth distribution.

**Males vs. females** Figures A.4-A.5 show the distributions of employment rates and hours worked by wealth deciles for males and females, and for females with and without children, respectively. Consistently with the main sample of household heads, the subsamples of male heads and females (heads/spouses) show the pattern that employment rates and hours worked are nearly flat across the wealth distribution. As is well known, employment rates and hours worked are generally lower for females. Another difference between the two subsamples is the highest wealth decile: employment rates and hours worked fall for females, while they remain flat males.

Similar patterns emerge from the subsamples of females (heads/spouses) with and without children. Notably, employment rates and hours worked for females with children

Table A.5: Employment and Wealth – Transformed Wealth

| | | | | |
|---|---|---|---|---|
| Wealth (log) | 0.0251** | 0.0171 | −0.00159 | −0.000140 |
| | (0.0111) | (0.0110) | (0.00752) | (0.00757) |
| Gender | −0.0318*** | −0.0337*** | −0.0287*** | −0.0291*** |
| | (0.00825) | (0.00824) | (0.00681) | (0.00673) |
| Age | 0.0410*** | 0.0410*** | 0.0165*** | 0.0161*** |
| | (0.00178) | (0.00178) | (0.00144) | (0.00144) |
| Age$^2$ | −0.000545*** | −0.000545*** | −0.000205*** | −0.000201*** |
| | (0.0000207) | (0.0000207) | (0.0000166) | (0.0000165) |
| Education | 0.0230*** | 0.0218*** | 0.000934 | 0.000404 |
| | (0.000946) | (0.000957) | (0.000877) | (0.000878) |
| Children | ✓ | ✓ | ✓ | ✓ |
| Spouse | ✓ | ✓ | ✓ | ✓ |
| Race | ✓ | ✓ | ✓ | ✓ |
| Year | ✓ | ✓ | ✓ | ✓ |
| State | ✗ | ✓ | ✓ | ✓ |
| Occupation | ✗ | ✗ | ✓ | ✓ |
| Industry | ✗ | ✗ | ✗ | ✓ |
| Observations | 50,516 | 50,284 | 44,635 | 44,550 |

*Notes*: Robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Data are from the 2001-2015 waves of the PSID for household heads. All regressions include a constant.

resemble those for the main sample of household heads. For females without children, employment rates and hours are nearly flat until the highest wealth decile. In fact, the fall in employment rates and hours at the highest wealth decile for females is due to the subset of females without children.

**Stability of the wealth-hours relation over time across PSID waves** Figures A.6-A.7 show employment rates by wealth deciles for each biannual PSID waves separately (2003, 2005, 2007, 2009, 2011, 2013, 2015). Overall, the pattern that employment rates are nearly flat across the wealth distribution is remarkably stable over time across waves.

**Age and education** Figures A.8-A.9 show the distributions of employment rates by wealth deciles for age and education groups. Overall, there is either a flat or a mildly positive relation between employment rates and wealth, consistently with the patterns for the main sample of household heads. Employment rates are remarkably flat for the subsamples of household heads with high school, some college, and college education.

Figures A.10-A.12 show the employment rates by wealth deciles for age-education groups. For the subsamples of young and prime age household heads with high school diploma, some college and college education, employment rates are, again, nearly flat or mildly increasing across the wealth distribution.

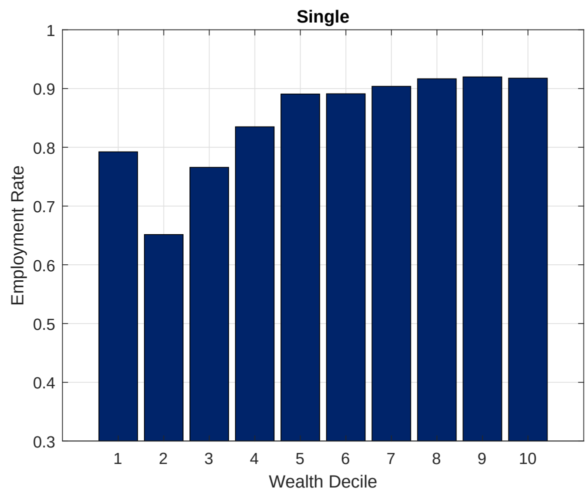


Figure A.1: Employment Rates by Wealth – Single Household Heads

*Notes*: The figure shows the employment rate by wealth deciles for households in which household heads do not have a spouse. Data are from the 2001-2015 waves of the PSID for households heads of 25-65 years old.

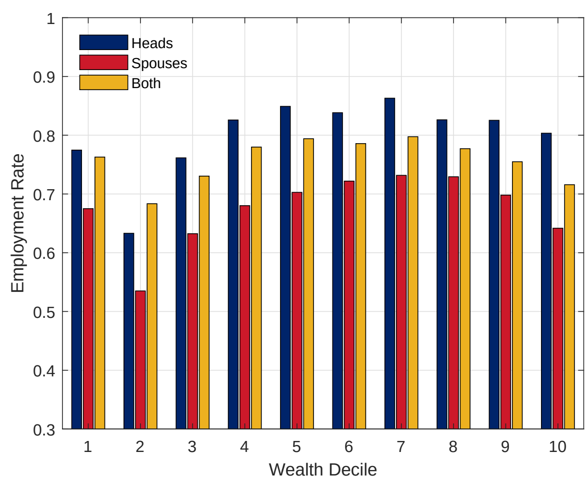


Figure A.2: Employment Rates by Wealth – Household Heads and Spouses

*Notes*: The figure shows the employment rate by wealth deciles for households heads and spouses. Data are from the 2001-2015 waves of the PSID for households heads and spouses of 25-65 years old.

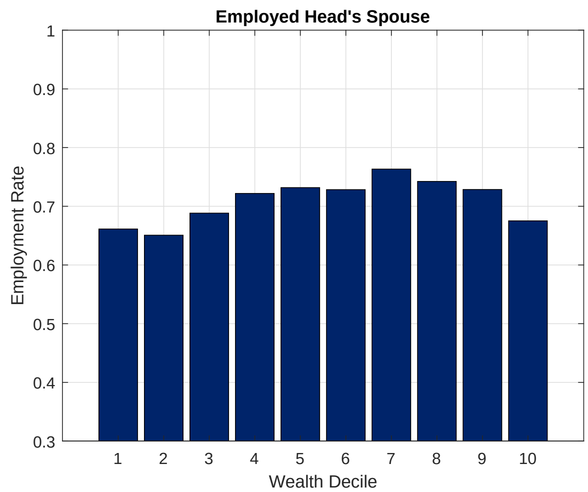


Figure A.3: Employment Rates by Wealth – Employed Head's Spouse

*Notes*: The figure shows the employment rate by wealth deciles for the spouses of employed heads. Data are from the 2001-2015 waves of the PSID for households heads and spouses of 25-65 years old.

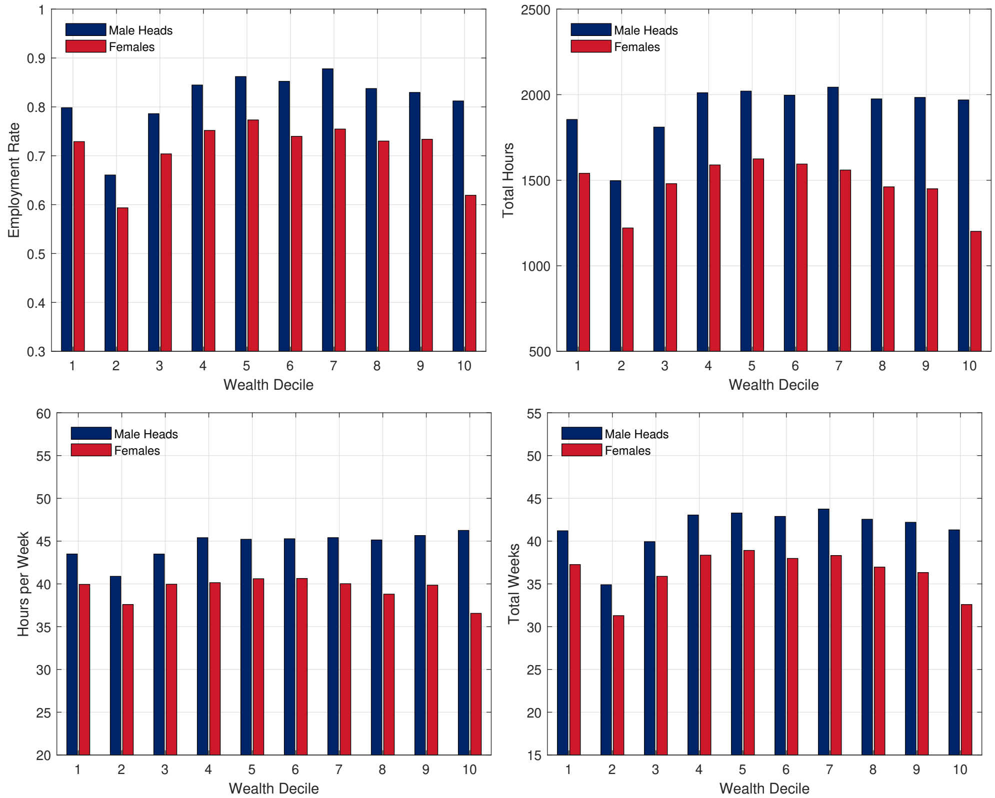


Figure A.4: Employment and Hours by Wealth – Males vs. Females

*Notes*: The figure shows the employment rate (top left panel), total hours worked (top right panel), weekly hours worked (bottom left panel), and weeks worked (bottom right panel) by wealth deciles for male heads and females (heads/spouses) of 25-65 years old. Data are from the 2001-2015 waves of the PSID. Wealth is total assets minus total liabilities at the household level.

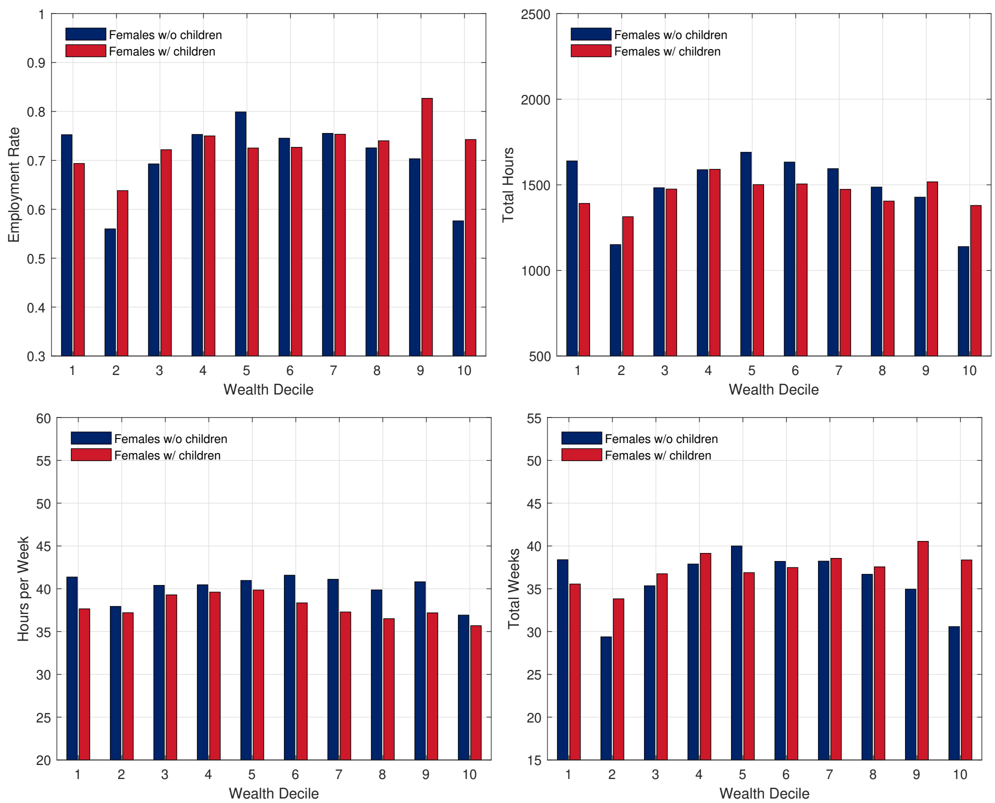


Figure A.5: Employment and Hours by Wealth – Females with/without Children

*Notes*: The figure shows the employment rate (top left panel), total hours worked (top right panel), weekly hours worked (bottom left panel), and weeks worked (bottom right panel) by wealth deciles for females (heads/spouses) of 25-65 years old with and without children. Data are from the 2001-2015 waves of the PSID. Wealth is total assets minus total liabilities at the household level.

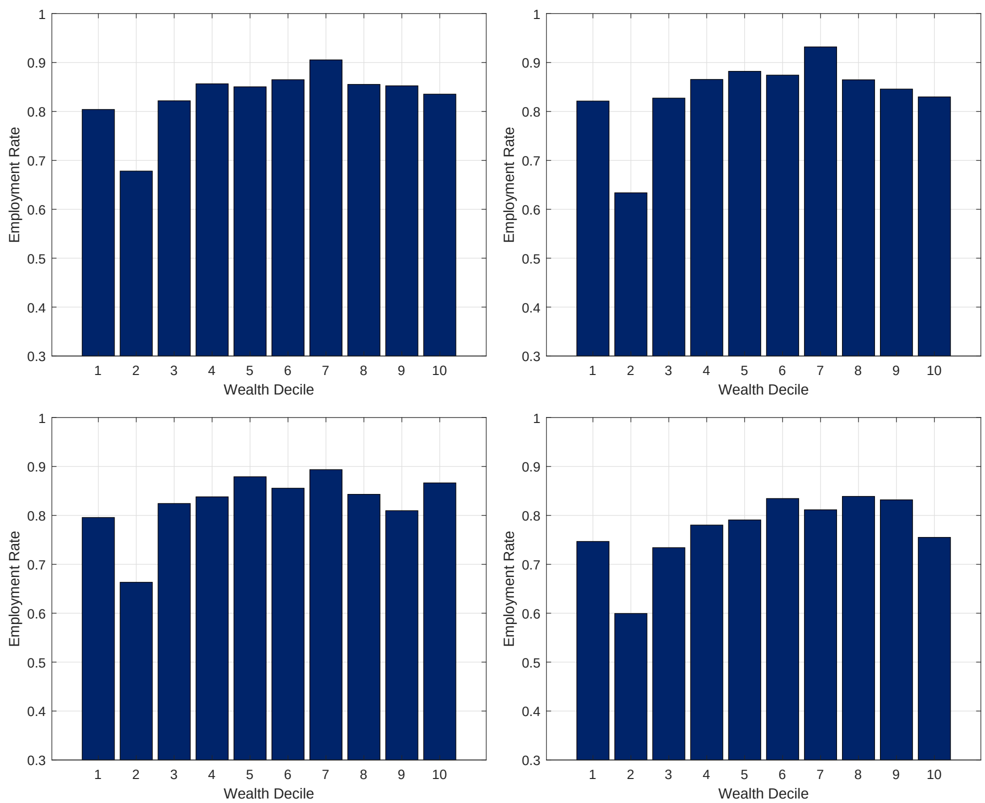


Figure A.6: Employment Rates by Wealth – 2003-2009 PSID Waves

*Notes*: The figure shows employment rates by wealth deciles for household heads of 25-65 years old from the 2003-2009 biannual PSID waves. Top left panel: 2003 wave. Top right panel: 2005 wave. Bottom left panel: 2007 wave. Bottom right panel: 2009 wave. Wealth is total assets minus total liabilities at the household level.

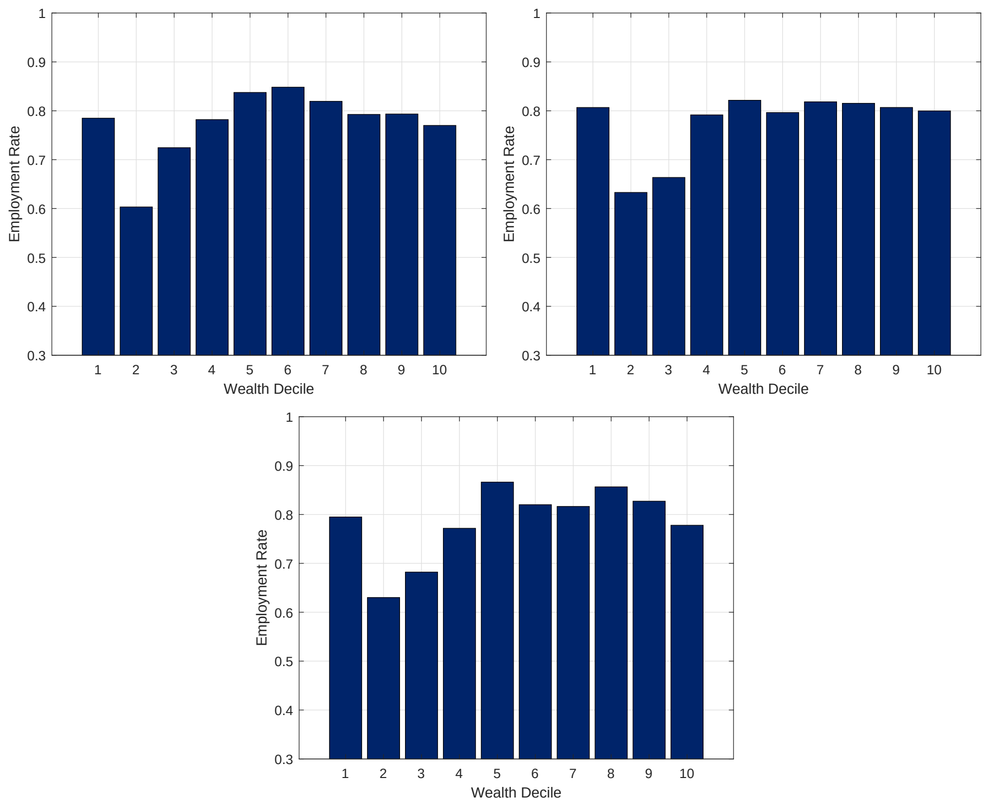


Figure A.7: Employment Rates by Wealth – 2011-2015 PSID Waves

*Notes*: The figure shows employment rates by wealth deciles for household heads of 25-65 years old from the 2011-2015 biannual PSID waves. Top left panel: 2011 wave. Top right panel: 2013 wave. Bottom panel: 2015 wave. Wealth is total assets minus total liabilities at the household level.

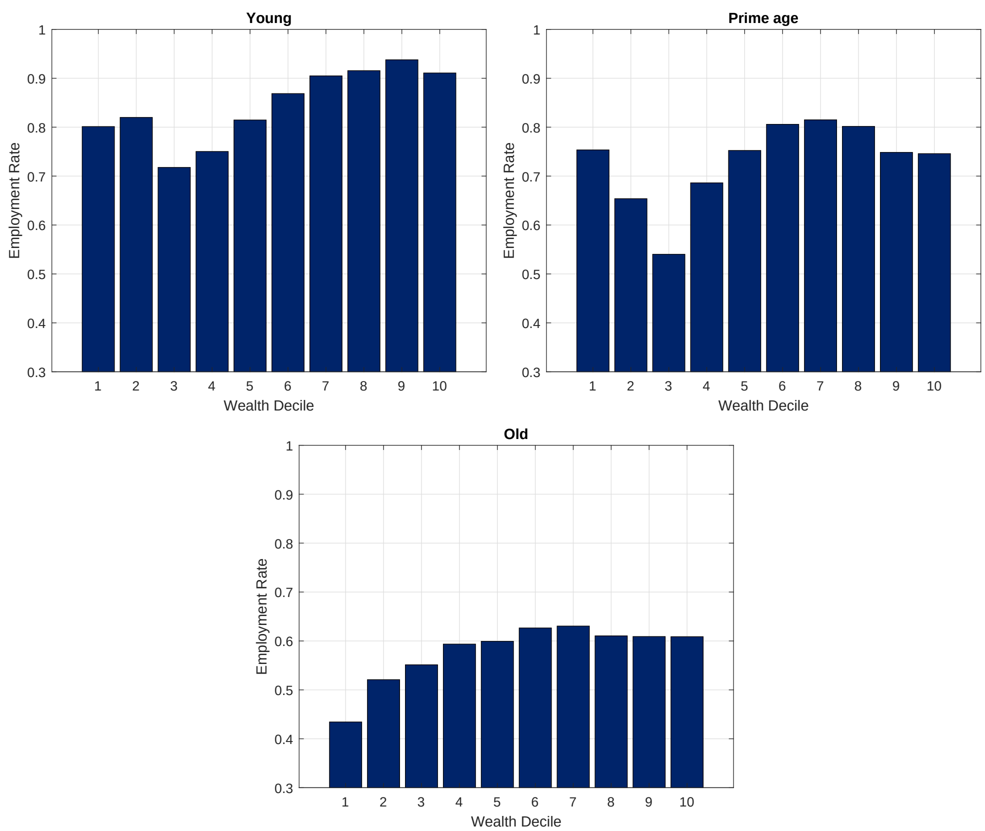


Figure A.8: Employment Rates by Wealth – Age

*Notes*: The figure shows employment rates by wealth deciles for household heads by three age groups from the biannual 2001-2015 PSID waves. Top left panel: 24-29 years old. Top right panel: 30-59 years old. Bottom panel: 60-65 years old. Wealth is total assets minus total liabilities at the household level.

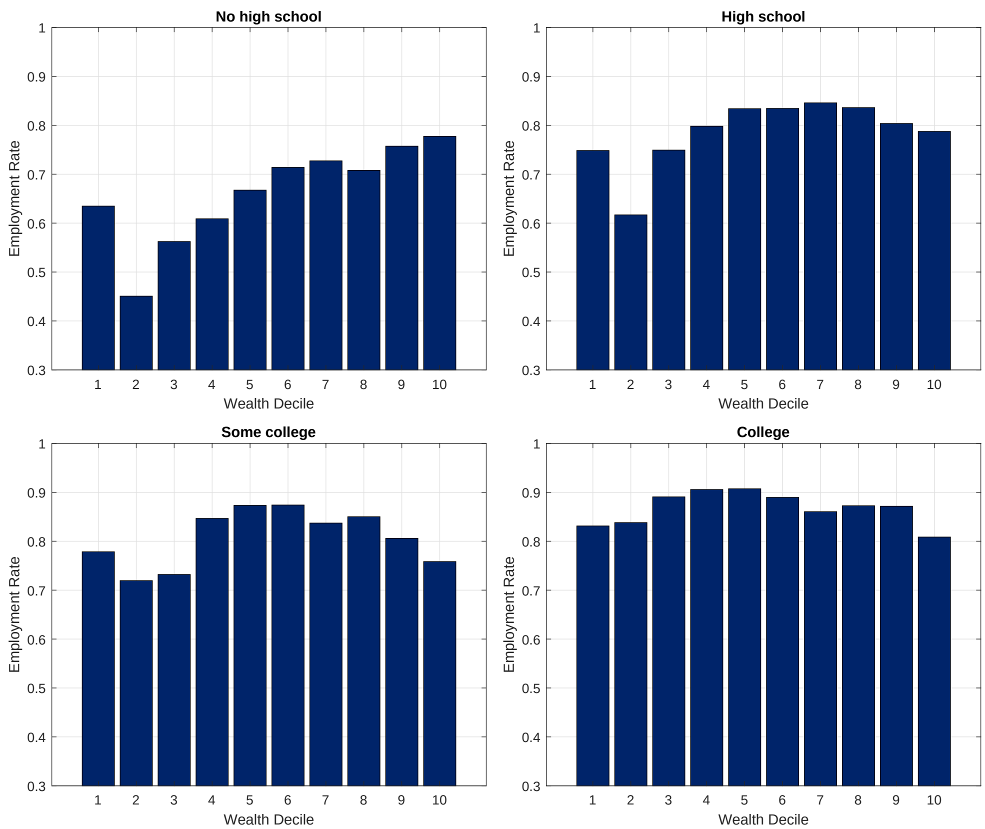


Figure A.9: Employment Rates by Wealth – Education

*Notes*: The figure shows employment rates by wealth deciles for household heads by education groups from the biannual 2001-2015 PSID waves. Top left panel: No high school. Top right panel: High school. Bottom left panel: Some college. Bottom right panel: College. Wealth is total assets minus total liabilities at the household level.

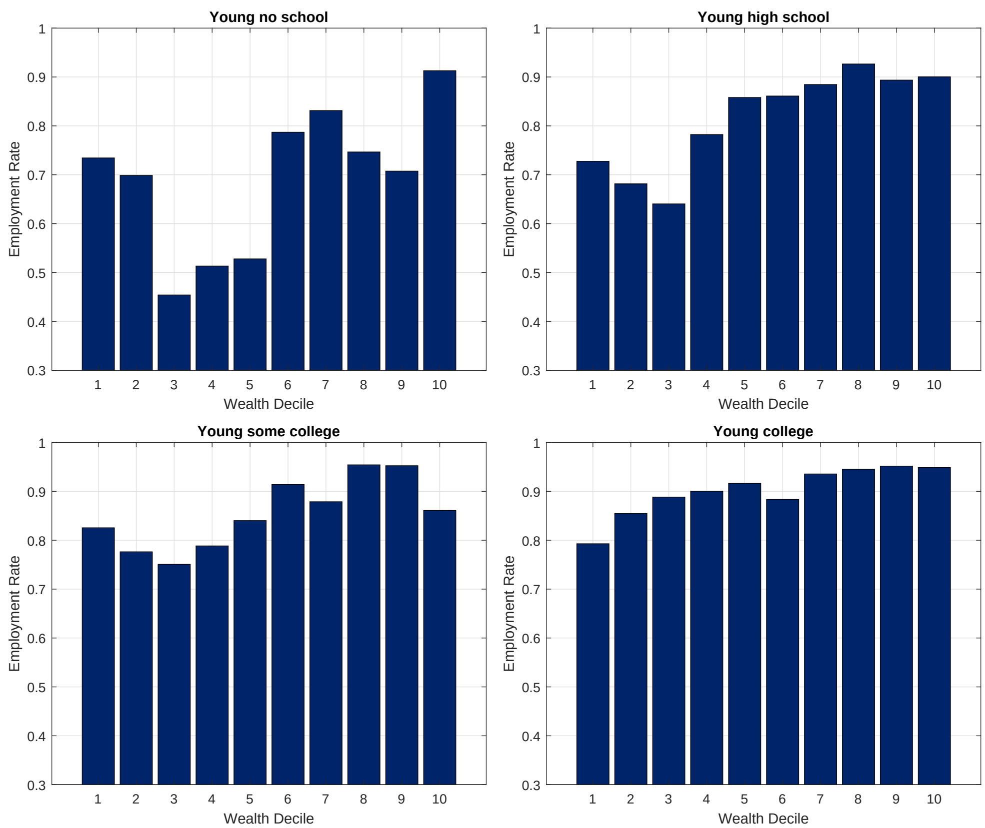


Figure A.10: Employment Rates by Wealth – Young by Education

*Notes*: The figure shows employment rates by wealth deciles for household heads of 24-29 years old by education groups from the biannual 2001-2015 PSID waves. Top left panel: No high school. Top right panel: High school. Bottom left panel: Some college. Bottom right panel: College. Wealth is total assets minus total liabilities at the household level.

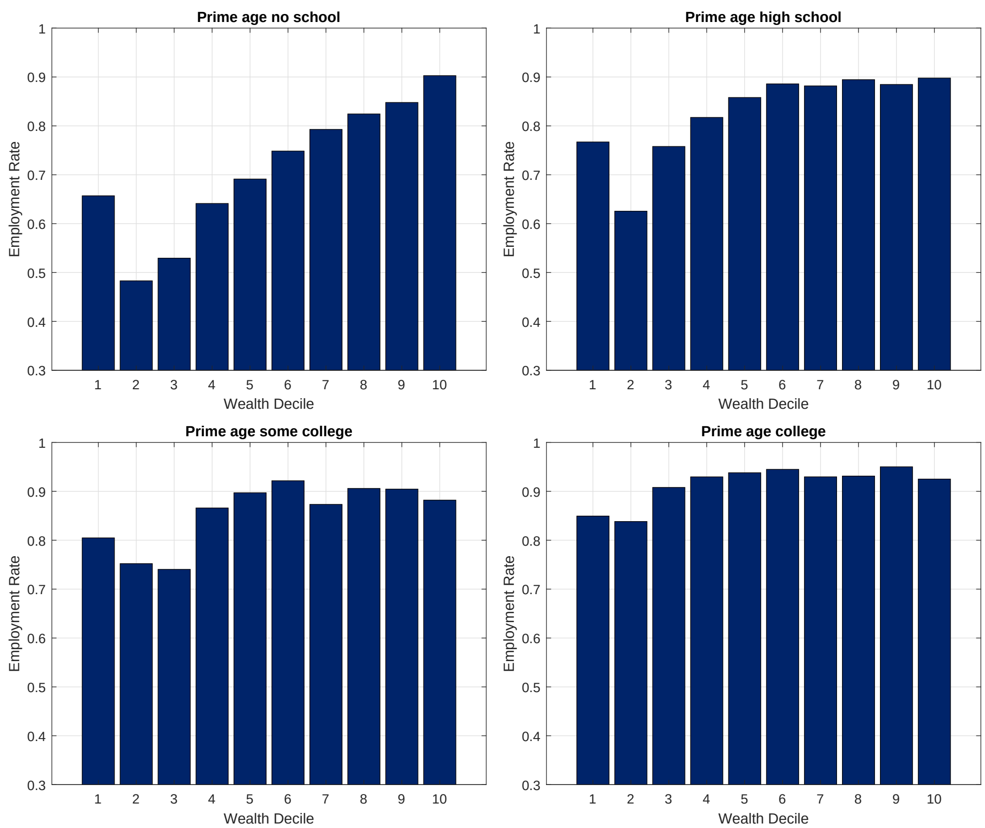


Figure A.11: Employment Rates by Wealth – Prime Age by Education

*Notes*: The figure shows employment rates by wealth deciles for household heads of 30-59 years old by education groups from the biannual 2001-2015 PSID waves. Top left panel: No high school. Top right panel: High school. Bottom left panel: Some college. Bottom right panel: College. Wealth is total assets minus total liabilities at the household level.

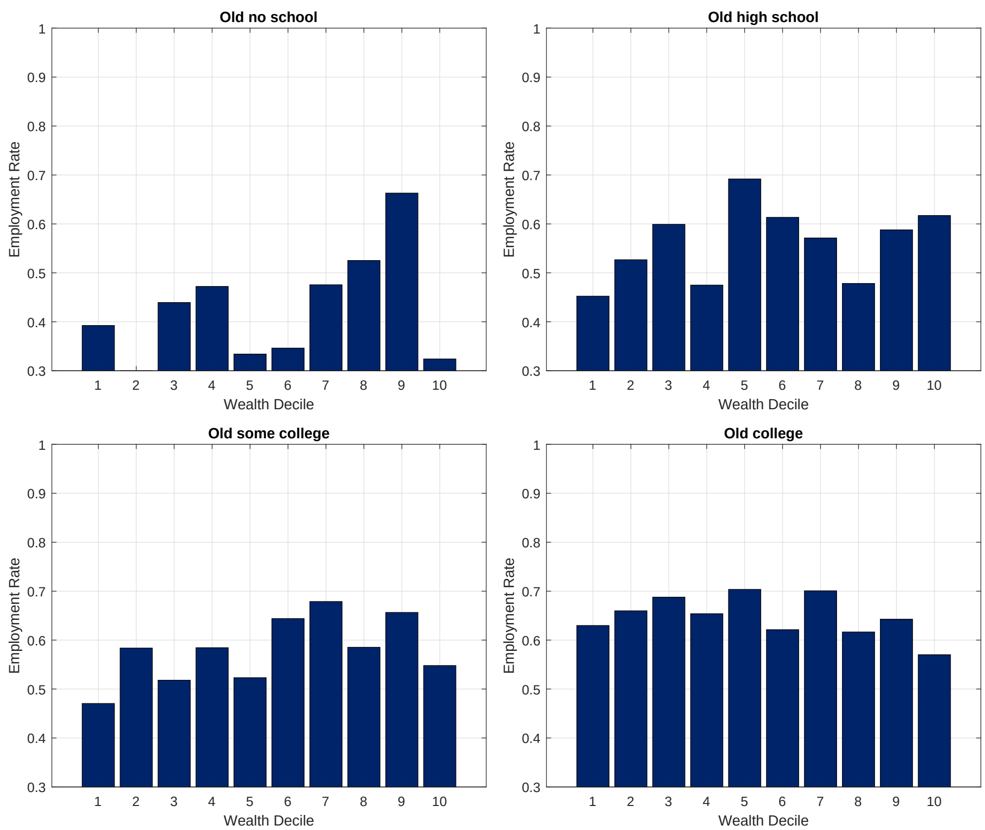


Figure A.12: Employment Rates by Wealth – Old by Education

*Notes*: The figure shows employment rates by wealth deciles for household heads of 60-65 years old by education groups from the biannual 2001-2015 PSID waves. Top left panel: No high school. Top right panel: High school. Bottom left panel: Some college. Bottom right panel: College. Wealth is total assets minus total liabilities at the household level.

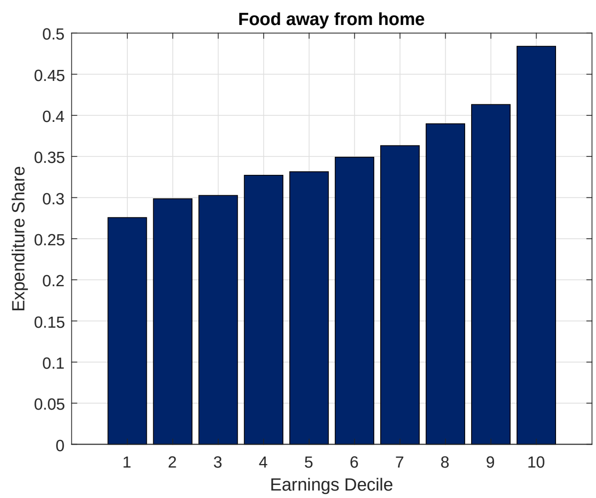


Figure A.13: Food Expenditure Share in Food Away from Home in the Data

*Notes*: The figure shows the shares of food expenditures on food away from home by earnings deciles. Data are from the 2001-2015 waves of the PSID for households heads of 25-65 years old.

## A.3 CSFII - Data and Variables' Construction

The sample includes households from the 1989-91 and 1994-96 waves of the CSFII. For our analysis, we use the following variables:[21] *food expenditures* (see below), *household income* (INCOME: During the previous calendar year, approximately how much income from all sources did you and other household members have before taxes? MINC_TOT in the 1989-91 survey), *employment status* (EMP_STAT: full-time; part-time; not at work last week; not employed. R_EMP in the 1989-91 survey), *age* (AGE), *gender* (SEX: Male; female), *race* (RACE: White; Black; Asian; Pacific Islander; American Indian, Alaskan native; Other), *education level* (GRADE: highest grade of formal schooling completed), *household size* (HHSIZE: Household size; count of household members. HHSZ in the 1989-91 survey), *region* (REGION: Northeast; Midwest; South; West), *urbanization* (URB: MSA, central city; MSA, outside central city; Non-MSA), weight (WGT_SP: How much do you weigh without shoes? R_WGT in the 1989-91 survey), *height* (HGT_SP: How tall are you without shoes? R_HGT in the 1989-91 survey), *food intake* (see below), *health measures* (see below), and *occupation* (EMP_OCC: Professional and technical; Manager, officer or proprietor; Farmer; Clerical or sales worker; Craftsman or foreman; Operative; Service worker or other similar job; Other. R_OCC in the 1989-91 survey).[22]

**Food Expenditures (1989-91 CSFII variable's name in parenthesis)**

- SHP_GROC: H3. During the last three months, how much money has this household spent per week or per month at grocery stores, including the stores' salad bars, soup bars, delis, etc.? Include purchases made with food stamps. (AMT_GRO)
- SHP_NONF: H4. About how much of the amount reported in H3, if any, was for nonfood items such as cleaning or paper products, food bought for feeding a pet, or cigarettes? (AMT_NON)
- SHP_SPEC: H5. During the last three months, how much has this household spent

[21]Variables' names and definitions are from the 1994-96 CSFII. When different, we also report the name of the variable from the 1989-91 CSFII.

[22]Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont. Midwest: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin. South: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia. West: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming.

per week on food at specialty stores – such as bakeries, liquor stores, delicatessens, meat markets, vegetable stands, health food stores, and other similar places – when the food was brought into your home? (AMT_SPE)

- SHP_FAST: H6. During the last three months, how much has this household spent per week at fast food or carryout places when the food was brought into your home? (Not available in the 1989-91 survey.)
- SHP_AWAY: H7. During the last three months, what has been this household's usual amount of money spent per week for food bought and eaten away from home? Include food and beverages that never entered your home, that is, eaten at restaurants, fast food places, cafeterias at work or at school or purchased from vending machines, for all household members. (AMT_AWY)

We construct our food expenditure variables as follows:

- EXP_FOOD = SHP_AWAY + SHP_FAST + SHP_GROC + SHP_SPEC − SHP_NONF.
- EXP_FOOD_HOME = SHP_GROC + SHP_SPEC − SHP_NONF.
- EXP_FOOD_AWAY = SHP_AWAY.

**Food Intake (1989-91 CSFII variable's name in parenthesis)**

- ENERGY: Food energy - kilocalories. (TOTNUT2)
- PROTEIN: Protein - grams. (TOTNUT3)
- TFAT: Total fat - grams. (TOTNUT4)
- SFAT: Saturated fatty acids - grams. (TOTNUT5)
- PFAT: Polyunsaturated fatty acids - grams. (TOTNUT7)
- CHOLES: Cholesterol - milligrams. (TOTNUT8)
- VITA: Vitamin A - IU - milligrams. (TOTNUT12)
- VITE: Vitamin E - milligrams alpha-tocopherol equivalents. (TOTNUT15)
- VITC: Vitamin C - milligrams. (TOTNUT16)
- CALCIUM: Calcium - milligrams.(TOTNUT23)

**Health Status**

- HEALTH: In general, would you say your health is excellent, very good, good, fair, or poor?
- DOCTOR1: Has a doctor ever told you that you have: diabetes?
- DOCTOR2: Has a doctor ever told you that you have: high blood pressure (hypertension)?
- DOCTOR3: Has a doctor ever told you that you have: heart disease?
- DOCTOR4: Has a doctor ever told you that you have: cancer?
- DOCTOR5: Has a doctor ever told you that you have: osteoporosis?
- DOCTOR6: Has a doctor ever told you that you have: high blood cholesterol?
- DOCTOR7: Has a doctor ever told you that you have: stroke?

## A.4 CSFII - Additional Evidence

This appendix contains additional evidence on food expenditures and income based on CSFII data. Our estimating regression model is

$$\log(expenditure_{i,t}) = \alpha_0 + \alpha_1 \log(income_{i,t}) + \alpha_2 emp_{i,t} + \alpha_3 X_{i,t} + u_{i,t}, \qquad \text{(A.2)}$$

where $expenditure_{i,t}$ is expenditure on food away from home and expenditure on food at home for household $i$ and year $t$, $income_{i,t}$ is total household income, $emp_{i,t}$ is a dummy variable that equals one if the household head is employed, and zero otherwise, and $X_{i,t}$ is a vector of covariates that includes age, gender, and race, household size, and dummies for survey years, region and metropolitan area of residence, height, and a number of health-related variables.

Tables A.6-A.7 report the results from OLS and IV regressions, respectively. Across all specifications, the estimates of the income elasticity of food expenditure away from home is positive, statistically significant at the 1% level, and centered around 0.2. The income elasticity of food expenditure at home is instead negative, again, statistically significant at the 1% level, and roughly centered around 0.07. Such estimates are broadly consistent with the previous findings in the literature, i.e., food at home is a necessity, whereas food away from home is a luxury.

Table A.6: Income Elasticity of Food Expenditure – OLS Estimates

| | Food away | | Food at home | |
|---|---|---|---|---|
| Income (log) | 0.189*** | 0.171*** | −0.060*** | −0.047*** |
| | (0.0228) | (0.0232) | (0.0087) | (0.0089) |
| Employment | ✗ | 0.133*** | ✗ | −0.082*** |
| | | (0.0357) | | (0.0138) |
| Age | ✓ | ✓ | ✓ | ✓ |
| Gender | ✓ | ✓ | ✓ | ✓ |
| Race | ✓ | ✓ | ✓ | ✓ |
| Household size | ✓ | ✓ | ✓ | ✓ |
| Region | ✓ | ✓ | ✓ | ✓ |
| Urban | ✓ | ✓ | ✓ | ✓ |
| Health | ✓ | ✓ | ✓ | ✓ |
| Year | ✓ | ✓ | ✓ | ✓ |
| Observations | 6,471 | 6,471 | 7,376 | 7,376 |

*Notes*: Data is from the 1989-91 and 1994-96 waves of the CSFII for household heads of 25-55 years old. The table reports the coefficients on the log of income and employment estimated from OLS regressions of food expenditure away from home and at home (in logs) on the log of income, employment, and a list of control variables, that includes age, gender, race, household size, and dummies for survey years, region and metropolitan area of residence, height, and health-related variables (weight, HEALTH, DOCTOR1, DOCTOR2, DOCTOR3, DOCTOR4, DOCTOR5, DOCTOR6, and DOCTOR7). Regressions include a constant and the log of total food expenditure as an additional control. Robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. See Appendix A.3 for details on variables' definitions.

Table A.7: Income Elasticity of Food Expenditure – IV Estimates

| | Food away | | Food at home | |
|---|---|---|---|---|
| Income (log) | 0.212*** | 0.212*** | −0.092*** | −0.092*** |
| | (0.0601) | (0.0601) | (0.0267) | (0.0267) |
| Employment | ✗ | 0.156*** | ✗ | −0.094** |
| | | (0.0484) | | (0.0401) |
| Age | ✓ | ✓ | ✓ | ✓ |
| Gender | ✓ | ✓ | ✓ | ✓ |
| Race | ✓ | ✓ | ✓ | ✓ |
| Household size | ✓ | ✓ | ✓ | ✓ |
| Region | ✓ | ✓ | ✓ | ✓ |
| Urban | ✓ | ✓ | ✓ | ✓ |
| Health | ✓ | ✓ | ✓ | ✓ |
| Year | ✓ | ✓ | ✓ | ✓ |
| Observations | 5,755 | 5,755 | 6,438 | 6,438 |

*Notes*: Data is from the 1989-91 and 1994-96 waves of the CSFII for household heads of 25-55 years old. The table reports the coefficients on the log of income and employment estimated from IV regressions of food expenditure away from home and at home (in logs) on the log of income, employment, and a list of control variables, that includes age, gender, race, household size, and dummies for survey years, region and metropolitan area of residence, and health-related variables (height, weight, HEALTH, DOCTOR1, DOCTOR2, DOCTOR3, DOCTOR4, DOCTOR5, DOCTOR6, and DOCTOR7). Following Aguiar and Hurst (2005), we instrument the log of income with occupation, education (highest grade of formal schooling completed), education-occupation interactions, and gender-race interactions. First-stage F statistics equal 67.47 and 65.25 for food away regressions, and 72.16 and 70 for the food at home regressions. Regressions include a constant and the log of total food expenditure as an additional control. Robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. See Appendix A.3 for details on variables' definitions.

## A.5 CEX - Data and Variables' Construction

The main sample includes households from 1996:Q1 to 2019:Q4. The regressions using product codes that have both quantity and quality information (CLOTHYA) use the data from 1996 to 2011 only, as CLOTHYA was discontinued after 2011. Data for household income and demographic controls is from the FMLI files; expenditure on specific UCC product codes is extracted from MTBI; and the information about purchase prices and quantity (CLOTHYA) is from CLA files. The data is merged using the unique household identifier (NEWID).

### Product Codes

Bicycles (600310), New cars (450110), New motorcycles (450220), New trucks (450210), Used cars (460110), Used motorcycles (460902), Used trucks (460901), Refrigerators and freezers (sum of 300112 for home owners and 300111 for renters), Clothes dryers (sum of 300222 for home owners and 300221 for renters), Washing machines (sum of 300217 for home owners and 300216 for renters), Computers and computer hardware for non-business use (690111), Watches (430110), Rent (210110), and Rent equivalent (910050).

### Household Income

Household income is total family income after taxes (FINCATXM before 2013, FINATXEM after 2013). The measurement of earnings differs by survey year as some income variables have been discontinued. Before 2013 earnings are the sum of wage and salary income (FSALARYX before 2003 and FSALARYM after 2003), non-farm business, partnership or professional practice income (FNONFRMX before 2003 and FNONFRMM after 2003), and income or loss received from own farm (FFRMINCX before 2003 and FFRMINCM after 2003). After 2013 earnings are measured as the sum of wage and salary income (FSALARYM) and income or loss from self-employment (FSMPFRMX).

### Demographic Controls

Age (AGE_REF), sex (SEX_REF), race (REF_RACE), number of members in the consumption unit (FAM_SIZE), region (REGION: Midwest, Northeast, South, and West), urban location (BLS_URBN), occupation (OCCUCOD1), and education (EDUC_REF).

## A.6 CEX - Additional Evidence

### A.6.1 Consumer Durables

This appendix contains evidence on the relationship between durables' expenditures and household income based on CEX data. Our estimating regression model is

$$\log(expenditure_{i,t}) = \alpha_0 + \alpha_1 \log(income_{i,t}) + \alpha_2 X_{i,t} + u_{i,t}, \tag{A.3}$$

where the dependent variable $expenditure_{i,t}$ is durables' expenditures for household $i$ and year $t$ (bicycle, new car, new motorbike, new truck, used car, used motorbike, used truck, fridge, dryer, washer, clothwash, computers, rent, rent equivalent, and watches), $income_{i,t}$ is total household income, and $X_{i,t}$ is a vector of covariates that includes age, gender, race, household size, and a set of dummies for whether a spouse is in the household, region of residence, whether the household head resides in a urban location, and year fixed effects.

Table A.8 reports estimates of the income elasticity of durables' expenditures from OLS and IV regressions. To address concerns related to measurement error and omitted variable bias, we instrument the log of income with occupation, education, education-occupation interactions, and gender-race interactions. These are the same instruments used in the IV regressions based on the CSFII data; first-stage F statistics reported in the notes to the table confirm that such instruments remain relevant in the CEX. The lowest F statistic is 37.41 for used motorbike.

In all cases, but used motorbike, the income elasticity is estimated to be positive and statistically significant at the 1% level. Of course, a positive elasticity of expenditures to income is not necessarily evidence that higher-income households buy higher-quality goods. A positive relationship between expenditures and income could be the result of higher-income households buying more of the same quality good. Such a concern, while valid in principle, is much less relevant for durables. This is because durables are well-known to be infrequently purchased, and indivisible in nature, so that one can expect little variation in the quantity purchased by households. This implies that the estimates in Table A.8 capture to a large extent a positive relationship between unit prices and income, a pattern consistent with the model's predictions.

### A.6.2 Clothing

The CEX contains data on both *clothing prices* and *quantities*. Using such data, in this subsection, we estimate the elasticity of price and quantities to household income. Table A.9 reports the estimates from OLS and IV regressions. To obtain the IV estimates, as in the previous subsection, we instrument household income with occupation, education, education and occupation interactions, and gender and race interactions. First-stage F statistics reported in the notes to the table confirm that such instruments remain relevant in the CEX. We find that the income elasticity of clothing prices is twice as large as the elasticity of clothing quantities for OLS, and more than twice as large for IV regressions.

Table A.8: Income Elasticity of Durables

| | OLS | IV |
|---|---|---|
| Bicycle | 0.240*** | 0.308*** |
| | (0.0214) | (0.0461) |
| New cars | 0.079*** | 0.167*** |
| | (0.0148) | (0.0409) |
| New motorbike | 0.489*** | 0.458*** |
| | (0.1114) | (0.1519) |
| New truck | 0.049*** | 0.077*** |
| | (0.0107) | (0.0292) |
| Used cars | 0.269*** | 0.764*** |
| | (0.0235) | (0.0609) |
| Used motorbike | 0.090 | 0.156 |
| | (0.0696) | (0.1344) |
| Used truck | 0.232*** | 0.709*** |
| | (0.0293) | (0.0615) |
| Fridge | 0.236*** | 0.517*** |
| | (0.0197) | (0.0472) |
| Dryer | 0.297*** | 0.498*** |
| | (0.0328) | (0.0593) |
| Washer | 0.299*** | 0.552*** |
| | (0.0266) | (0.0553) |
| Clothwash | 0.200*** | 0.432*** |
| | (0.0252) | (0.0650) |
| Computers | 0.135*** | 0.221*** |
| | (0.0117) | (0.0310) |
| Rent | 0.238*** | 0.560*** |
| | (0.0038) | (0.0070) |
| Rent equivalent | 0.176*** | 0.642*** |
| | (0.0027) | (0.0058) |
| Watches | 0.379*** | 0.533*** |
| | (0.0185) | (0.0407) |

*Notes*: Data is from the CEX for the period 2005-2019. The table reports the coefficient on the log of income estimated from OLS and IV regressions of the log of durables' expenditures on the log of income and a list of control variables, that includes age, gender, race, household size, and a set of dummies for whether a spouse is in the household, region of residence, whether the household head resides in a urban location, and year fixed effects. For IV regressions, we instrument the log of income with occupation, education, education-occupation interactions, and gender-race interactions. First-stage F statistics: 92.71 (bicycle), 101.95 (new cars), 981.21 (new motorbike), 240.57 (new truck), 130.44 (used cars), 37.41 (used motorbike), 580.72 (used truck), 222.55 (fridge), 562.85 (dryer), 94.48 (washer), 55.62 (clothwash), 227.86 (computers), 1106.65 (rent), 1984.73 (rent equivalent), and 171.85 (watches). Regressions include a constant. Robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. See Appendix A.5 for details on variables' definitions.

Table A.9: Income Elasticity of Clothing Prices and Quantities

| | OLS | | IV | |
|---|---|---|---|---|
| | Price (log) | Quantity (log) | Price (log) | Quantity (log) |
| Income (log) | 0.206*** | 0.100*** | 0.506*** | 0.196*** |
| | (0.0078) | (0.0034) | (0.0243) | (0.0103) |
| Age | ✓ | ✓ | ✓ | ✓ |
| Gender | ✓ | ✓ | ✓ | ✓ |
| Race | ✓ | ✓ | ✓ | ✓ |
| Household size | ✓ | ✓ | ✓ | ✓ |
| Spouse | ✓ | ✓ | ✓ | ✓ |
| Region | ✓ | ✓ | ✓ | ✓ |
| Urban | ✓ | ✓ | ✓ | ✓ |
| Year | ✓ | ✓ | ✓ | ✓ |
| Observations | 102,010 | 102,010 | 75,210 | 75,210 |

*Notes*: Data is from the CEX for the period 2005-2011. The table reports estimates from OLS and IV regressions of the log of clothing prices (CLOTHXA) and quantities (CLOTHQA) on the log of income and a list of control variables. For IV regressions, we instrument the log of income with occupation, education, education-occupation interactions, and gender-race interactions. First-stage F statistic equals 5012.3 for the IV-price regression and 1375.32 for the IV-quantity regression. Regressions include a constant. In all price regressions, the log of quantity is included as an additional control. Robust standard errors in parentheses. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. See Appendix A.5 for details on variables' definitions.

## A.7 Nielsen - Additional Evidence

# B Proofs, Derivations, and Extensions

This appendix contains proofs, derivations, and additional results related to: (i) the role of capital income taxes (Appendix B.1); (ii) the neoclassical growth model with wealth heterogeneity (Appendix B.2); (iii) the neoclassical growth model with idiosyncratic wage shocks and complete markets (Appendix B.3); (iv) restrictions on preferences in the labor supply model with a quality choice in consumption (Appendix B.4); and (v) the growth model with quality choice and wealth heterogeneity (Appendix B.5).

## B.1 Role of Capital Income Taxes

Here we examine how capital income taxes alter the relationship between the reservation wage and wealth. We do so for the standard model of labor supply with indivisible labor, and for the version of the model with the quality choice in consumption.

We specify the capital income tax rate $\tau(a)$ as a generic function of assets to allow for tax progressivity. When $\tau'(a) = 0$, the tax system is flat, the marginal tax rate is constant and equals the average tax rate, i.e., $MTR = ATR = \tau$. When $\tau'(a) > 0$, the tax system is progressive in the sense that the marginal tax rate is larger than the average tax rate. Conversely, when $\tau'(a) < 0$, the tax system is regressive, and the marginal tax rate is smaller than the average tax rate.

### B.1.1 Capital Income Taxes in the Standard Model of Labor Supply

The individual's problem is to maximize $u(c) - Bh$, by choosing whether to work $(h = 1)$, or not to work $(h = 0)$, subject to the budget constraint $c = wh + \tilde{a}$, where $\tilde{a} \equiv (1 - \tau(a))a$ is after-tax wealth. The labor supply choice follows a reservation wage rule according to which if $w \leq w_R$, the individual does not work, otherwise if $w > w_R$, the individual works. The reservation wage is implicitly determined by the indifference condition

$$u(w_R + \tilde{a}) - B = u(\tilde{a}). \tag{B.1}$$

Total differentiation of equation (B.1) yields

$$\frac{dw_R}{da} = \underbrace{\frac{u'(\tilde{a}) - u'(w_R + \tilde{a})}{u'(w_R + \tilde{a})}}_{\geq 0} \left[1 - \tau(a) - \tau'(a)a\right]. \tag{B.2}$$

The first term on the right-hand side is positive as $u'(\tilde{a}) \geq u'(w_R + \tilde{a})$ from the concavity of the utility function. The sign of the comparative statics thus depends on the sign of the second term on the right-hand side $1 - MTR$, where $MTR \equiv \partial(\tau(a)a)/\partial a = \tau(a) + \tau'(a)a$ is the marginal tax rate. Note that in the case of a flat-rate capital income tax, i.e., $\tau(a) = \tau < 1$, $1 - MTR > 0$, so that the reservation wage remains monotonically increasing in wealth, as in the model without capital income taxation.

For the United States, available empirical estimates yield marginal tax rates that are monotone in income and substantially below one for the bulk of the income distribution. Higher marginal tax rates, possibly above one, can be found at the bottom of the income distribution where means-tested programs are phased out (see Heathcote, Storesletten and Violante, 2020). Given these estimates, the relationship between the reservation wage and wealth in (B.2) remains positive, as in the model without capital income taxes, for the middle and the top of the income distribution, and potentially close to zero or even slightly negative at the very bottom.

### B.1.2 Capital Income Taxes in the Labor Supply Model with Quality Choice

The individual's problem is to maximize $u(c, q) - Bh$, by choosing whether to work ($h = 1$), or not to work ($h = 0$), subject to the budget constraint $p(q)c = wh + \tilde{a}$, where $\tilde{a} \equiv (1 - \tau(a))a$ is after-tax wealth. The reservation wage is implicitly determined by the indifference condition

$$u\left(\frac{w_R + \tilde{a}}{p(q_e)}, q_e\right) - B = u\left(\frac{\tilde{a}}{p(q_u)}, q_u\right). \tag{B.3}$$

Total differentiation of equation (B.3), after some algebra, yields

$$\frac{dw_R}{da} = \left[\frac{p(q_e)}{p(q_u)} \cdot \frac{u_1(c_u, q_u)}{u_1(c_e, q_e)} - 1\right] \left(1 - \tau(a) - \tau'(a)a\right) \lesseqgtr 0. \tag{B.4}$$

## B.2 Neoclassical Growth Model with Wealth Heterogeneity

The analysis builds on Chatterjee (1994). Specifically, we introduce an extensive margin of labor supply with indivisible labor into a neoclassical growth model with time separable preferences and wealth heterogeneity across households. There is no idiosyncratic or aggregate risk. Markets are complete in that households can freely transfer resources over time.

Time is discrete and continues forever, indexed by $t$. There are $N$ types of infinitely-lived households indexed by $i = 1, 2, \ldots, N$. The number (mass) of each type is $\mu^i$, such that $\sum_{i=1}^{N} \mu^i = 1$. Households differ solely in terms of their initial wealth endowments, $a_t^i = s_t^i A_t$, or, equivalently, in terms of their share $s_t^i$ of aggregate wealth $A_t = \sum_{i=1}^{N} \mu^i a_t^i$.

#### Preferences, Budget Constraint, and Household Problem

Household's preferences are described by

$$\sum_{\tau=t}^{\infty} \beta^{\tau-t} u(c_\tau^i, h_\tau^i), \tag{B.5}$$

where $0 < \beta < 1$ is the time discount factor, $u(\cdot)$ is a strictly increasing and concave, and twice continuously differentiable utility function, $c_\tau^i \geq 0$ is consumption and $h_\tau^i \in \{0, 1\}$ is (indivisible) labor supply of household $i$ at time $\tau \geq t$. Here, we focus on the case in which the utility function is quasi-homothetic and logarithmic in consumption:

$$u(c, h) = \log(c + \bar{c}) - Bh, \tag{B.6}$$

where $\bar{c} \leq 0$ allows for subsistence consumption, and $B > 0$ captures the disutility of work.

We use $p_\tau$ to denote the price of the consumption good in period $\tau \geq t$. A household chooses sequences of consumption and labor supply to maximize lifetime utility (B.5) subject to the intertemporal budget constraint,

$$\sum_{\tau=t}^{\infty} p_\tau c_\tau^i \leq p_t a_t^i + \sum_{\tau=t}^{\infty} p_\tau w_\tau h_\tau^i, \tag{B.7}$$

where $a_t^i$ is the initial wealth of household $i$ in terms of consumption units at time $t$.

Let $\lambda_i$ denote the Lagrange multiplier on the household $i$ budget constraint (B.7). The FOC of the household problem at time $t$ with respect to consumption at time $\tau$ is

$$\beta^{\tau-t}\left(\frac{1}{c_\tau^i+\bar{c}}\right)=\lambda_i p_t \rightarrow c_\tau^i=\frac{\beta^{\tau-t}}{\lambda_i p_t}-\bar{c}. \tag{B.8}$$

Substituting (B.8) into the budget constraint (B.7), and rearranging terms, yields

$$\sum_{\tau=t}^{\infty} p_\tau\left(\frac{\beta^{\tau-t}}{\lambda_i p_\tau}-\bar{c}\right)=p_t a_t^i+\sum_{\tau=t}^{\infty} p_\tau w_\tau h_\tau^i, \tag{B.9}$$

$$\frac{1}{(1-\beta)\lambda_i}-\bar{c}\sum_{\tau=t}^{\infty} p_\tau=p_t a_t^i+\sum_{\tau=t}^{\infty} p_\tau w_\tau h_\tau^i, \tag{B.10}$$

$$\frac{1}{\lambda_i}=(1-\beta)\left(p_t a_t^i+\sum_{\tau=t}^{\infty} p_\tau w_\tau h_\tau^i+\bar{c}\sum_{\tau=t}^{\infty} p_\tau\right). \tag{B.11}$$

Next, for $\tau=t$, the FOC for consumption (B.8) reduces to

$$c_t^i=\frac{1}{\lambda_i p_t}-\bar{c}. \tag{B.12}$$

Substituting (B.11) into (B.12), yields

$$c_t^i=(1-\beta)\left[a_t^i+\sum_{\tau=t}^{\infty}\left(\frac{p_\tau}{p_t}\right)w_\tau h_\tau^i+\bar{c}\sum_{\tau=t}^{\infty}\left(\frac{p_\tau}{p_t}\right)\right]-\bar{c}, \tag{B.13}$$

$$c_t^i=\bar{c}\left[(1-\beta)\sum_{\tau=t}^{\infty}\left(\frac{p_\tau}{p_t}\right)-1\right]+(1-\beta)\left[a_t^i+\sum_{\tau=t}^{\infty}\left(\frac{p_\tau}{p_t}\right)w_\tau h_\tau^i\right]. \tag{B.14}$$

**Technology and Firm Problem**

A representative firm produces output $Y_t$ with a CRS neoclassical production function, $Y_t=F(K_t,Z_tH_t)$, where $Z_t$ is a technology parameter, $K_t$ is the stock of capital and $H_t$ is the aggregate labor input. The representative firm owns the physical capital stock, so it demands labor and makes the investment decision by maximizing the present discounted value of profits $\sum_{\tau=t}^{\infty}(p_\tau/p_t)\,\pi_t$, where $\pi_t\equiv Y_t-I_t-w_tH_t$, subject to the law of motion for capital $K_{t+1}=(1-\delta)K_t+I_t$.

The FOCs with respect to $K_{t+1}$ and $H_t$ are, respectively:

$$p_t = p_{t+1} \left[ F_K(K_{t+1}, Z_{t+1}H_{t+1}) + 1 - \delta \right], \tag{B.15}$$

$$w_t = F_H(K_t, Z_t H_t). \tag{B.16}$$

### Steady-State Equilibrium

We consider a steady-state equilibrium in which aggregate variables are constant and $Z_{t+1} = Z_t = Z$ for all $t$. In such a steady state, $F_K(K, ZH) = 1/\beta - (1 - \delta)$, and $w = F_H(K, ZH)$, where $K$ and $H$ are the steady-state capital stock and aggregate hours, respectively. Note that in steady state, $p_\tau / p_t = \beta^{\tau - t}$, so that $p_{t+1}/p_t = \beta$.

Substituting $p_\tau / p_t = \beta^{\tau - t}$ into (B.14), we obtain

$$c_t^i = \bar{c} \left[ (1 - \beta) \sum_{\tau = t}^{\infty} \beta^{\tau - t} - 1 \right] + (1 - \beta) \left[ a_t^i + \sum_{\tau = t}^{\infty} \beta^{\tau - t} w_\tau h_\tau^i \right]. \tag{B.17}$$

Finally, using $\sum_{\tau=t}^{\infty} \beta^{\tau - t} = 1/(1 - \beta)$ and the property that the steady-state wage $w$ as well as individual hours worked $h^i$ are constant, the expression (B.17) collapses to

$$c^i = (1 - \beta) a^i + w h^i. \tag{B.18}$$

### Cross-Sectional Wealth-Hours Relation

In the steady state, the value of working for household $i$ is $V_i^E = u(c^i, 1)/(1 - \beta)$, whereas her value of not working is $V_i^U = u(c^i, 0)/(1 - \beta)$. Without loss of generality, we can work with $\tilde{V}_i^E \equiv (1 - \beta) V_i^E$ and $\tilde{V}_i^U \equiv (1 - \beta) V_i^U$, i.e., monotone transformation of $V_i^E$ and $V_i^U$, respectively. The reservation wage for household $i$, $w_R^i$, is then determined by the indifference condition $\tilde{V}_i^E(w_R^i) = \tilde{V}_i^U$. Using the utility function specification in (B.6), we obtain a closed-form solution for the reservation wage:

$$w_R^i = (e^B - 1) \left[ (1 - \beta) a^i + \bar{c} \right]. \tag{B.19}$$

(Note that in the case in which households live for one period ($\beta = 0$) and $\bar{c} = 0$, $w_R^i = (e^B - 1) a^i$, which is the same reservation wage obtained in the simple, one-period labor supply model.)

Two important insights emerge from the expression for the reservation wage above. First, the higher the level $\bar{c}$ of subsistence consumption, the higher the reservation wage. (Recall that $\bar{c} \leq 0$.) This is the well-known income effect on labor supply from Stone-Geary utility functions. Second, and more importantly, the reservation wage is increasing in the household $i$'s share $s^i$ of aggregate wealth $A$. Wealthier households with a larger share of aggregate wealth have higher reservation wages, and thus lesser incentives work.

**Aggregate Wealth-Hours Relation**

In general equilibrium, aggregate wealth is equal to the physical capital stock, i.e., $A = K$. Using the firm's FOC for labor, $w = F_H(K, ZH)$, the indifference condition between working and not-working $w = w_R^i$ yields a cutoff for the share of aggregate wealth:

$$\bar{s} = \frac{1}{1-\beta}\left[\frac{1}{(e^B - 1)} \cdot \frac{F_H(K, ZH)}{K} - \frac{\bar{c}}{K}\right], \tag{B.20}$$

such that household $i$ works if and only if $s^i < \bar{s}$. Given this cutoff rule, total hours worked are $H = \Gamma(\bar{s})$, where $\Gamma(\cdot)$ is the cumulative distribution function (CDF) of steady-state wealth shares, $\{s^i\}_{i=1}^{I}$. The higher the cutoff $\bar{s}$, the larger is the number of hours worked in the economy.

Let us consider first the standard case of $\bar{c} = 0$ and Cobb-Douglas production function $Y_t = K_t^{\alpha} (Z_t H_t)^{1-\alpha}$ with $0 < \alpha < 1$. In the steady state, $F_K(K, ZH) = 1/\beta - 1 + \delta$, where $\delta$ is the capital depreciation rate, so that the ratio of capital to effective units of labor $k \equiv K/ZH$ is constant. Using standard techniques, it is easy to show that an increase in $Z$ induces a one-to-one increase in $K$, leaving $k$ and so $\bar{s}$ unchanged. Thus, a change in aggregate wealth induced by a change in $Z$ has no effect on aggregate hours.

For the Stone-Geary case of $\bar{c} < 0$, instead, an increase in aggregate wealth leads to a *fall* in aggregate hours. Again, across households with different aggregate wealth shares, it remains true that wealthier households have higher reservation wages than wealth-poor households.

## B.3 Neoclassical Growth Model with Idiosyncratic Wage Shocks and Complete Markets

Here we present a version of the neoclassical growth model with idiosyncratic wage shocks and complete markets. There is no aggregate risk, however, households face idiosyncratic i.i.d. shocks to efficiency units of labor ("skills"), $z$. To keep things simple, we assume that there are only two states of the world: $z \in \{z_1, z_2\}$, where the good state of the world $z_1$ occurs with probability $\pi$, whereas the bad state of the world $z_2 < z_1$ occurs with probability $1 - \pi$. In the first period, there is no idiosyncratic uncertainty: households are endowed with $\bar{z} \equiv \pi z_1 + (1 - \pi) z_2 = 1$ units of skills.

Markets are complete in that households can freely transfer resources over time and across states of the world by trading Arrow-Debreu securities. Households can also invest in an asset with a non-contingent payoff, that is, physical capital.

Time is discrete and continues forever, indexed by $t$. There are $N$ types of infinitely-lived households indexed by $i = 1, 2, \ldots, N$. The number (mass) of each type is $\mu^i$, such that $\sum_{i=1}^{N} \mu^i = 1$. Households differ ex ante in terms of their initial wealth endowments, $a_t^i$. As shocks to skills are i.i.d. across households, a law of large number applies such that the fraction of households with skills $z_1$ is $\pi$. (Similarly, the fraction of households with skills $z_2$ is $1 - \pi$.)

#### Preferences, Budget Constraint, and Household Problem

Abusing notation slightly, let's $\pi_s$ denote the probability that the event $s \in \{1, 2\}$ occurs. Household's preferences are described by

$$u(c_t^i, h_t^i) + \sum_{\tau=t+1}^{\infty} \sum_{s=1}^{2} \beta^{\tau-t} \pi_s u(c_{\tau s}^i, h_{\tau s}^i), \tag{B.21}$$

where $0 < \beta < 1$ is the time discount factor, $u(\cdot)$ is a strictly increasing and concave, and twice continuously differentiable utility function, $c_{\tau s}^i \geq 0$ is consumption and $h_{\tau s}^i \in \{0, 1\}$ is labor supply of household $i$ at time $\tau$, conditional on the realization of event $s$. Again, we focus on the case in which the utility function is quasi-homothetic and logarithmic in consumption:

$$u(c,h) = \log(c + \bar{c}) - Bh. \tag{B.22}$$

We use $p_t$ to denote the spot price of the current consumption good, that we choose as the numéraire, that is $p_t = 1$. There are contingent markets for future consumption and the two states of the world. We denote $q^s_\tau$ the price of an Arrow-Debreu security that pays off one unit of consumption at time $\tau$ if the state of the world $s$ occurs, and zero otherwise. A household chooses sequences of consumption and labor supply over time and across states of the world to maximize lifetime utility (B.21) subject to the intertemporal budget constraint,

$$c^i_t + \sum_{\tau=t+1}^{\infty} \sum_{s=1}^{2} q^s_\tau c^i_{\tau s} \leq a^i_t + w_t h^i_t + \sum_{\tau=t+1}^{\infty} \sum_{s=1}^{2} q^s_\tau w_\tau z^i_{\tau s} h^i_{\tau s}. \tag{B.23}$$

Let $\lambda_i$ denote the Lagrange multiplier on the budget constraint (B.23). The FOCs of the household problem with respect to current consumption $c^i_t$ and consumption at future date $\tau$ and state $s$ are, respectively:

$$u'(c^i_t, h^i_t) = \lambda_i, \tag{B.24}$$

$$\pi_s \beta^{\tau-t} u'(c^i_{\tau s}, h^i_{\tau s}) = \lambda_i q^s_\tau. \tag{B.25}$$

Combining (B.24) and (B.25) yields the well-known pricing formula for Arrow-Debreu securities:

$$q^s_\tau = \pi_s \beta^{\tau-t} \frac{u'(c^i_{\tau s}, h^i_{\tau s})}{u'(c^i_t, h^i_t)}. \tag{B.26}$$

Equation (B.25) implies that the ratio of marginal utilities for all pairs of households $(i, j)$ equals the ratio of Lagrange multipliers, and so it is constant across all states of the world and dates:

$$\frac{u'(c^i_{\tau s}, h^i_{\tau s})}{u'(c^j_{\tau s}, h^j_{\tau s})} = \frac{\lambda_i}{\lambda_j}. \tag{B.27}$$

#### Technology and Firm Problem

Production function and representative firm's problem are as in Appendix B.2. Output is produced with a CRS technology $Y_t = F(K_t, Z_t N_t)$, where $Z_t$ is a technology parameter, $K_t$ is the stock of capital and $N_t \equiv \sum_{i=1}^{N} \mu^i z_t^i h_t^i$ is aggregate efficiency-weighted hours. The firm owns the capital stock and makes the investment decision subject to the law of motion for capital $K_{t+1} = (1-\delta)K_t + I_t$, where $I_t$ denotes investment.

The FOCs with respect to $K_{t+1}$ and $N_t$ are, respectively:

$$p_t = p_{t+1}\left[F_K(K_{t+1}, Z_{t+1}N_{t+1}) + 1 - \delta\right], \tag{B.28}$$

$$w_t = F_H(K_t, Z_t N_t). \tag{B.29}$$

#### Steady-State Equilibrium

Equilibrium allocations must satisfy the feasibility constraint:

$$\sum_{i=1}^{N} \mu^i c_t^i = Y_t - I_t. \tag{B.30}$$

Here we consider a steady-state equilibrium in which aggregate variables are constant with $Z_{t+1} = Z_t = Z$ for all $t$. In such equilibrium, the right-hand side of equation (B.30) is constant and equal to $F(K, ZN) - \delta K$, where $K$ and $N$ are the steady-state capital stock and efficiency-weighted hours, respectively. From equations (B.27) and (B.30), it then follows that individual consumption is constant over time as well as across states of the world, that is $c_t^i = c^i$ for all $t$. Hence, households achieve "full insurance."

Using the full insurance result, we can conveniently rewrite the intertemporal budget constraint as

$$c^i\left(1 + \sum_{\tau=t+1}^{\infty}\sum_{s=1}^{2} q_\tau^s\right) = a_t^i + w_t h_t^i + \sum_{\tau=t+1}^{\infty}\sum_{s=1}^{2} q_\tau^s w_\tau z_{\tau s}^i h_{\tau s}^i. \tag{B.31}$$

Note also that since consumption and thereby the marginal utility of consumption is the same over time and across states, the pricing equation (B.26) reduces to

$$q_\tau^s = \pi_s \beta^{\tau - t}. \tag{B.32}$$

Finally, substituting (B.32) into (B.31), and rearranging terms, yields

$$c^i = (1-\beta)a^i + wh^i. \tag{B.33}$$

Using the expression for individual consumption (B.33), after some manipulations, we obtain the reservation wage,

$$w_R^i = (e^B - 1)\left[(1-\beta)a^i + \bar{c}\right], \tag{B.34}$$

that is identical to that obtained from the model with wealth heterogeneity but without idiosyncratic shocks, see equation (B.19) in Appendix B.2.

## B.4 Proofs

### Proof of Proposition 1

In the case of separable preferences, $u_{21}(c,q) = u_{12}(c,q) = 0$. From equation (4) it follows that $dq/dc = 0$ if and only if

$$\frac{1}{c} + \frac{u_{11}(c)}{u_1(c)} = 0, \tag{B.35}$$

where we make explicit that in the separable case $u_{11}$ and $u_1$ depend on consumption, $c$, not quality. Taking the integral of the left- and right-hand side of equation (B.35) yields

$$\int \frac{1}{c} dc + \int \frac{u_{11}(c)}{u_1(c)} dc = 0. \tag{B.36}$$

Using standard integral calculus, equation (B.36) becomes

$$\log c + \log u_1(c) + K = 0, \tag{B.37}$$

where $K$ is an arbitrary constant of integration. Exponentiating both sides of equation (B.37), and rearranging terms, yields

$$e^K u_1(c) = \frac{1}{c}. \tag{B.38}$$

Finally, taking the integral of both sides of equation (B.38),

$$\int u_1(c)dc = \frac{1}{e^K} \int \frac{1}{c} dc. \tag{B.39}$$

Using again standard integral calculus yields

$$u(c) = \alpha \log(c), \tag{B.40}$$

where $\alpha \equiv 1/e^K$ and the additional integration constant is set to zero without loss of generality. **QED**

**Proof of Proposition 2**

In the case of nonseparable preferences, $u_{21}(c,q) = u_{12}(c,q) \neq 0$. From equation (4) it follows that $dq/dc = 0$ if and only if

$$\frac{1}{c} - \frac{u_{21}(c,q)}{u_2(c,q)} + \frac{u_{11}(c,q)}{u_1(c,q)} = 0. \tag{B.41}$$

Taking the integral of the left- and right-hand side of equation (B.41) yields

$$\int \frac{1}{c} dc - \int \frac{u_{21}(c,q)}{u_2(c,q)} dc + \int \frac{u_{11}(c,q)}{u_1(c,q)} dc = 0. \tag{B.42}$$

Using standard integral calculus, equation (B.42) becomes

$$\log c - \log u_2(c,q) + \log u_1(c,q) + K = 0, \tag{B.43}$$

where $K$ is an arbitrary constant of integration. Exponentiation of both sides of equation (B.43), and rearranging terms, yields

$$\frac{u_2(c,q)}{u_1(c,q)} = \frac{c}{e^K} \propto c, \tag{B.44}$$

where the left-hand side of equation (B.44) is the marginal rate of substitution (MRS) between the quantity and the quality of consumption. **QED**

## B.5 Growth Model with Quality Choice and Wealth Heterogeneity

Here we develop a growth model with quality choice and wealth heterogeneity across households. There is no idiosyncratic or aggregate risk. Markets are complete in that households can freely transfer resources over time.

Time is discrete and continues forever, indexed by $t$. There are $N$ types of infinitely-lived households indexed by $i = 1, 2, \ldots, N$. The number (mass) of each type is $\mu^i$, such that $\sum_{i=1}^N \mu^i = 1$. Households differ solely in terms of their initial endowments of capital, $k_0^i = s_0^i K_0$, or, equivalently, in terms of their share $s_0^i$ of the aggregate capital stock $K_0 = \sum_{i=1}^N \mu^i k_0^i$.

#### Preferences, Budget Constraint, and Household Problem

Household's preferences are described by

$$\sum_{t=0}^{\infty} \beta^t \left[ \frac{\left(q_t^i\right)^{1-\theta}}{1-\theta} \log\left(\frac{c_t^i}{Z_t}\right) - B h_t^i \right], \tag{B.45}$$

where $0 < \beta < 1$ is the time discount factor, $q_t^i$ and $c_t^i$ are the quality and quantity of consumption, respectively, and $h_t^i \in \{0, 1\}$ is indivisible labor supply of household $i$ at time $t$.

A household chooses sequences of quality and quantity of consumption and labor supply to maximize lifetime utility (B.45) subject to the budget constraint,

$$p(q_t^i) c_t^i + I_t^i \leq w_t h_t^i + R_t k_t^i, \tag{B.46}$$

where $I_t^i = k_{t+1}^i - (1-\delta) k_t^i$ is investment and $k_t^i$ is the capital stock owned by household $i$ at time $t$.

Let $\lambda_t^i$ denote the Lagrange multiplier on the household $i$'s budget constraint (B.46). FOCs of the household problem at time $t$ with respect to consumption, quality, and next period capital are, respectively:

$$\beta^t \frac{(q_t^i)^{1-\theta}}{1-\theta}\left(\frac{1}{c_t^i}\right) = \lambda_t^i p(q_t^i), \tag{B.47}$$

$$\beta^t (q_t^i)^{-\theta} \log(c_t^i / Z_t) = \lambda_t^i p'(q_t^i) c_t^i, \tag{B.48}$$

$$\lambda_t^i = \lambda_{t+1}^i \left(R_{t+1} + 1 - \delta\right). \tag{B.49}$$

Combining equations (B.47) and (B.48), and substituting the expressions for $\lambda_t^i$ and $\lambda_{t+1}^i$ from (B.47) into (B.49), we obtain an intratemporal condition describing the quantity-quality tradeoff of consumption and Euler equation:

$$\frac{p'(q_t^i) q_t^i}{p(q_t^i)} = (1-\theta) \log\left(\frac{c_t^i}{Z_t}\right), \tag{B.50}$$

$$\frac{c_{t+1}^i}{c_t^i}\left(\frac{q_t^i}{q_{t+1}^i}\right)^{1-\theta} = \beta \frac{p(q_t^i)}{p(q_{t+1}^i)} \left(R_{t+1} + 1 - \delta\right). \tag{B.51}$$

**Technology and Firm Problem**

Production of consumption goods takes place in perfectly competitive markets. Also, we assume that capital and labor can freely move across sectors, such that wages and capital rental rates are equalized across sectors. We assume a multi-sector production structure in which each sector produces consumption goods $Y_{q,t}$ of quality $q$ with a Cobb-Douglas production function:

$$Y_{q,t} = K_{q,t}^{\alpha}\left(\frac{Z_t N_{q,t}}{q_t}\right)^{1-\alpha}, \tag{B.52}$$

where $Z_t$ is labor-augmenting technical change, that is common across sectors, and $K_{q,t}$ and $N_{q,t}$ are capital stock and labor input in sector $q$, respectively.

The representative firm maximizes profits taking the wage, capital rental rate, and output price as given:

$$\max_{K_{q,t}, N_{q,t}} \Pi_{q,t} \equiv p(q_t) Y_{q,t} - R_t K_{q,t} - w_t N_{q,t}, \tag{B.53}$$

subject to the production technology (B.52). FOCs with respect to capital $K_{q,t}$ and labor services $N_{q,t}$ are

$$\frac{R_t}{p(q_t)} = \alpha \left(\frac{N_{q,t}Z_t}{K_{q,t}q_t}\right)^{1-\alpha}, \tag{B.54}$$

$$\frac{w_t}{p(q_t)} = (1-\alpha)\left(\frac{K_{q,t}q_t}{N_{q,t}Z_t}\right)^{\alpha}\frac{Z_t}{q_t}. \tag{B.55}$$

Using (B.54) and (B.55), we obtain the expression for the capital-labor ratio:

$$\frac{K_{q,t}}{N_{q,t}} = \left(\frac{\alpha}{1-\alpha}\right)\frac{w_t}{R_t}. \tag{B.56}$$

Next, using (B.55) and (B.56), we obtain an expression relating unit prices to quality:

$$p(q_t) = \left(\frac{1}{1-\alpha}\right)^{1-\alpha}\left(\frac{1}{\alpha}\right)^{\alpha}\left(\frac{w_t}{Z_t}\right)^{1-\alpha} R_t^{\alpha} q_t^{1-\alpha} = G_t q_t^{1-\alpha}, \tag{B.57}$$

where $G_t \equiv \left(\frac{1}{1-\alpha}\right)^{1-\alpha}\left(\frac{1}{\alpha}\right)^{\alpha}\left(\frac{w_t}{Z_t}\right)^{1-\alpha} R_t^{\alpha}$.

**Steady-State Equilibrium**

Equation (B.57) implies a constant unit price elasticity to quality, i.e., $p'(q_t)q_t/p(q_t) = 1-\alpha$ for all quality levels demanded by households. Using this result, the household's intratemporal condition (B.50) reduces to

$$\frac{1-\alpha}{1-\theta} = \log\left(\frac{c_t^i}{Z_t}\right). \tag{B.58}$$

Given (B.58), the quantity of consumption and unit prices are, respectively:

$$c_t^i = Z_t e^{\frac{1-\alpha}{1-\theta}}, \tag{B.59}$$

$$p(q_t^i) = \frac{1}{Z_t e^{\frac{1-\alpha}{1-\theta}}}\left(w_t h_t^i + R_t k_t^i - I_t^i\right). \tag{B.60}$$

We consider a balanced growth path (BGP) equilibrium in which technology grows at a constant rate, i.e., $Z_{t+1} = (1+g_Z)Z_t$ for all $t \geq 0$. Along such BGP, from equation (B.59), the quantity of consumption grows at the same rate of technology, $g_Z$, so that equation (B.51) becomes

$$(1+g_Z)\left(\frac{q_t^i}{q_{t+1}^i}\right)^{1-\theta} = \beta\frac{p(q_t^i)}{p(q_{t+1}^i)}\left(R_{t+1}+1-\delta\right). \tag{B.61}$$

Given the specification of the utility function in (B.45), and the assumption of factor-augmenting technical change in (B.52), there exists a BGP in which real wages, aggregate consumption, expenditures, output, and capital stock grow at the same rate of technology, $g_Z$, whereas quality, unit prices, and aggregate hours are constant.

To establish this result, we proceed in steps.

1. Along such BGP, from equation (B.61), the capital rental rate is constant and equal to $R_t = R = (1+g_Z)/\beta - 1 + \delta$ for all $t \geq 0$.
2. From equation (B.54), the ratio $\frac{N_{q,t}Z_t}{K_{q,t}q_t}$ is constant, such that from equation (B.55) it follows that the ratio $w_t/Z_t$ is constant, too.
3. Given a constant rental rate $R$, and a constant ratio $\tilde{w} \equiv w/Z$, equation (B.57) gives that the unit price $p(q_t)$ is constant insofar as quality $q_t$ is constant.
4. What is left to show is that equation (B.60) is consistent with such BGP and then that aggregate hours are constant.

   To this goal, we rewrite equation (B.60) as

$$p(q_t^i) = \frac{1}{e^{\frac{1-\alpha}{1-\theta}}}\left[\frac{w_t}{Z_t}h_t^i + \left(R_t+1-\delta\right)s_t^i\frac{K_t}{Z_t} - s_{t+1}^i(1+g_Z)\frac{K_{t+1}}{Z_{t+1}}\right]. \tag{B.62}$$

   Along the BGP in which wages and capital grow at the same rate $g_Z$, and assuming that households' shares of aggregate capital are constant along the BGP, i.e., $s_{t+1}^i = s_t^i = s^i$ for all $t \geq 0$, equation (B.62) simplifies to

$$p(q^i) = \frac{1}{e^{\frac{1-\alpha}{1-\theta}}}\left[\tilde{w}h^i + \left(R-\delta-g_Z\right)s^i\tilde{K}\right], \tag{B.63}$$

   where the ratios $\tilde{w} \equiv w/Z$ and $\tilde{K} \equiv K/Z$ are constant. Equation (B.63) gives that unit prices are constant along the BGP insofar as household-level hours $h^i$ and shares $s^i$ of aggregate capital remain constant along the postulated BGP.

Next, given the expression for unit prices (B.63), and using (B.57), we obtain that quality is constant along the BGP:

$$q^i = \left[\frac{p(q^i)}{G}\right]^{\frac{1}{1-\alpha}} = \left[\frac{\tilde{w}h^i + (R-\delta-g_Z)\, s^i\tilde{K}}{e^{\frac{1-\alpha}{1-\theta}}G}\right]^{\frac{1}{1-\alpha}}, \tag{B.64}$$

where $G \equiv \left(\frac{1}{1-\alpha}\right)^{1-\alpha}\left(\frac{1}{\alpha}\right)^{\alpha}\tilde{w}^{1-\alpha}R^{\alpha}$.

5. The indifference condition between working and not-working (after some algebra) gives that the reservation wage $w_R^i$ grows at rate $g_Z$ for all households:

$$\tilde{w}_R^i = \left[\left([r-g_Z]\, s^i\tilde{K}\right)^{\frac{1-\theta}{1-\alpha}} + \frac{(1-\theta)^2}{1-\alpha}eBG\right]^{\frac{1-\alpha}{1-\theta}} - (r-g_Z)s^i\tilde{K}, \tag{B.65}$$

where $\tilde{w}_R^i \equiv w_R^i/Z$ is constant along the BGP and $r \equiv R-\delta$. Equation (B.65) implicitly determines a cutoff $\bar{s}$, so that if $s^i < \bar{s}$ households $i$ is employed, otherwise if $s^i \geq \bar{s}$ household $i$ is nonemployed:

$$\tilde{w} = \left[\left([r-g_Z]\, \bar{s}\tilde{K}\right)^{\frac{1-\theta}{1-\alpha}} + \frac{(1-\theta)^2}{1-\alpha}eBG\right]^{\frac{1-\alpha}{1-\theta}} - (r-g_Z)\bar{s}\tilde{K}. \tag{B.66}$$

Importantly, since $\bar{s}$ is constant along the BGP, aggregate hours worked are constant, too.

6. Are households' shares of aggregate capital constant along the BGP? Let us rewrite the budget constraint (B.46) as

$$E_t^i = w_t h_t^i + (R_t + 1 - \delta)\, s_t^i K_t - s_{t+1}^i K_{t+1}, \tag{B.67}$$

where $E_t^i \equiv p(q_t^i)c_t^i$ denotes household's consumption expenditures. Next, using the fact that along the BGP $K_{t+1} = (1+g_Z)K_t$, and rearranging terms, we can rewrite equation (B.67) as

$$s_{t+1}^i(1+g_Z)K_t = w_t h_t^i + (R_t + 1 - \delta)\, s_t^i K_t - E_t^i. \tag{B.68}$$

Finally, dividing left- and right-hand side of equation (B.68) by $Z_t$, and rearranging terms, we obtain

$$s^i_{t+1} = \frac{\tilde{w}h^i - \tilde{E}^i}{(1+g_Z)\tilde{K}} + \frac{(R+1-\delta)}{1+g_Z} s^i_t, \tag{B.69}$$

where the ratios $\tilde{w} \equiv w/Z$ and $\tilde{K} \equiv K/Z$, and the rental rate $R$, are constant along the BGP. Since along the BGP $R - \delta - g_Z > 1$, the term multiplying $s^i_t$ on the right-hand side is larger than one, implying that equation (B.69) is an unstable difference equation with solution $s^i_{t+1} = s^i_t = s^i$, for all $t \geq 0$. Thus, household $i$'s share of the aggregate capital stock is

$$s^i = \frac{\tilde{w}h^i - \tilde{E}^i}{(R-\delta-g_Z)\tilde{K}}. \tag{B.70}$$

# C Solution Method and Basic Properties of the Model

This appendix contains: (i) a description of the solution method used to compute the equilibrium of the heterogeneous-agent, incomplete-markets model with quality choice (Appendix C.1); (ii) a plot of the value function and decision rules (Appendix C.2); (iii) grid and transition probabilities for the discretized process of idiosyncratic productivity shocks (Appendix C.3).

## C.1 Model Solution

**Algorithm**

1. Initialize a grid for assets $a$ and idiosyncratic shocks $z$. And make an initial guess for the triplet $(r, w, \tau)$.

2. Solve household value functions given $(r, w, \tau)$:

   (a) To save on notation, let $exp$ denote expenditures $p(q)c$. Given the guess for $(r, w, \tau)$ and using the intra-temporal optimality condition pre-solve for $c$ and $q$ given household's total consumption expenditure. More specifically, we create a grid for $p(q)c$ and solve for $q(exp)$ by setting $exp = p(q) \exp\left[\frac{\partial p/\partial q}{p(q)}\left(\frac{q}{1-\theta}\right)\right]$. This also gives us $c(exp)$.

   (b) Given the guess for $(r, w, \tau)$ and the results in (a), solve household's value function on the grid for $a$ and $z$ to get the policy functions for $a'(a,z)$, $q(a,z)$, $c(a,z)$, $h(a,z)$.

3. Given household policy functions in step 2.b and exogenous process for $z$, find the invariant wealth distribution $\lambda(a,z)$.

4. Given household policy functions in step 2.b and the wealth distribution calculate the demand for every level of quality $\int c_q(a,z)d\lambda(a,z)$.

5. Given $\int c_q(a,z)d\lambda(a,z)$ and optimal capital labor ratio in the production of each level of quality, get the total demand for capital and labor in the consumption good sector: $K_C = \int_q \int K_q(a,z)d\lambda(a,z)dq$ and $N_C = \int_q \int N_q(a,z)d\lambda(a,z)dq$. This step imposes that markets for every quality clear as long as the aggregate goods and labor market clearing conditions hold.

6. Given demand for capital in the consumption sector, we can calculate demand for labor and capital in the investment sector $(K_I, N_I)$ using equilibrium conditions in that sector.

7. Market clearing: check that capital and labor markets clear and government budget constraint holds. If not, update $(r, w, \tau)$ and go back to step 1:

   (a) Given $\lambda(a, z)$ and $zh(a, z)$ evaluate the government budget constraint and if needed update the tax rate, $\tau$.

   (b) Given $K$ and $\int a'(a, z) d\lambda(a, z)$ evaluate the capital market clearing condition and if needed update the real interest rate, $r$.

   (c) Given $N$ and $\int zh(a, z) d\lambda(a, z)$ evaluate the labor market clearing and if needed update the wage per efficiency units, $w$.

**Implementation Details**

- In the numerical implementation we use 450 points for the $a$ grid putting more points close to the no borrowing constraint. We discretize the $z$ process using the Rouwenhorst's method and use 12 grid points with extreme values of 3 standard deviations away from the mean. Since we also add an extra productivity state, the final grid for $z$ has 13 values.

- In step 2.a we use 2,000 point for the $exp$ grid with more points clustered towards the low values. We use golden-section search to find $q(exp)$. In step 2.b when we first solve for $exp$, we use piece-wise linear spline interpolation of $q(exp)$ to get the policy functions for $q(a, z)$ and $c(a, z)$.

- In step 2.b we solve for a fixed point by using a combination of value function and policy function iteration. In the maximization step we use golden-section search to find $q(a, z)$ and $c(a, z)$. In doing this we approximate $V^E(a, z)$ and $V^U(a, z)$ using a piece-wise linear spline in the direction of $a$.

## C.2 Basic Properties of the Model Solution

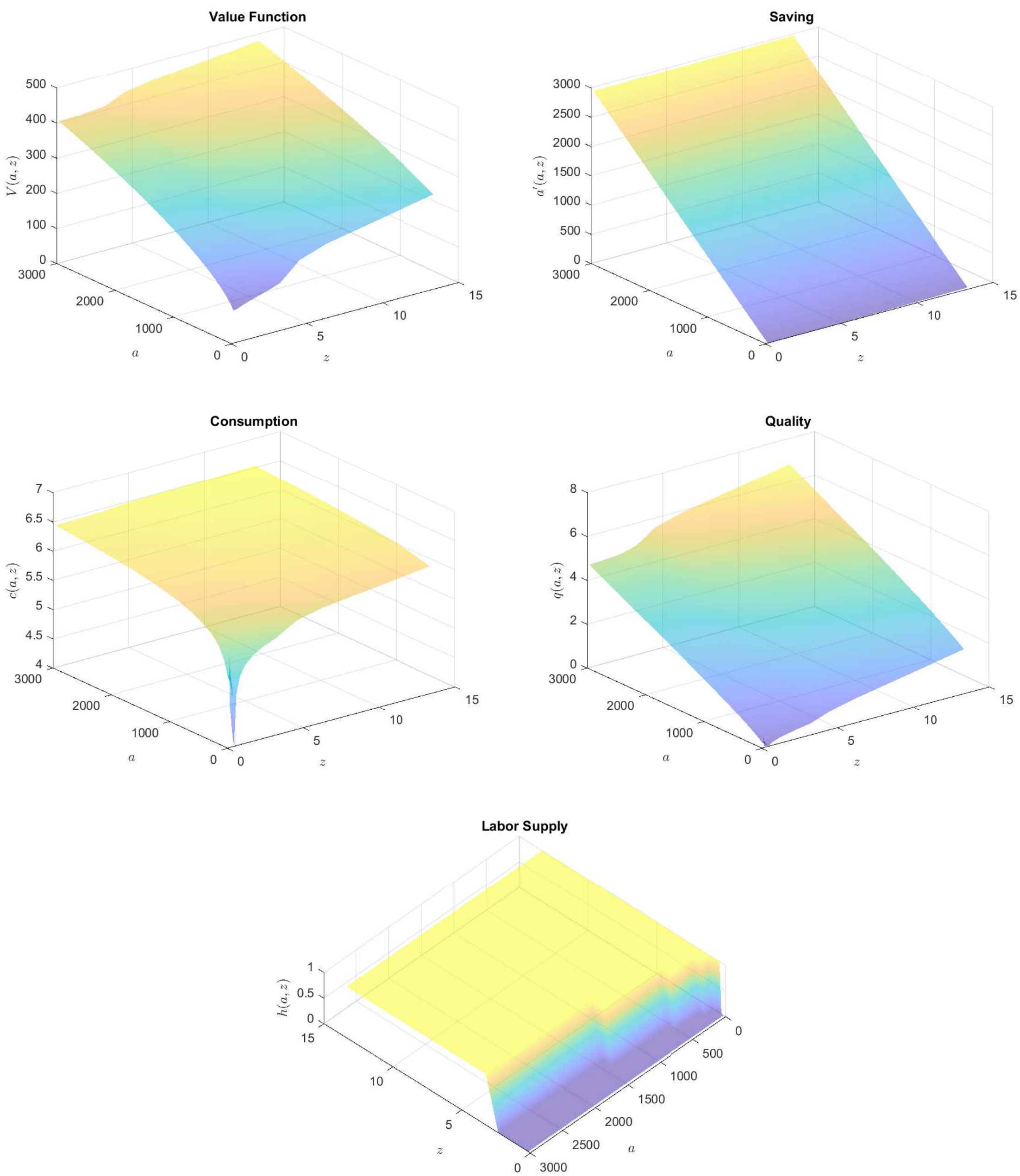


Figure C.1: Value Function and Decision Rules

*Notes*: The figure shows the value function (top left panel), and decision rules for asset holdings (top right panel), quantity of consumption (mid-left panel), quality of consumption (mid-right panel), and labor supply (bottom panel).

## C.3 Markov Process for Idiosyncratic Productivity Shocks

The grid for idiosyncratic productivity shocks is

$$z = \begin{bmatrix} 0.1588 & 0.2219 & 0.3101 & 0.4333 & 0.6054 & 0.8460 & 1.1821 & 1.6518 & 2.3081 & 3.2252 & 4.5067 & 6.2974 & 13.3413 \end{bmatrix}.$$

The transition probability matrix for idiosyncratic productivity shocks is

$$\Pi_z = \begin{bmatrix}
0.6719 & 0.2720 & 0.0501 & 0.0055 & 0.0004 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0 \\
0.0247 & 0.6810 & 0.2488 & 0.0411 & 0.0040 & 0.0003 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0 \\
0.0009 & 0.0498 & 0.6884 & 0.2250 & 0.0330 & 0.0028 & 0.0002 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0 \\
0.0000 & 0.0027 & 0.0750 & 0.6939 & 0.2007 & 0.0257 & 0.0019 & 0.0001 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0 \\
0.0000 & 0.0001 & 0.0055 & 0.1003 & 0.6976 & 0.1759 & 0.0193 & 0.0012 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0 \\
0.0000 & 0.0000 & 0.0003 & 0.0092 & 0.1257 & 0.6994 & 0.1509 & 0.0138 & 0.0007 & 0.0000 & 0.0000 & 0.0000 & 0 \\
0.0000 & 0.0000 & 0.0000 & 0.0007 & 0.0138 & 0.1509 & 0.6994 & 0.1257 & 0.0092 & 0.0003 & 0.0000 & 0.0000 & 0 \\
0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0012 & 0.0193 & 0.1759 & 0.6976 & 0.1003 & 0.0055 & 0.0001 & 0.0000 & 0 \\
0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0001 & 0.0019 & 0.0257 & 0.2007 & 0.6939 & 0.0750 & 0.0027 & 0.0000 & 0 \\
0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0002 & 0.0028 & 0.0330 & 0.2250 & 0.6884 & 0.0498 & 0.0009 & 0 \\
0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0002 & 0.0035 & 0.0356 & 0.2154 & 0.5896 & 0.0214 & 0.1343 \\
0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0004 & 0.0048 & 0.0433 & 0.2355 & 0.5817 & 0.1343 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.0313 & 0.0313 & 0.9375
\end{bmatrix}.$$

# D Additional Results

This appendix contains results from additional experiments run in the heterogeneous-agent, incomplete-markets model with and without a quality choice.

**Role of quality choice** To highlight the role of quality, here, we consider a standard heterogeneous-agent incomplete-markets model with endogenous labor supply, without a quality choice. We keep the baseline values for the externally calibrated parameters, and re-calibrate the other parameters to match the same empirical targets in the baseline calibration. In Table D.1, the column labeled "No Quality" reports the new values for the re-calibrated parameters.

Table D.1: Alternative Parametrizations

| Parameter | Baseline | No Quality | Cobb-Douglas | Target |
|---|---|---|---|---|
| $B$ | 0.86 | 0.8926 | 0.9312 | Emp. rate (80.23%) |
| $\bar{c}$ | 2.0164 | 1.0486 | 0.8995 | Emp. rate, lowest wealth quintile (71.32%) |
| $z^{\max}$ | 13.342 | 6.2974 | 14.312 | Wealth share, top decile (65.53%) |
| $\pi^{\text{up}}$ | 0.1343 | 0.0492 | 0.2030 | Earnings share, top decile (35.87%) |
| $\pi^{\text{stay}}$ | 0.9374 | 0.9897 | 0.8931 | Earnings share, top 1% (11.76%) |

*Notes*: See Section 5 for further details on the baseline parametrization of the model.

Figure D.1 shows employment rates by wealth deciles in the calibrated model without a quality choice and in the data. As it is evident, the standard model, without a quality choice, largely fails in reproducing the near-zero correlation between employment rates and wealth in the data. The model predicts an employment rate of one for households in the third wealth decile, as opposed to about a 0.75 employment rate in the data. After the third decile, employment rates fall sharply with wealth, due to the negative wealth effect on labor supply. For the first two wealth deciles, the model predicts employment rates of about 0.7. In the absence of government transfers, these employment rates would be equal to one. Households with zero or near-zero wealth, have no source of income other than labor income, so that they must work to afford positive consumption.

**Role of capital-labor substitutability** To study the role of the capital-labor elasticity of substitution, here, we consider a variant of the model with a quality choice and Cobb-

Douglas technologies. We keep the same values of the externally calibrated parameters, and re-calibrate the remaining parameters to match the same empirical targets as in the baseline calibration. In Table D.1, the column labeled "Cobb-Douglas" reports the new values for the re-calibrated parameters.

Figure D.2 shows employment rates by wealth deciles in the model with Cobb-Douglas production functions and in the data. In a nutshell, the fit of the Cobb-Douglas model is noticeably worse than the benchmark model with CES production functions. Specifically, the Cobb-Douglas model significantly overshoots in terms of the employment rates of households in the eighth and ninth wealth decile. Also, it largely misses the employment rates of households in the first and second wealth decile. Notably, the model predicts an employment rate of nearly 0.9 for the second decile, as opposed to an employment rate that is slightly above 0.6 in the data. Conversely, the model under-predicts the average employment rate for the first wealth decile. In the data, it is above 0.75, whereas in the model is about 0.5.

**Role of quality curvature** Here, we examine the role of the utility function curvature with respect to quality. Given the utility function, $u(c,q) = q^{1-\theta}/(1-\theta)\log(c)$, quality curvature is governed by the parameter $0 < \theta < 1$, which also controls how fast the marginal utility of consumption increases with quality: $u_2(c,q) = q^{-\theta}\log(c)$, $u_{22}(c,q) = -\theta q^{-\theta-1}\log(c)$, and $u_{12}(c,q) = q^{-\theta}/c$. For $\theta = 0$, the utility function is linear in quality: $u_2(c,q) = \log(c)$, $u_{22}(c,q) = 0$, and $u_{12}(c,q) = 1/c$. For $\theta = 1$, the utility function limits to $\log(c)\log(q)$, such that $u_2(c,q) = \log(c)/q$, $u_{22}(c,q) = -\log(c)/q^2$, and $u_{12}(c,q) = 1/qc$.

In the baseline calibration, $\theta = 0.5$. As $\theta$ describes individual preferences for quality, there is little or no direct information, data, or measurement, we can readily use to pin down a specific value for the parameter. Figure D.3 shows the distribution of employment rates by wealth implied by the model for four different values of $\theta = (0.1, 0.3, 0.7, 0.9)$: (i) $\theta = 0.1$ (top left panel); (ii) $\theta = 0.3$ (top right panel); (iii) $\theta = 0.7$ (bottom left panel); (iv) $\theta = 0.9$ (bottom right panel). We do no recalibrate the model. When we vary $\theta$, all the other parameters are as in the baseline calibration.

For $\theta = 0.1$, and for $\theta = 0.3$, the model generates employment rates that are too low compared to the data, and increasing in wealth. Under these two parametrizations, then, the implied distributions of employment rates by wealth are way off the observed, empirical distribution in the data. For $\theta = 0.7$, and $\theta = 0.9$, employment rates are, instead, too high compared to the data, and decreasing in wealth. These parametrizations, too, yield unrealistic distributions of employment rates relative to the data.

To sum, in the model, the equilibrium distribution of employment rates by wealth critically depends on the value of the utility parameter governing curvature in quality. Given the values of the other model parameters, the shape of the empirical distribution of employment rates contains useful information that allows us to rule out empirically implausible values for $\theta$.

**Engel curves with Cobb-Douglas production** Figure D.4 shows quantity and quality Engel curves generated by the model with Cobb-Douglas production functions. Again, we keep the value of the externally calibrated parameters unchanged, and re-calibrate the other parameters to match the same empirical targets in the baseline calibration. In Table D.1, the column labeled "Cobb-Douglas" reports the new parameter values.

In the Cobb-Douglas case, the quantity of consumption is evenly distributed across the wealth distribution. In contrast, expenditures vary a great deal by wealth deciles, implying that virtually all inequality in consumption expenditure comes from quality choices, and so from the unit prices paid by households with different wealth.

**Reservation wages and aggregate labor supply elasticity** In our model, the aggregate labor supply depends on the distribution of reservation wages. Figure D.5 shows the cumulative distribution function of reservation wages as implied by the calibrated model with and without quality. Based on Chang and Kim (2006), we use the distribution of reservation wages to calculate an approximate "aggregate labor supply elasticity." In the model without quality, such elasticity is 1.32. In the baseline model with quality, it is 0.91.

**More on labor taxation** Table D.2 and Figures D.6 through D.11 show additional results related to the labor tax experiment.

Table D.2: Large-Scale Transfer Program (20% of GDP)

| | GDP | $E$ | $K$ | $C$ | $EXP$ | $R$ | $w$ |
|---|---|---|---|---|---|---|---|
| Panel A. Model with quality | | | | | | | |
| before | 6.27 | 0.80 | 34.17 | 5.30 | 5.42 | 0.0262 | 4.27 |
| after | 7.85 | 0.68 | 80.60 | 5.79 | 5.84 | 0.0103 | 6.04 |
| Panel B. Model without quality | | | | | | | |
| before | 2.64 | 0.80 | 16.41 | 2.23 | 2.23 | 0.0214 | 1.88 |
| after | 2.85 | 0.74 | 29.40 | 2.12 | 2.12 | 0.0094 | 2.42 |

*Notes*: The experiment consists of using labor taxes to finance a transfer program equivalent to 20% of GDP, in addition to the preexisting means-tested transfers. The new transfers are not means-tested, rather they are distributed across households as proportional to their wealth. In the model with quality (panel A), this implies that the labor tax rate that clears the government budget goes from 0.36% to 22.44%. In the model without quality (panel B), the labor tax rate that clears the government budget goes from 0.93% to 22.40%.

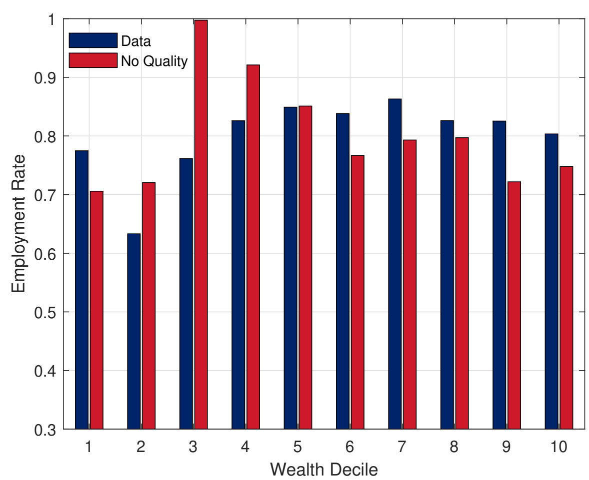


Figure D.1: Employment by Wealth – Standard Model without Quality

*Notes*: The figure shows the distribution of employment rates by wealth deciles in the standard model without a quality choice and in the data. Data are from the PSID based on the biannual 2001-2015 waves for household heads of 25-65 years old. Wealth is total assets minus total liabilities at the household level. See Appendix A for details on data sources and variables' construction.

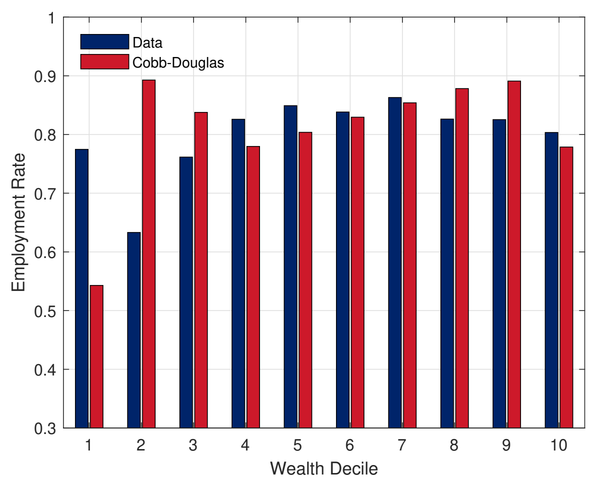


Figure D.2: Employment by Wealth – Cobb-Douglas Production

*Notes*: The figure shows the distribution of employment rates by wealth deciles in the model with a quality choice and Cobb-Douglas production functions and in the data. Data are from the PSID based on the biannual 2001-2015 waves for household heads of 25-65 years old. Wealth is total assets minus total liabilities at the household level. See Appendix A for details on data sources and variables' construction.

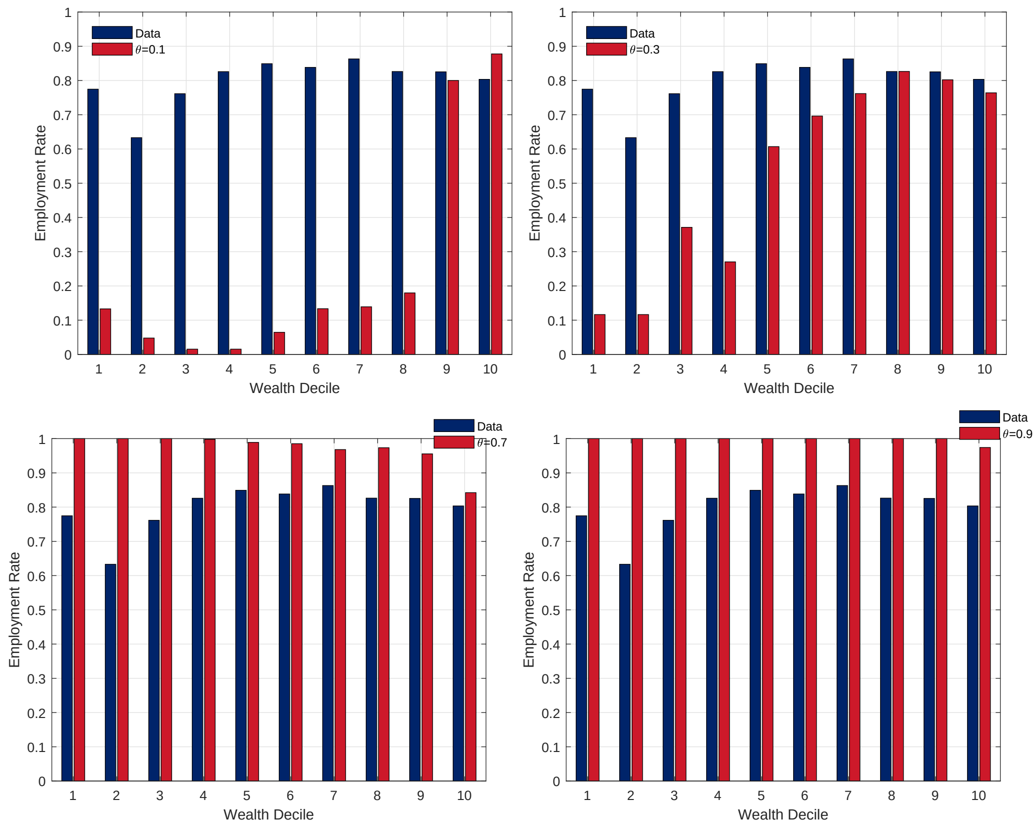


Figure D.3: Employment by Wealth – Role of Quality Curvature

*Notes*: The figure shows the distribution of employment rates by wealth deciles in the model with $\theta = 0.1$ (top left panel), $\theta = 0.3$ (top right panel), $\theta = 0.7$ (bottom left panel), and $\theta = 0.9$ (bottom right panel) and in the data. Data are from the PSID based on the biannual 2001-2015 waves for household heads of 25-65 years old. Wealth is total assets minus total liabilities at the household level. See Appendix A for details on data sources and variables' construction.

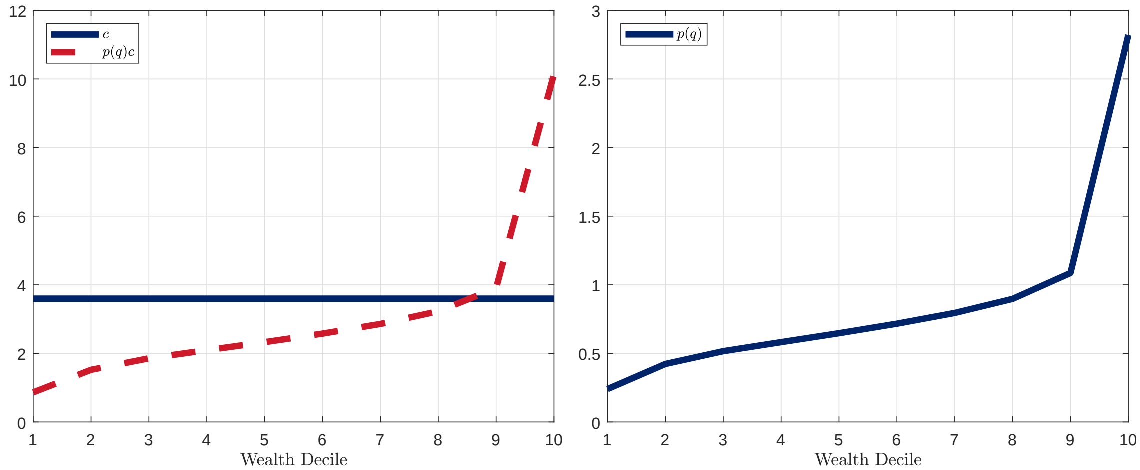


Figure D.4: Quantity and Quality Engel Curves – Cobb-Douglas Production

*Notes*: The figure shows consumption and expenditures (left panel) and prices (right panel) by wealth deciles in a calibrated version of the model with quality and Cobb-Douglas production functions. See Table D.1 for details on the alternative parametrization of the model.

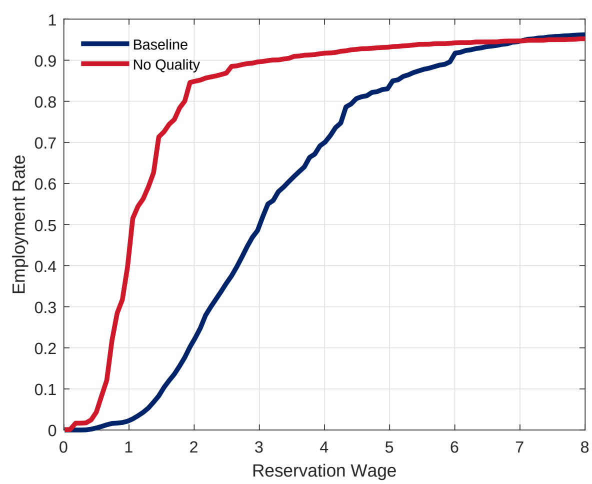


Figure D.5: Reservation Wages

*Notes*: The figure shows the cumulative distribution function of reservation wages as implied by the calibrated model with and without quality.

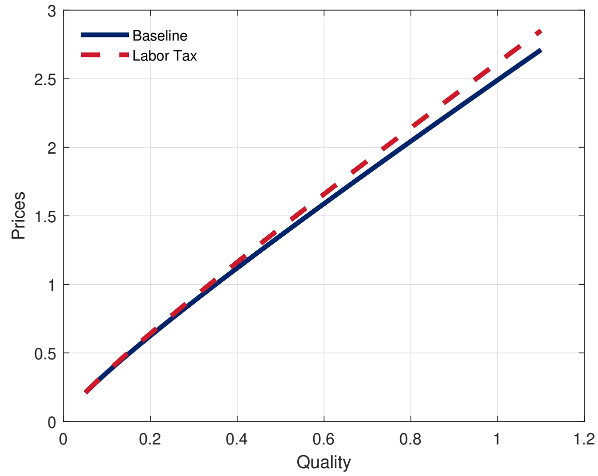


Figure D.6: Price Function – Labor Tax Experiment

*Notes*: The figure shows the price function in the model with quality before and after the labor tax change. The experiment consists of using labor taxes to finance a transfer program equivalent to 5% of GDP, in addition to the preexisting means-tested transfers. The new transfers are not means-tested, rather they are distributed across households as proportional to their wealth. In the model with quality, this implies that the labor tax rate that clears the government budget goes from 0.36% to 5.99%. In the model without quality, the labor tax rate that clears the government budget goes from 0.93% to 6.07%.

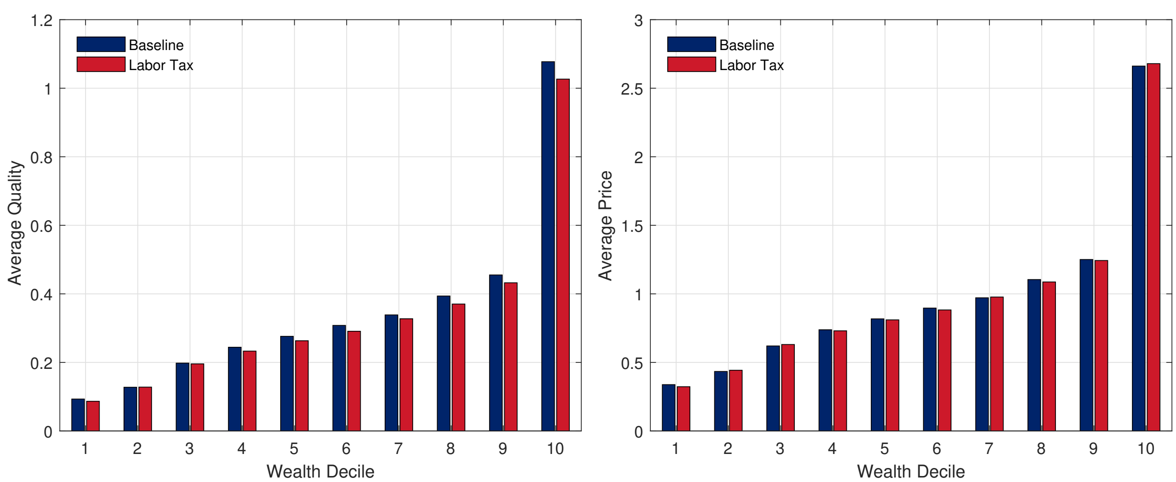


Figure D.7: Average Quality and Prices by Wealth Deciles – Labor Tax Experiment

*Notes*: The figure shows the distribution of average quality (left panel) and average prices (right panel) by wealth deciles before and after the labor tax change. The experiment consists of using labor taxes to finance a transfer program equivalent to 5% of GDP, in addition to the preexisting means-tested transfers. The new transfers are not means-tested, rather they are distributed across households as proportional to their wealth. In the model with quality, this implies that the labor tax rate that clears the government budget goes from 0.36% to 5.99%. In the model without quality, the labor tax rate that clears the government budget goes from 0.93% to 6.07%.

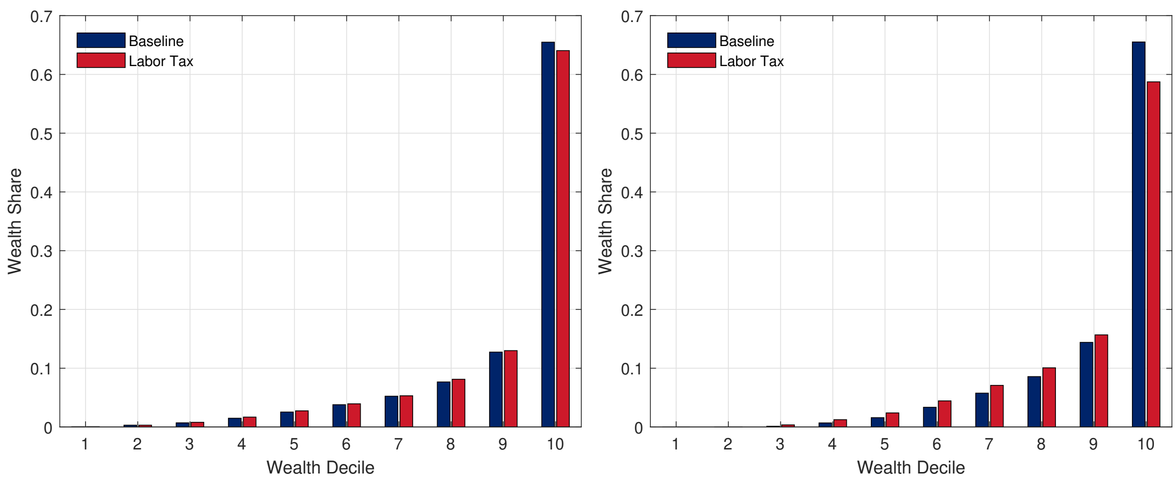


Figure D.8: Wealth Shares by Wealth Deciles – Labor Tax Experiment

(Left panel: Model with quality. Right panel: Model without quality.)

*Notes*: The figure shows the wealth distribution in the model with quality (left panel) and without quality (right panel) before and after the labor tax change. The experiment consists of using labor taxes to finance a transfer program equivalent to 5% of GDP, in addition to the preexisting means-tested transfers. The new transfers are not means-tested, rather they are distributed across households as proportional to their wealth. In the model with quality, this implies that the labor tax rate that clears the government budget goes from 0.36% to 5.99%. In the model without quality, the labor tax rate that clears the government budget goes from 0.93% to 6.07%.

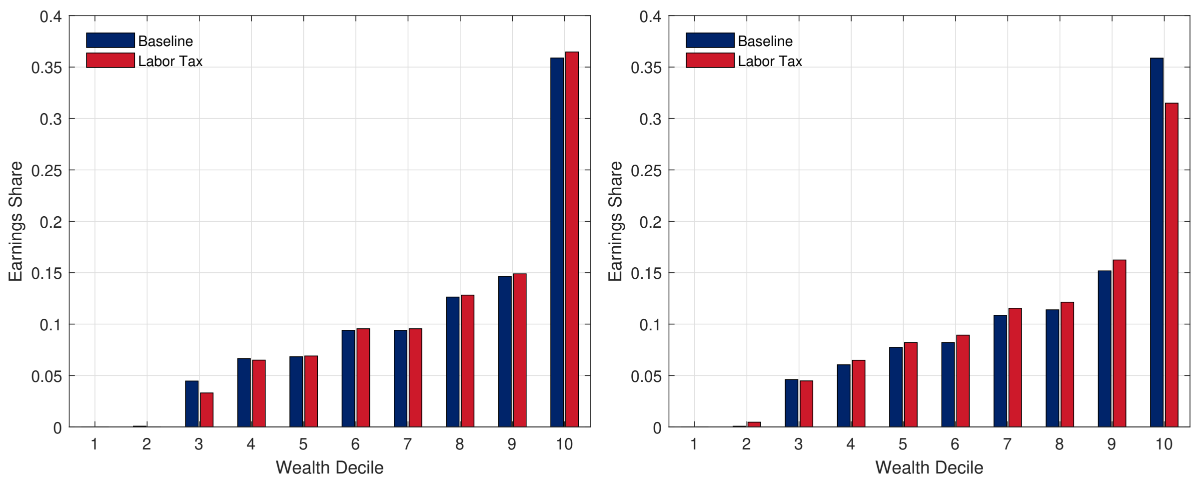


Figure D.9: Earnings Shares by Wealth Deciles – Labor Tax Experiment

(Left panel: Model with quality. Right panel: Model without quality.)

*Notes*: The figure shows the earnings distribution in the model with quality (left panel) and without quality (right panel) before and after the labor tax change. The experiment consists of using labor taxes to finance a transfer program equivalent to 5% of GDP, in addition to the preexisting means-tested transfers. The new transfers are not means-tested, rather they are distributed across households as proportional to their wealth. In the model with quality, this implies that the labor tax rate that clears the government budget goes from 0.36% to 5.99%. In the model without quality, the labor tax rate that clears the government budget goes from 0.93% to 6.07%.

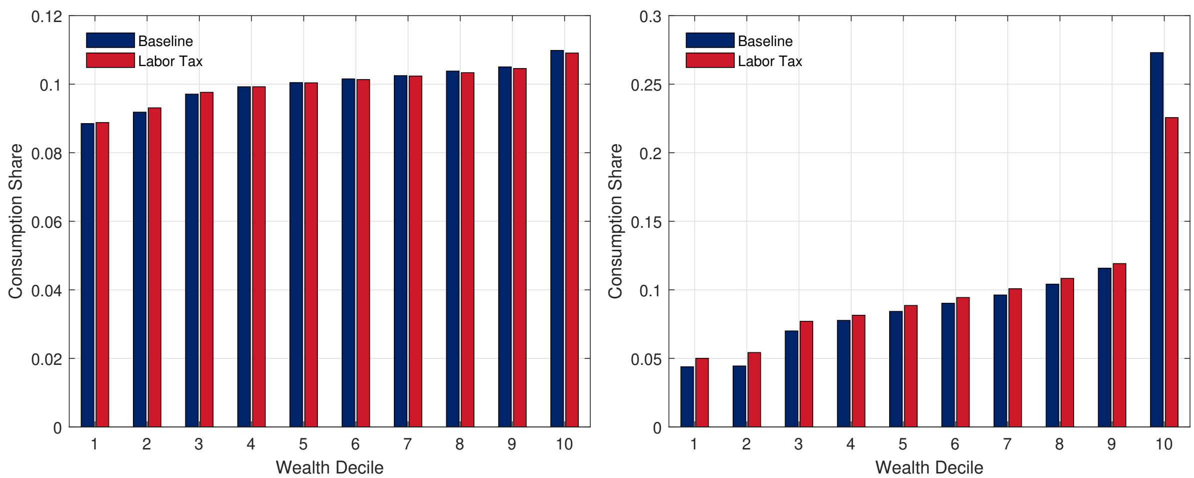


Figure D.10: Consumption Shares by Wealth Deciles – Labor Tax Experiment

(Left panel: Model with quality. Right panel: Model without quality.)

*Notes*: The figure shows the consumption distribution in the model with quality (left panel) and without quality (right panel) before and after the labor tax change. The experiment consists of using labor taxes to finance a transfer program equivalent to 5% of GDP, in addition to the preexisting means-tested transfers. The new transfers are not means-tested, rather they are distributed across households as proportional to their wealth. In the model with quality, this implies that the labor tax rate that clears the government budget goes from 0.36% to 5.99%. In the model without quality, the labor tax rate that clears the government budget goes from 0.93% to 6.07%.

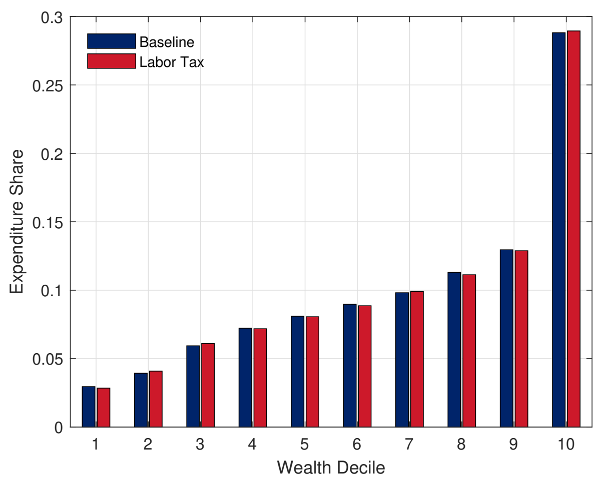


Figure D.11: Expenditure Shares by Wealth Deciles – Labor Tax Experiment

*Notes*: The figure shows the expenditure distribution in the model with quality before and after the labor tax change. The experiment consists of using labor taxes to finance a transfer program equivalent to 5% of GDP, in addition to the preexisting means-tested transfers. The new transfers are not means-tested, rather they are distributed across households as proportional to their wealth. In the model with quality, this implies that the labor tax rate that clears the government budget goes from 0.36% to 5.99%. In the model without quality, the labor tax rate that clears the government budget goes from 0.93% to 6.07%.