ONLINE APPENDIX
Taxation of Consumption and Labor Income: a Quantitative Approach

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A Almost Ideal Demand System

AIDS is a special case of the general class of PIGLOG preferences. PIGLOG preferences are characterized by an expenditure function formulation that ensures that the resulting demand functions are first-order approximations to any set of demand functions derived from utility-maximizing behavior. Specifically, the PIGLOG expenditure function - the minimum expenditure as a function of given level of utility and prices - is the following:

$$log(c(u,p)) = (1-u)log(a(p)) + (u)log(b(p)) \qquad u \in [0,1]$$

where, $a(p)$ represents cost of subsistence ($u = 0$) and $b(p)$ represents cost of bliss ($u = 1$).

When specific functional forms for $log(a(p))$ and $log(b(p))$ are assumed, AIDS expenditure function obtains:

$$log(c(u,p)) = \alpha_0 + \sum_k \alpha_k logp_k + \frac{1}{2}\sum_k \sum_j \gamma^*_{k,j} logp_k logp_j + u\beta_0 \prod_k p_k^{\beta_k} \tag{1}$$

Provided that $\sum_i \alpha_i = 0$ and $\sum_j \gamma^*_{k,j} = \sum_k \gamma^*_{k,j} = \sum_j \beta_j = 0$, equation (1) has enough parameters to be a flexible functional form.

For a utility-maximizing consumer, total expenditure x coincides with the value of the expenditure function $c(u,p)$ and this equality can be inverted so to obtain u as a function of x and p, which is precisely the AIDS indirect utility function specification used in the model:

$$v(x,p) = exp\left[\frac{log(x) - log(a(p))}{b(p)}\right]$$

B Data

B.1 SHIW dataset

The SHIW (Bank of Italy, 2016*b*) was first conducted in 1965 and then repeated annually with time-independent samples (repeated cross sections) of households up to 1987. Since 1987 the Survey was conducted every other year (except for a three year interval between 1995 and 1998) and, starting from the 1989 wave, each wave includes households interviewed in previous years (panel households) in the sample. The overall sample comprises around 8000 households in each wave since 1987 and is representative of the Italian resident households population. The unit of analysis is the household, defined as the group of persons residing in the same dwelling who are related by blood, marriage or adoption. Institutional population is not included. The numerosity of the panel component has increased gradually over time and is now roughly 57% of the overall sample.

More in detail, SHIW collects the following information: socio-economic and demographic characteristics of the household; current occupational status and past employment history of adult household members; different sources of income including payroll and self-employment income, pensions, transfers, and property income of adult household members; household's wealth at the end of the year in terms of properties lived in or owned by the household, imputed rents, household financial and real assets and liabilities; household's expenditure in non-durables and durables during the year.

The sample for the survey is drawn in two stages: first, the municipalities (stratified by region and population) are selected; second, the households to be interviewed are selected within each municipality from civic registers. Panel households are selected according to a rotating-panel sampling design: households that had participated in at least two earlier surveys are all included in the sample, plus a fraction of those interviewed only in the previous wave are randomly selected to be interviewed again in the current wave, while a fresh sample is drawn in every wave. The adoption of this rotating-panel strategy allows to minimize dropout problems and therefore reduces the problem of non random sample attrition. In the most recent wave of the survey the rate of response among contacted households was much higher for panel households (82,2%) than for non panel ones (35,8%) and non random attrition is reportedly not a major problem in the SHIW data. Appendix A.3 reports more details on panel structure and non random attrition in the SHIW.

Table 1 shows in some more detail the structure and numerosity of the the SHIW rotating panel by reporting the number of households interviewed in more than one wave. For instance, among the 8156 households in the last wave (2014), 13 participate since 1987, 64 since 1989, 166 since 1991 and so on. Table 1 also allows to pin down how many households are observed for, say, three subsequent waves in each year: in 2014 there are 579 households that have been interviewed in three subsequent waves, 806 households in 2012 wave, 856 households in 2010 wave, 995 households in the 2008 sample and so on.

Table 1: Structure of SHIW

Year first interview	Year of survey 1987	1989	1991	1993	1995	1998	2000	2002	2004	2006	2008	2010	2012	2014
1987	8027	1206	350	173	126	85	61	44	33	30	28	23	21	13
1989		7068	1837	877	701	459	343	263	197	159	146	123	102	64
1991			6001	2420	1752	1169	832	613	464	393	347	293	244	166
1993				4619	1066	583	399	270	199	157	141	124	106	78
1995					4490	373	245	177	117	101	84	75	62	46
1998						4478	1993	1224	845	636	538	450	380	267
2000							4128	1014	667	475	398	330	256	170
2002								4406	1082	672	525	416	340	221
2004									4408	1334	995	786	631	395
2006										3811	1143	856	648	414
2008											3632	1145	806	481
2010												3330	1015	579
2012													3540	1565
2014														3697
sample size	8027	8274	8188	8089	8135	7147	8001	8011	8012	7768	7977	7951	8151	8156
% panel hhs		14.6	26.7	42.9	44.8	37.3	48.4	45.0	45.0	50.9	54.4	58.1	56.6	54.7

Table 2 shows that panel and non panel households are similar in terms of demographic and socio-economic characteristics, thus suggesting that nonrandom attrition is not a major problem in the SHIW data.

Table 2: Comparison of means and standard deviations

Variable	hhs in 2010 sample only	hhs in 2010 and 2012 samples	hhs in 2012 sample only
consumption	25299.21	26381.97	24180.87
	(16200.07)	(15376.81)	(14579.85)
durable consumption	1627.81	1233.78	952.76
	(5086.05)	(4300.55)	(3596.78)
non-durable consumption	23671.40	25148.18	23228.106
	(14515.29)	(14069.37)	(13409.34)
disposable income	33146.58	31788.48	29289.21
	(25129.62)	(22629.14)	(22604.65)
gender of head of hh	1.46	1.45	1.46
	(0.5)	(0.5)	(0.5)
age of head of hh	55.10	53.09	55.81
	(17.18)	(15.37)	(17.21)
education of head of hh	3.25	3.43	3.19
	(1.07)	(1.04)	(1.07)
family size	2.49	2.60	2.43
	(1.28)	(1.32)	(1.31)
geographic area	1.81	1.85	1.80
	(0.85)	(0.88)	(0.87)
observations	2315	1015	3540

B.2 HBS

HBS (Istituto Nazionale di Statistica, 2014) sampling scheme is organized in two-stages: firstly, municipalities are selected among two groups according to the size of population; chief towns of provinces are fully included and selected to take part to the survey every month, while the remaining are grouped in strata according to some economic and geographic characteristics and are extracted every 3 months; second, households are randomly selected within the stratum from the registry office records. As a result, the survey unit is the legal family recorded by the registry office. Sample size is around 28,000 households from 480 municipalities and weights allowing for a recalibration of population in each stratum and for the distribution by household size within region are also provided for.

Data are recorded by means of two complementary methods: a diary (Libretto degli Acquisti) where the household keeps track of expenditures made and of quantities of internally produced goods consumed in the previous 7 days (Taccuino degli Autoconsumi); a proper interview for the remaining purchases done in the previous month and for durables bought in the previous 3 months. It has to be remarked that expenditure is provided on a monthly basis, so commodities recorded on a wider recording period are made monthly in the survey by dividing the amount for the number of months they are recorded for.

B.3 Sample selection

I use the SHIW waves 1989 to 2014 and HBS waves 2003 to 2012. Sample selection in both data sets satisfies the following criteria. Given that the model focuses on households' economic choices during working age, only households whose head is aged 30-59 are kept in the sample. Most young people still live with their parents around age 20 in Italy. Moreover, there is a well known (Jappelli and Pistaferri (2000)) head of household bias in SHIW data at early ages due to a strong positive correlation between wealth and young household headship.

As the model does not allow for singles and family transitions, such as marriage, divorce and widowhood, single households or households whose head reports changing marital status at a given wave are dropped from all waves in which they are observed. In SHIW, this means dropping about 20% of observations in the original sample of households in the selected age range (15% of the dropped observations are singles). Hence, the final SHIW dataset is an unbalanced panel of around 43,000 household-year observations, where about 25% of households are observed for at least five subsequent waves (i.e. ten years).

All monetary values are CPI adjusted (base year 2014). Variables for durables stock and flow, non-durable consumption and financial assets are all trimmed at the 95th percentile of the age specific distribution in order to mitigate the impact of misreporting. The variable for financial assets includes bank and postal accounts, government bonds and stocks net of consumption debt, but, for consistency with the model, it excludes housing and mortgages[1].

The variable for individual's net earnings is defined as the sum of compensation of employees and net income from self-employment and entrepreneurial income. It excludes pensions and income from property and assets, but includes government transfers. It is trimmed at the 1st and 98th percentiles of the education specific distribution. SHIW only collects data on net earnings of households' members. The corresponding gross earnings are obtained by means of a grossing-up procedure that uses the Bank of Italy microsimulation model for the Italian tax and benefit system (Curci, Savegnago and Cioffi (2017))[2].

Lastly, the equivalence scale adopted (from ISTAT) takes value .60 for household of 1 member, 1 for 2 members, 1.33 for 3 members, 1.63 for 4 members, 1.90 for 5 members, 2.16 for 6 members and 2.40 for more. I use this equivalence scale, instead of the commonly used OECD one, for consistency with the Italian data that I use for estimating the model. This equivalence scale is used by ISTAT to determine the poverty line for households that have a number of members different from 2. For instance, the poverty line for a 4-person household is 1.63 times that for a 2-member household, the poverty line for a 6-person household is 2.16 times that for a 2-member one, and so on.

[1] In order to be fully consistent with the choice of modelling financial assets as completely liquid, the data measure for net financial assets is adjusted for down payment for non home owners. Details in Appendix B.4.

[2] Data from The Household Finance and Consumption Survey (Bank of Italy, 2016*a*).

B.4 Financial assets measure

I adjust the financial assets variable in the SHIW data so to net out down payment for non-homeowners. Specifically, the financial assets measure that I use is net of downpayment for non-homeowners with non-negative assets, who are assumed to become homeowners at some point in the future, while it coincides with the original measure of financial assets for homeowners and for non-homeowners with negative assets. The downpayment for households that only appear in the data as non-homeowners is not observed and, therefore, it is imputed on the basis of the downpayment accumulated by those households who have same demographic characteristics (age, region, education) and are observed before and after the purchase of the first house. This adjustment allows to account for the fact that some households, especially young ones, might be saving towards the purchase of their first house and, therefore, might perceive part of the financial wealth they report in the survey as effectively illiquid.

In the adjustment procedure I take into account the following observed and derived measures:

- X_a : proportion of homeowners aged a. As a consequence, $(1 - X_a)$ is the proportion of those who still do not have a house at age a and $(0.75 - X_a)$ is the proportion of those who do not have a house and are saving towards buying one, given that by age 60 around 0.75 of households in the data are homeowners
- $Y_a(1 - X_a)$: proportion of non-homeowners with positive assets at age a
- A_a^H: average assets of homeowners at age a
- A_a^{NH}: average assets of non-homeowners at age a
- A_a^{NH+} and A_a^{NH-}: average assets of non-homeowners with positive and negative assets at age a

Savings towards downpayment is a proportion $\frac{Dp}{A+Dp}$ of the savings of the $(0.75-X_a)$ fraction of households who aim to buy a house in the future. Hence, the final adjusted assets measure capturing liquid assets only is:

$$\tilde{A}_a = \begin{cases} X_a A_a^H + (1 - Y_a)(1 - X_a)A_a^{NH-} + Y_a(1 - X_a)\left(1 - \frac{0.75-X_a}{Y_a(1-X_a)}\frac{Dp}{A+Dp}\right)A_a^{NH+} & \text{if } Y_a(1 - X_a) > (0.75 - X_a) \\ X_a A_a^H + (1 - Y_a)(1 - X_a)A_a^{NH-} + Y_a(1 - X_a)\left(1 - \frac{Dp}{A+Dp}\right)A_a^{NH+} & \text{otherwise} \end{cases}$$

B.5 Durables measure

In the SHIW data, the net flow is computed as the difference between purchases and sales of durables at their respective prices, as reported by households. In solving and simulating the model, instead, I can only assign different prices to the durables net flow chosen by the agents in each period (x_t) depending on whether it is positive of negative. Tables 3 and 4 show that this is a reasonable approximation. Indeed, in my sample only 5% of net buyers also sell and about 25% of net sellers also buy, but the sub sample of net sellers is much smaller than the sub sample of net buyers.

Table 3: Net buyers

	1%	5%	10 %	25%	50%	75%	90%	95%	99%
% purchases	62.2	82.8	100	100	100	100	100	100	100
% sales	0	0	0	0	0	0	0	17.2	34.8

$N = 19,957$

Table 4: Net sellers

	1%	5%	10 %	25%	50%	75%	90%	95%	99%
% purchases	0	0	0	0	0	12.1	37.5	44	47.4
% sales	52.63	56	62.5	87.9	100	100	100	100	100

$N = 462$

C Income Tax schedule

Table 5: Personal income tax rates

Income brackets (annual gross income (euros))	tax rates (%)
≤ 15,000	23
15,000-28,000	27
28,000-55,000	38
55,000-75,000	41
≥ 75,000	43

D Computational details

Solution. The household maximisation problem described in Section I has no analytical solution. I solve it numerically by backward iteration starting from the final period of life (age 85). I obtain decision rules for household's non-durable consumption, investment in durables, investment in financial assets and women's participation decisions as functions of the information set (state variables) of the household in each period of the life cycle. During working life, the set of state variables consists of age, education, durables, financial assets, male productivity, female productivity and family composition. During retirement, instead, it consists of age, education, durables and financial assets. The two endogenous continuous state variables, stock of durables and stock of financial assets, are discretized on two logarithmically spaced grids of 30 points each. Following Tauchen (1986), the two continuous exogenous stochastic AR(1) processes for spouses' productivities are discretized and approximated using Markov chains over two grids of five points each. The exogenous state variable for family composition, instead, is defined as discrete and has three possible realizations. The model combines continuous choices of next period durables and financial assets stocks with the discrete employment choice of the wife. Moreover, the model features non-convexities due to the partial irreversibility of durable goods. To deal with these simultaneous discrete and continuous choices and with the non-convexities in durables choice, I discretize the space of continuous choices and solve the optimisation problem by grid search choosing the combination of grid points that maximizes households' expected utility in each period. Households' expected lifetime utility is computed by integrating the value function over the distributions of the three exogenous stochastic state variables for male productivity, female productivity and family composition. Given the optimal decision rules for employment, next period durables stock and next period financial assets, optimal choices for non-durable consumption and durables' flow are obtained as residual from the budget constraint and from the durables law of motion[3].

Simulation. Once obtained the optimal decision rules as functions of the state variables, I simulate the life-cycle economic behavior of 12,790 households. I initialize the simulations by drawing values of the state variables (education type, financial assets, durables, both spouses' earnings and family composition) from the data distribution in the sub sample of households in age range 25-30. This procedure implies that households' initial endowments not only differ across education groups, but also across households within the same education group. I simulate ten replications for each of the households observed in the data. Over the life-cycle, each simulated household draws specific profiles of realizations of productivities and family composition random shocks. Based on the initial set of information at the beginning of each period, optimal choices are computed starting from the first period in the model (age 31) and moving forward so that the durables and financial assets decisions made by the household in period t enter the state space on which period $t + 1$ choices depend.

[3] The solution is computed in Fortran90 using parallelization on multiple nodes.

E Identification

E.1 Identification of male earning process parameters

Given that I assumed the stochastic component of earnings, $\tilde{y}$, to be the sum of a persistent shock (AR(1) process with non constant variance) and of a transitory shock, the theoretical variance-covariance matrix of $\tilde{y}$ consists of the following theoretical moments[4]

$$var(\tilde{y}_{i,t}) = var(z_{i,t}) + var(\varepsilon_{i,t}) = \rho^{2t}\sigma^2_{z_0} + (1-\rho^{2t})\frac{\sigma^2_u}{1-\rho^2} + \sigma^2_\varepsilon \tag{2}$$

$$cov(\tilde{y}_{i,t}, \tilde{y}_{i,t-j}) = cov(z_{i,t}, z_{i,t-j}) = \rho^j var(z_{i,t-j}) \qquad if \qquad j > 0 \tag{3}$$

The predicted residuals from the estimation of the deterministic component of y are consistent estimators of $\tilde{y}$, hence, to construct the empirical counterparts of the theoretical moments, the corresponding empirical moments are computed on the predicted residuals so to build the empirical variance-covariance matrix.

Identification of the four parameters of interest follows the following steps:

- ρ is identified from the slope of the covariance at lags greater than zero:

$$\frac{cov(\tilde{y}_{i,t}, \tilde{y}_{i,t-4})}{cov(\tilde{y}_{i,t-2}, \tilde{y}_{i,t-4})} = \frac{\rho^4 var(z_{i,t-4})}{\rho^2 var(z_{i,t-4})}$$

- σ^2_ε is identified from difference between variance and covariance at first lag:

$$var(\tilde{y}_{i,t-2}) - \frac{1}{\rho^2}cov(\tilde{y}_{i,t}, \tilde{y}_{i,t-2}) = var(z_{i,t-2}) + \sigma^2_\varepsilon - \frac{1}{\rho^2}\rho^2 var(z_{i,t-2})$$

- $\sigma^2_{z_0}$ is identified residually from variance at age zero:

$$var(\tilde{y}_{i,0}) - \sigma^2_\varepsilon$$

- σ^2_u is identified from difference between variance and covariance at second lag :

$$var(\tilde{y}_{i,t-2}) - cov(\tilde{y}_{i,t}, \tilde{y}_{i,t-4}) - \sigma^2_\varepsilon = \rho^4 var(z_{i,t-4}) + \sigma^2_u + \sigma^2_\varepsilon - \rho^4 var(z_{i,t-4}) - \sigma^2_\varepsilon$$

Full identification is achieved with two lags of the current age $(t, t-2, t-4)$, therefore the same household must be interviewed for at least three subsequent waves of SHIW in order to

[4]Given that SHIW is conducted every other year, I do not observe household earnings at every age, but only at age $t, t+2, t+4...$ and have to adjust the model accordingly.

be included in the earning process' estimation sample.

Let $\mathbf{f}(\psi)$ be the vector of the unique moments of the symmetric theoretical variance-covariance matrix, which are functions of the parameters $\psi = \{\rho, \sigma_u^2, \sigma_\epsilon^2, \sigma_{z_0}^2\}$ to be estimated, and $\mathbf{m}$ be the vector of the corresponding empirical moments. The estimators of the parameters in ψ are found by minimizing the weighted (diagonal weighting matrix W) distance between theoretical and empirical moments:

$$\hat{\psi} = \arg\min_{\psi} [\mathbf{m} - \mathbf{f}(\psi)]' \mathbf{W} [\mathbf{m} - \mathbf{f}(\psi)] \tag{4}$$

Standard errors of estimating parameters are computed by repeating the estimation procedure above on 500 bootstrapped samples.

In principle the term $\varepsilon_{i,t}$ might be thought of as a mix between transitory shock and measurement error, however, as already mentioned, I assume that all estimated transitory shocks to wages represent measurement error. In SHIW the fundamental cause of measurement error for income data is under reporting of earnings. It has been shown (Biancotti et al., 2008) that income and wealth are voluntarily underestimated by the respondents more severely in the South and when the head of the household is self employed, poorly educated or older. If under reporting is not systematic the tendency to under report can be a relevant cause of additional variance of the measurement error. This might partially explain the large magnitude of the variance of the stochastic transitory component of earnings that I find.

E.2 Identification of second step parameters

Identification of each preference parameter hinges on all the moments targeted in estimation. However, some moments contribute more heavily to the identification of particular parameters. Mean life-cycle profiles of financial assets and non-durable consumption contribute to the identification of the coefficient of relative risk aversion, as suggested by other studies (Cagetti (2003), Gourinchas and Parker (2002)). A higher level of assets and a smoother life cycle consumption path imply a larger γ. Savings in durables and financial assets influence the identification of the discount factor β, larger holdings of wealth suggest that households are more patient and discount the future less. In particular, γ and β can be separately identified because thay have different quantitative implications at different ages, depending on the relative importance of precautionary savings (risk aversion) and life cycle-savings for retirement (discount factor). Mean profiles of non-durable and durable consumption together inform the identification of θ and ϵ^d. Indeed, a higher ratio of durable to non-durable consumption implies that households value non-durable consumption relatively more with respect to durables and that they perceive durables as luxury goods.

Mean female employment rate over the life cycle, in particular around the birth of the first child, help identifying disutility from work parameters. Lower participation at the beginning of life implies that working is more costly when there are young children in the households and therefore ψ_1 and ψ_2 are higher. The fraction of durables stock that is collateralizable, χ, is identified by the mean patterns of financial assets and durables at beginning of working life, when individuals are more likely to borrow. The higher the ratio between assets liabilities and durables, the higher is the collateral value of durables.

The rest of the structural parameters can be cleanly identified by exploiting the longitudinal structure of SHIW data. The parameters of the deterministic and stochastic components of female earning process are identified by the mean age profile of wages and by the elements of the variance covariance matrix of the time series of unobserved productivity shocks, respectively.

The identification strategy for durables depreciation rate, δ, and reversibility rate, π, relies on the availability of reported measures for value of durables stock and value of durables flow in each wave of the panel data. Specifically, δ and π are separately identified by the relationship between the end of period value of the stock net of the period value of the flow and the previous period value of the stock. Identification of δ exploits the fact that the values of both durables stocks and flows reported by net sellers in the data embed irreversibility. Thus, it is possible to isolate the effect of depreciation from that of irreversibility by expressing the durables law of motion in terms of observables for the sub sample of net sellers. Once δ is identified, identification of π follows a similar reasoning and hinges on the fact that, among net buyers, only the observed stock - but not the observed flow - includes irreversibility.

The formal proof starts from durables law of motion: $d_t = (1-\delta)d_{t-1} + x_t$ and goes as follows:

- For net sellers, $\tilde{d} = \pi d$ and $\tilde{x} = \pi x$ are observed in data and the durables law of motion can be rewritten in terms of observables:

$$\pi d_t = (1-\delta)\pi d_{t-1} + \pi x_t \rightarrow \tilde{d}_t = (1-\delta)\tilde{d}_{t-1} + \tilde{x}_t$$

$$1-\delta = \frac{\tilde{d}_t - \tilde{x}_t}{\tilde{d}_{t-1}}$$

  hence, δ is identified in the subsample of households who are net sellers between two subsequent waves.

- For net buyers, $\tilde{d} = \pi d$ and $\tilde{x} = (1+\tau^d)x$ are observed and the transformed durables law of motion in terms of observables is:

$$(1+\tau^d)\pi d_t = (1-\delta)(1+\tau^d)\pi d_{t-1} + (1+\tau^d)\pi x_t \rightarrow$$
$$(1+\tau^d)\tilde{d}_t = (1-\delta)(1+\tau^d)\tilde{d}_{t-1} + \pi\tilde{x}_t$$

$$1-\delta = \frac{\tilde{d}_t - \frac{\pi}{1+\tau^d}\tilde{x}_t}{\tilde{d}_{t-1}}$$

$$\pi = (1+\tau^d)\frac{\tilde{d}_t - (1-\delta)\tilde{d}_{t-1}}{\tilde{x}_t}$$

once δ has been identified, also π is identified in the subsample of households who are net buyers between two subsequent waves.

The moments that I target in estimation are tractable approximations of the above theoretical relationships:

$$\frac{1}{N_s T}\sum_{i=1}^{N_s}\sum_{t=1}^{T}\left[\frac{\tilde{D}_{i,t} - \tilde{X}_{i,t}}{\tilde{D}_{i,t-1}}\right] \qquad \text{and} \qquad \frac{1}{N_b T}\sum_{i=1}^{N_b}\sum_{t=1}^{T}\left[\frac{\tilde{D}_{i,t} - \tilde{X}_{i,t}}{\tilde{D}_{i,t-1}}\right]$$

computed separately over the subsamples of net sellers (N_s) and net buyers (N_b).

F Estimation

F.1 First step estimation procedures

Male earning process. I treat male earning process as exogenous to the structural model by assuming absence of non random selection into employment for men[5]. I estimate the process' parameters on gross earnings panel data from SHIW, following a standard estimation procedure (see Guvenen (2009)). As shown in equations (12)-(14) in the paper, I specify gross labor income as the sum of a deterministic component and of a stochastic component. I first estimate the parameters of the deterministic component as the coefficients of a regression of logarithm gross wages on a set of year dummies, a polynomial in age and a region fixed effect. I then predict the residuals from this regression and estimate the parameters of the stochastic component as the ones that minimize the distance between the empirical variance covariance matrix computed on the predicted residuals and the theoretical variance covariance matrix. In particular, I estimate the persistency of the AR(1) productivity shock, ρ, the variance of the innovation to the AR(1) productivity shock, σ_u^2, the variance of the initial productivity shock, $\sigma_{z_0}^2$, and the variance of

[5]This assumption is standard in the literature and is supported by the fact that employment rate of married men is close to 100% in the data.

the transitory shock σ^2_ε. All estimates are education specific. Details on estimation procedure and identification are in Appendix E.1.

Table 6: Estimated parameters of the stochastic component of male earnings

	Education level		
	Secondary	High School	College
ρ	0.94	0.95	0.97
	(0.03)	(0.04)	(0.10)
σ^2_u	0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)
$\sigma^2_{z_0}$	0.04	0.05	0.15
	(0.02)	(0.03)	(0.09)
σ^2_ε	0.10	0.07	0.08
	(0.02)	(0.02)	(0.03)
N	2,156	1,254	410

Bootstrapped standard errors in parentheses

Family composition dynamics. Family composition evolves stochastically and can assume one of three possible values: 0 for no children in household, 1 for youngest child of pre school age (0-5), 2 for youngest child of school age (6+). The probabilities of transitioning from one state to the other are estimated from SHIW panel data as functions of age and education level of the household. Figure 1 in Appendix G.1 shows that the estimated life cycle mean profiles of family composition line up very well with the ones observed in the data for working age households. The average probability of having at least one child in the household at the starting age of 30 is decreasing in household's education.

Tax function. To estimate the parameters of the non linear labor income tax function in (15) in the paper, I take its logarithmic transformation:

$$ln(y^{net}) = ln(\lambda) + (1 - \tau^y) ln(y^{gross}) \tag{5}$$

The chosen tax base is labor income, therefore, y^{net} represents wage net of taxes and inclusive of transfers and y^{gross} measures wage before taxes and transfers. As taxation of labor income is levied at the individual rather than at the household level in Italy, I estimate (5) on gross and net wages of each spouse from SHIW data. To take into account the fact that tax credits and family allowances depend on family composition and income sources, I estimate different tax functions for parents, non-parents and retirees. Estimates in Table 7 confirm that the level of taxation is lower for retirees than for working age households and is higher for non-parents than for parents with dependent children. Progressivity, instead, does not significantly differ by employment and family status.

Table 7: estimated parameters of labor income tax function

	dependent child(ren)	no dependent child(ren)	retirees
λ	2.39	2.23	2.98
τ^y	0.11	0.11	0.13

The estimated tax function in (5) provides a good approximation to the actual tax system with a R-squared of 0.96. Figure 2 in Appendix G.2 shows the actual and approximated relationship between gross and net earnings in the three sub groups of parents, non-parents and retirees.

F.2 Estimates and elasticities for model with homogeneous consumption-saving preferences

Table 8: AIDS estimated parameters

	α_1	β_1	η_{11}
share c_1	0.85	-0.06	-0.01
	(0.01)	(0.00)	(0.01)

$N = 13,989$

Standard errors in parentheses

Table 9: Predicted expenditure shares and elasticities at the means

	shares	budget elasticity	p_1 elasticity	p_2 elasticity
share c_1	0.34	0.83	-0.60	0.60
	(0.00)	(0.00)	(0.04)	(0.04)
share c_2	0.66	1.09	0.31	-0.31
	(0.00)	(0.00)	(0.02)	(0.02)

Standard errors in parentheses

Table 10: estimated preference parameters

	All education levels			
θ	0.85			non-durable consumption share
	(0.00)			
γ	3.36			coeff. of relative risk aversion
	(0.01)			
β	0.99			discount factor
	(0.00)			
ϵ^d	-300			Stone-Geary coeff for durables
	(3.49)			
	Sec	HS	College	
ψ_0	3.05	0.79	0.46	female participation: no children
	(14.73)	(0.03)	(0.04)	
ψ_1	0.98	0.95	0.91	female participation: youngest child 0-5
	(0.01)	(0.01)	(0.01)	
ψ_2	0.94	0.99	0.80	female participation: youngest child 6+
	(0.00)	(0.01)	(0.02)	

Table 11: estimated durable dynamics parameters

	All education levels	
δ	0.04	durables depreciation rate
	(0.00)	
π	0.50	fraction of non irreversible durables
	(0.00)	
χ	0.09	fraction of collateralizable durables
	(0.00)	

Table 12: simulated marshallian elasticities, All and by education

		All		
1% increase in	employment	necessities	luxuries	durables
female net wage	1.38	0.42	0.58	0.80
male net wage	-1.59	0.34	0.45	0.25
price of necessities	0.08	-0.84	-0.03	0.00
price of luxuries	-0.07	0.05	-1.03	0.01
price of durables	-0.04	0.03	0.05	-1.65
		Secondary		
1% increase in	employment	necessities	luxuries	durables
female net wage	1.46	0.37	0.51	0.61
male net wage	-1.68	0.40	0.53	0.31
price of necessities	0.07	-0.85	-0.04	0.00
price of luxuries	-0.05	0.06	-1.02	0.02
price of durables	-0.02	0.02	0.03	-1.44
		High School		
1% increase in	employment	necessities	luxuries	durables
female net wage	1.43	0.48	0.66	0.98
male net wage	-1.70	0.26	0.36	0.18
price of necessities	0.11	-0.82	-0.02	0.01
price of luxuries	-0.11	0.05	-1.04	0.01
price of durables	-0.06	0.07	0.10	-2.08
		College		
1% increase in	employment	necessities	luxuries	durables
female net wage	0.93	0.40	0.57	0.68
male net wage	-0.87	0.36	0.51	0.33
price of necessities	0.01	-0.83	-0.05	-0.01
price of luxuries	-0.00	0.07	-1.02	-0.03
price of durables	-0.01	-0.03	-0.05	-0.76

F.3 Estimates of earning process with human capital accumulation

Table 13: estimated female earning process parameters, with human capital accumulation

	Secondary	High School	College	
h_0	9.28	9.77	9.80	deterministic component: intercept
	(0.03)	(0.02)	(0.02)	
h_1	0.04	0.01	0.03	deterministic component: returns to experience
	(0.00)	(0.00)	(0.00)	
h_2	0.03	0.01	0.03	deterministic component: depreciation rate
	(0.00)	(0.00)	(0.00)	
ρ	0.98	0.94	0.88	AR(1) persistency
	(0.00)	(0.01)	(0.01)	
σ_u	0.11	0.12	0.17	std dev of AR(1) innovation
	(0.00)	(0.01)	(0.01)	
σ_{z0}	0.37	0.43	0.40	std dev of initial realization
	(0.02)	(0.01)	(0.03)	
σ_ϵ	0.36	0.26	0.24	std dev of transitoty shock
	(0.02)	(0.02)	(0.04)	

F.4 Test of non separability assumption in AIDS

$$w_i = \alpha_{0i} + \alpha_{1i}df + \sum_{j=1}^{k} \eta_{ij} lnp_j + (\beta_{0i} + \beta_{1i}df) ln \left\{ \frac{c}{a(p)} \right\} + e_i$$

where,

$$ln(a(P)) = \sum_{i=1}^{n} (\alpha_{0i} + \alpha_{1i}df) lnp_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \eta_{ij} lnp_i lnp_j$$

Table 14: AIDS estimated parameters by education

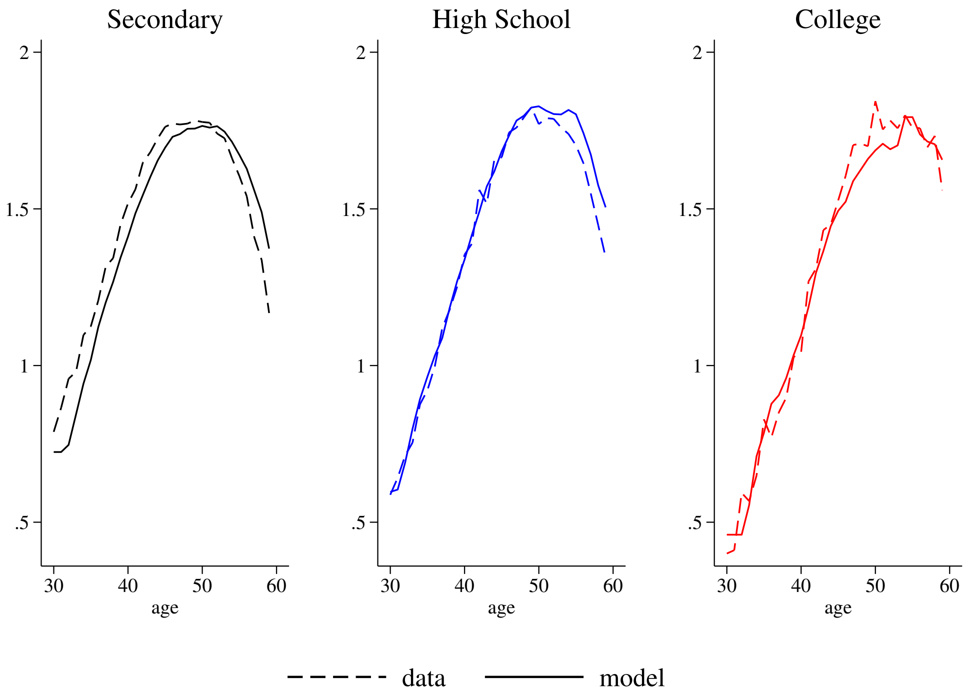
	Secondary	High School	College
α_0	0.46	0.70	0.88
	(0.03)	(0.03)	(0.04)
α_1	0.04	-0.21	-0.05
	(0.06)	(0.07)	(0.07)
β_0	-0.01	-0.04	-0.06
	(0.00)	(0.00)	(0.00)
β_1	-0.01	0.02	-0.00
	(0.01)	(0.01)	(0.01)
η_{11}	- 0.01	0.00	0.09
	(0.01)	(0.01)	(0.02)
N	2,193	2,185	1,999

Standard errors in parentheses

G Model Fit

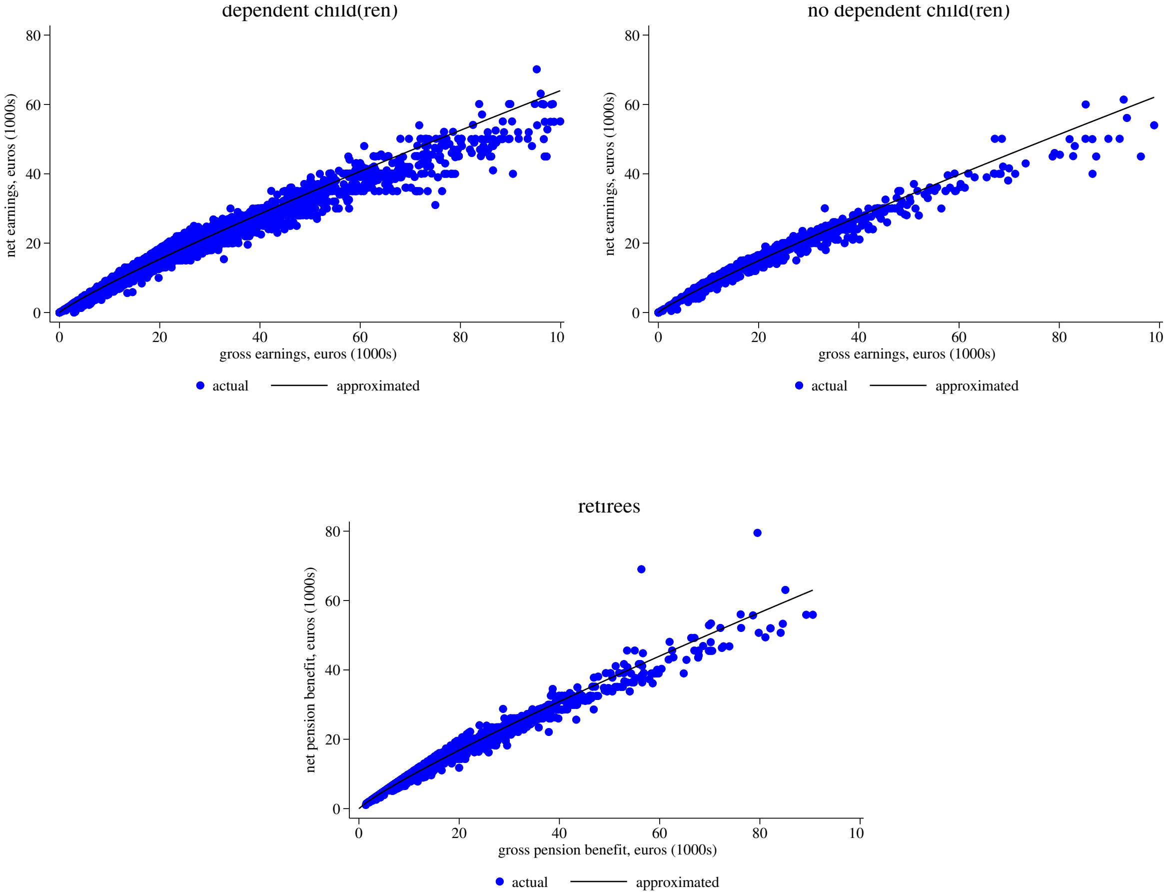
G.1 Family composition

Figure 1: family composition profiles



G.2 Tax function

Figure 2: labor income tax, actual vs approximated



G.3 Additional model fit

Figure 3: mean net earnings by education, data vs model

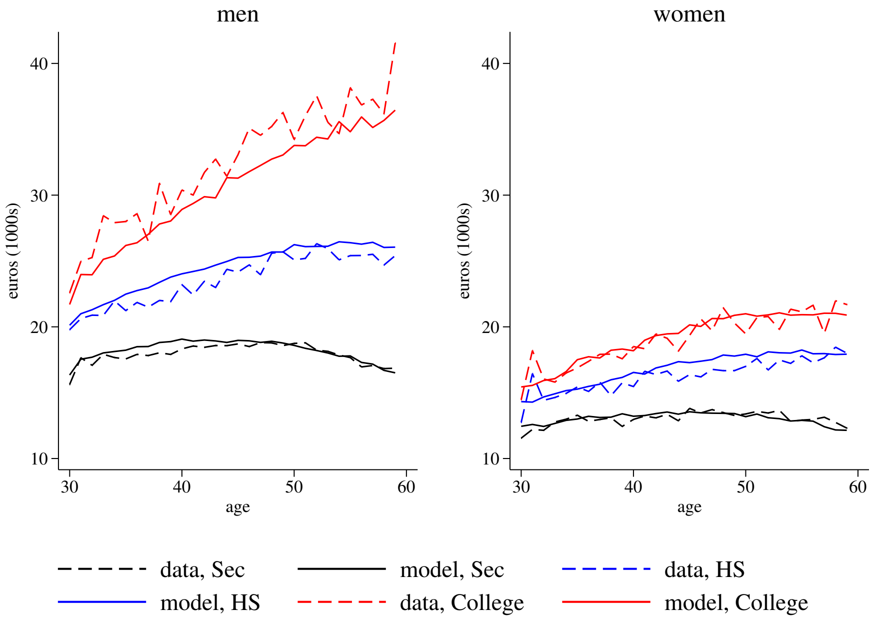


Table 15: Means at age 40-50 by education, data vs model

	Secondary		High School		College	
	Data	Model	Data	Model	Data	Model
non-durable consumption	23,828	21,163	28,984	28,891	33,070	36,729
women employment rate	0.43	0.48	0.63	0.59	0.75	0.73
durables	22,937	21,191	30,759	30,711	34,959	39,017
financial assets	9,002	9,696	15,819	14,293	21,888	14,386
men net wage	18,605	18,883	24,167	25,071	33,228	31,288
women net wage	13,337	13,390	16,397	17,260	19,516	19,854

G.4 Additional validation checks

Figure 4: distributions, data vs model

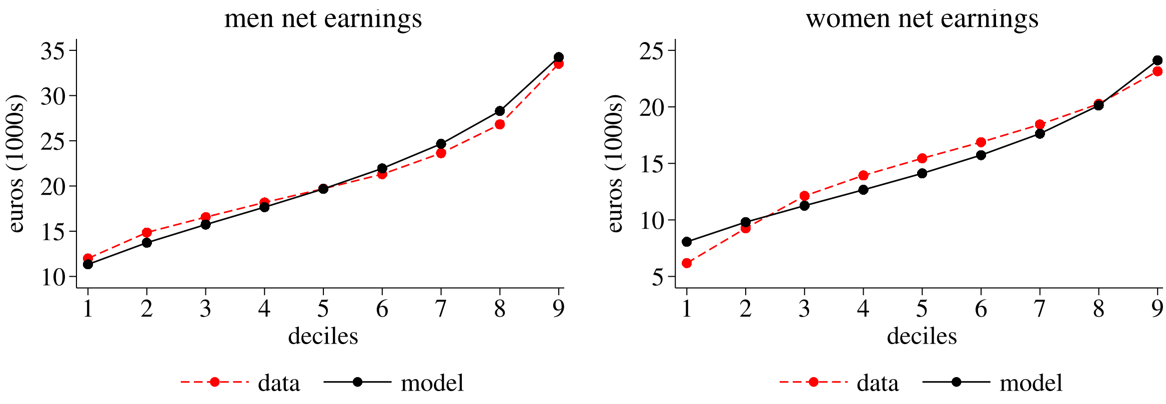
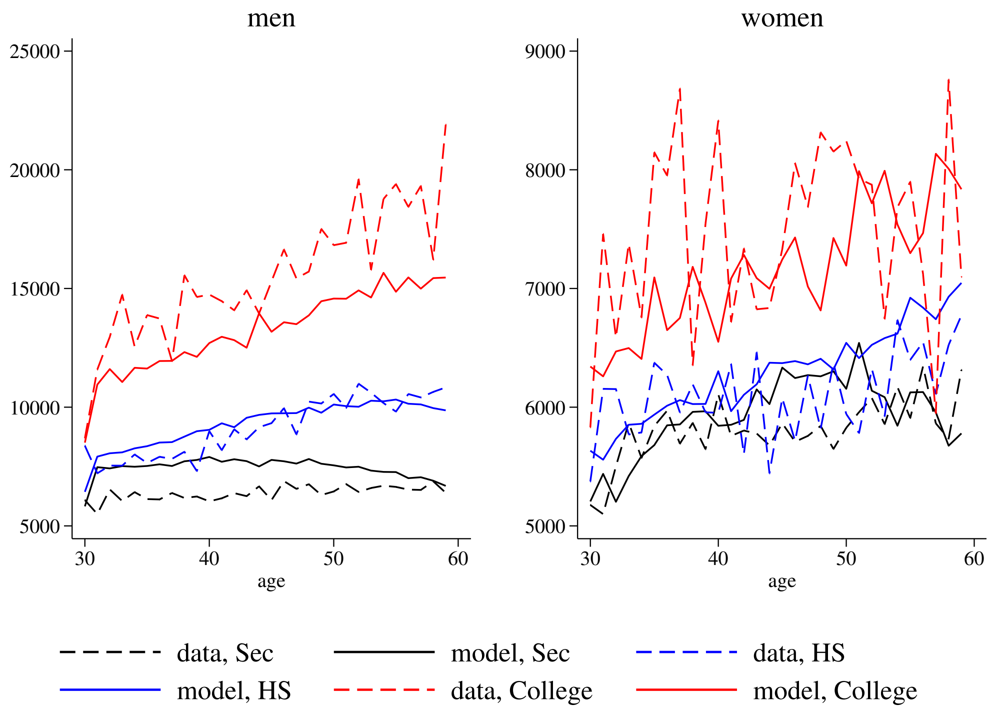


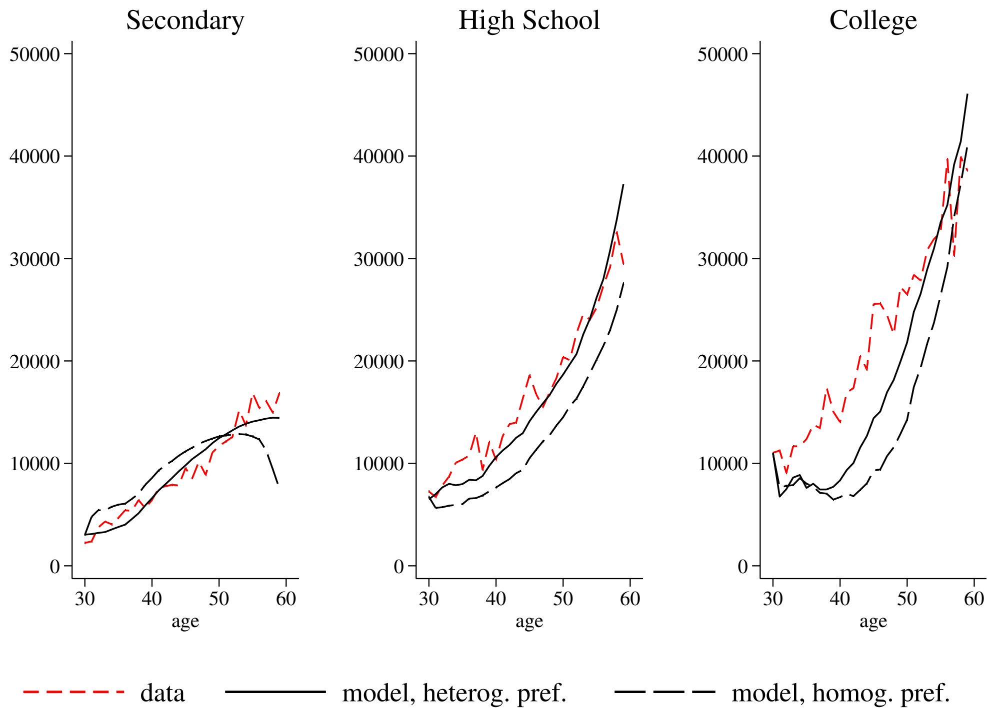
Figure 5: std. dev. of net wages by education, data vs model



G.5 Homogeneous versus heterogeneous consumption preferences

Figure 6 compares the performances of the two versions of the model- with and without heterogeneous consumption preferences across education groups - in reproducing the education-specific life-cycle profiles of financial assets observed in the data. Allowing for heterogeneous preferences for consumption and savings improves the fit to the data.

Figure 6: mean life cycle profiles of assets, data vs model



H Additional results from normative analysis

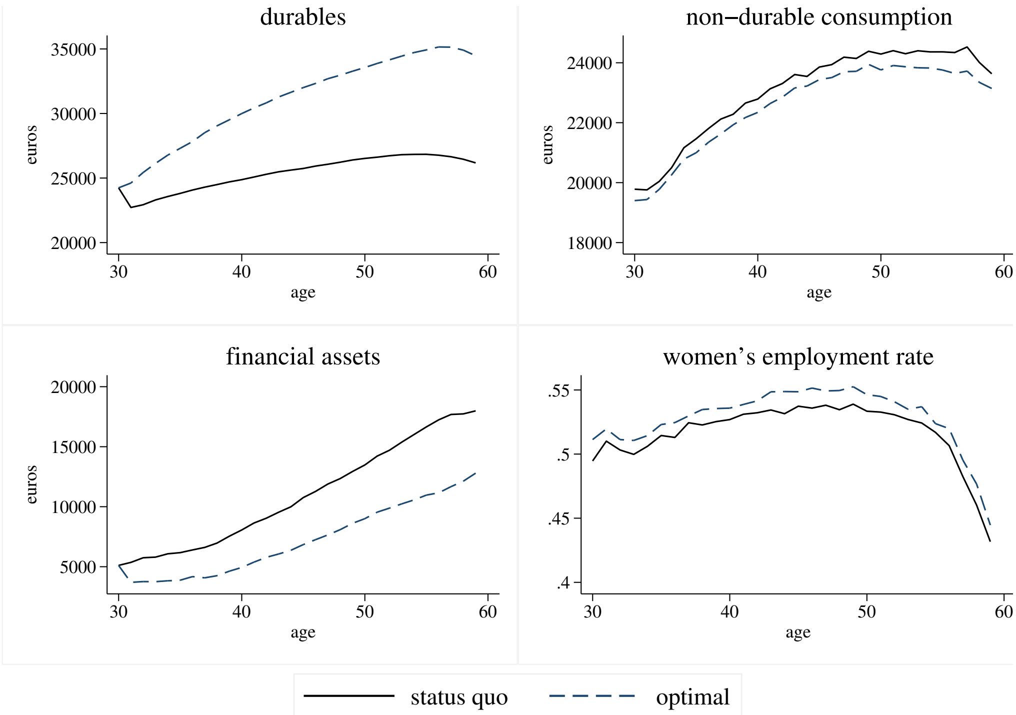
H.1 Homogeneous preferences under set of instruments $\{\tau^{n1}, \tau^{n2}, \tau^{d}, \tau^{y}\}$

Table 16: Optimal tax rates, various scenarios

Model	End.LS	LC	Irr.	BC	Sep.LS	τ^{n1}	τ^{n2}	τ^{d}	τ^{y}	MTR	ATR
M1	No	No	Yes	Yes	No	0	0	0	0.1229	41	33
M2	No	Yes	No	Yes	No	0	0	2	0.1222	40	32
M3	No	Yes	Yes	No	No	0	0	0	0.1218	40	32
M4	No	Yes	Yes	Yes	No	0	0	-12	0.1234	41	33
M5	Yes	Yes	Yes	Yes	Yes	0	0	-2	0.1235	41	33
M6	Yes	Yes	No	Yes	No	0	0	0	0.1228	41	32
M7	Yes	Yes	Yes	No	No	0	0	0	0.1225	41	32
Benchmark	Yes	Yes	Yes	Yes	No	0	0	-11	0.1238	41	33

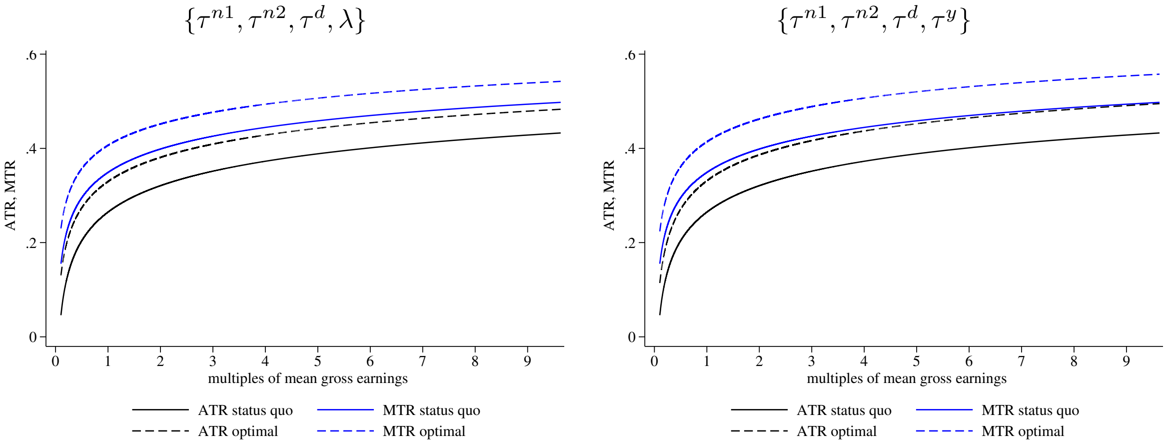
Notes: End. LS stays for endogenous labor supply; LC stays for Life-Cycle elements listed in the main text; Irr. indicates whether durables are partially irreversible; BC indicates the presence of a tight borrowing constraint; Sep. LS implies that labor supply is assumed to be separable from consumption in utility. $\tau^{n1}, \tau^{n2}, \tau^{d}$ expressed in %. MTR and ATR computed at mean gross earnings.

Figure 7: mean life cycle profiles, optimal vs status quo



H.2 ATR and MTR

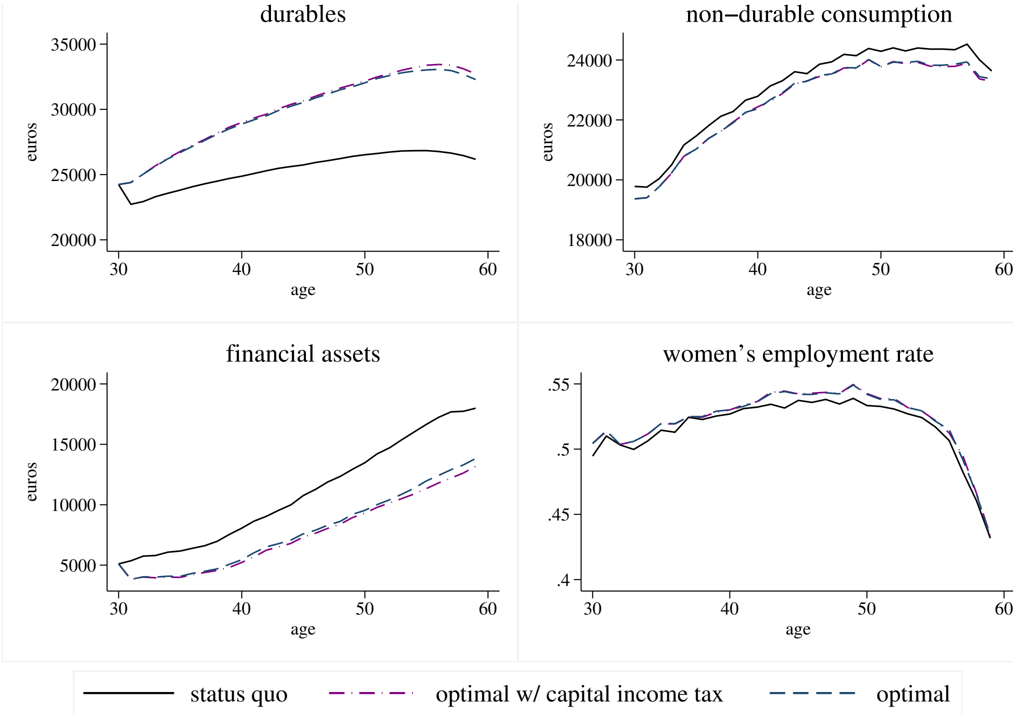
Figure 8: ATR, MTR under optimal tax system and status quo



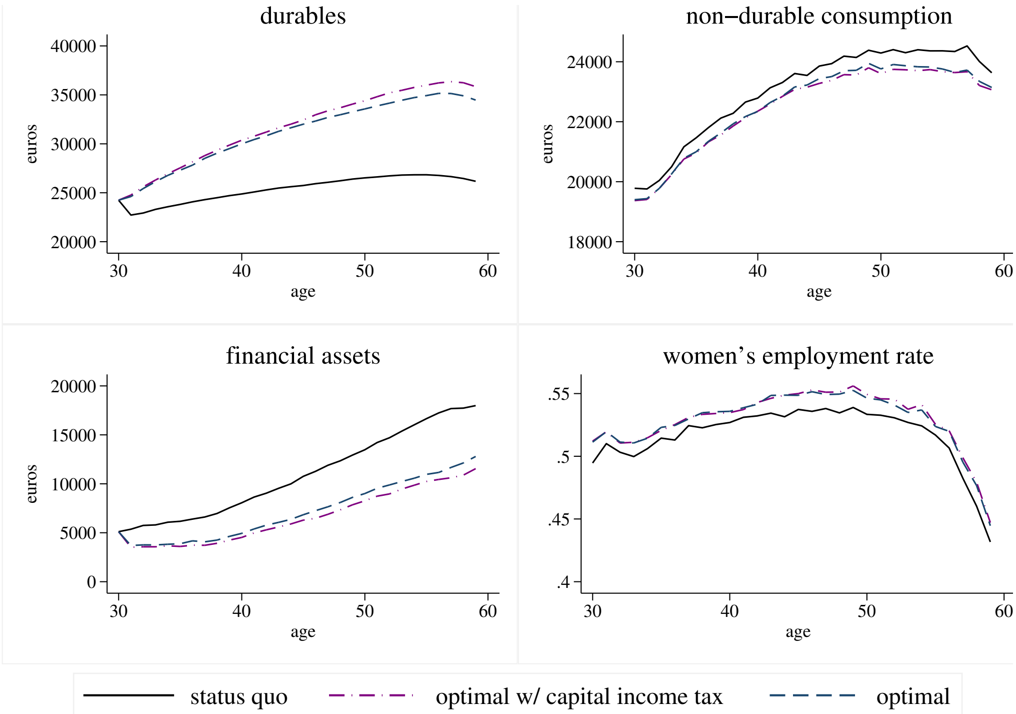
H.3 Capital income taxation

Figure 9: mean life cycle profiles, status quo vs optimal w/ and w/o capital income tax

$\{\tau^{n1}, \tau^{n2}, \tau^{d}, \tau^{a}, \lambda\}$



$\{\tau^{n1}, \tau^{n2}, \tau^{d}, \tau^{a}, \tau^{y}\}$



H.4 Heterogeneous preferences, comparison with status quo

Table 17: changes (%) in households' choices and lifetime welfare

	All	Secondary	High School	College
financial assets	-39.26	-29.78	-44.88	-46.74
durables stock	57.53	52.60	59.29	67.85
non-durable consumption	-8.20	-8.09	-8.05	-9.08
non-durable consumption, necessities	-11.83	-12.16	-11.79	-10.61
non-durable consumption, luxuries	-6.50	-6.04	-6.34	-8.49
durables flow	123.27	112.68	131.72	126.34
female participation	4.49	4.09	5.11	3.80
Expected lifetime income	4.87	4.68	5.14	4.82
CEV	0.23	-0.64	0.75	3.23
Expected lifetime utility	4.19	-1.46	1.35	4.57
Gini on expected lifetime income	0.87	1.81	1.37	0.89

Table 17 presents mean percentage changes in the main simulated outcomes between pre and post reform scenarios under heterogeneous preferences, when the set of tax instruments is $\{\tau^{n1}, \tau^{n2}, \tau^{d}, \lambda\}$ (similar results obtain with $\{\tau^{n1}, \tau^{n2}, \tau^{d}, \tau^{y}\}$). The subsidy on durables has a large positive effect on durables stock across all education groups. This effect is also reinforced by the increase in households disposable income due to lower rates of labor income tax. Publicly provided insurance in the form of durables subsidies also implies a large decrease in the stock of financial assets. Households have an incentive to run down their financial assets wealth and to invest in durables as a more convenient smoothing device. This change in portfolio composition in favor of durable goods is stronger for more educated households who are the least liquidity constrained.

In terms of consumption, the sharp increase in tax rates on non-durables together with the large subsidy on durables shift households expenditure away from non-durables toward durables for all households types. The effect is again stronger for college educated who have stronger preferences for durables. In particular, consumption of necessities decreases more than consumption of luxuries across all education groups with respect to the pre reform scenario. This is due to the fact that the price of necessities increases relatively more than the price of luxuries as a consequence of the reform. Also, budget elasticities are lower for necessities than for luxuries at all education levels and, therefore, the positive income effect is weaker for necessities. The larger decrease in non-durable necessities' purchases for lower education groups reflects the larger simulated own price demand elasticities for more constrained households.

As for the long run effects of the optimal reform on labor supply, I find that female participation to the labor market increases. This is driven by the lower taxation on labor earnings that incentivizes female employment. Higher female participation is also a result of the need for household insurance and consumption smoothing against the post reform sharp increase in non-durable consumption prices. These two mechanisms prevail on the income effect of higher net wage of the main earner, which discourages participation of the second earner. In line with simulated elasticities, participation decision is less responsive to changes in net income for college educated women than for lower educated ones.

Lifetime welfare effects of the optimal tax system are shown in the bottom panel of Table 17. Expected lifetime disposable income increases for all education groups as a consequence of the lower labor income taxes and of the increased female participation that increase the flow of household's net earnings over the whole life cycle. As a consequence of durables subsidies and lower labor income taxes, overall welfare increases by 0.23% of per-period non-durable consumption with respect to the baseline.

However, the optimal tax system redistributes in favor of the more wealthy and imposes a welfare loss on the poorer groups of the population. This is because the decrease in non-durable consumption and the higher female participation impose a larger disutility on households at the bottom of the wealth distribution.

H.5 Heterogeneous preferences, exogenous social welfare weights

I derive the optimal taxation results under an alternative generalized social welfare function, where the welfare weights are computed using expected lifetime income under the status quo (pre reform) scenario and, therefore, do not change endogenously with the evaluated tax system.

The results obtained using exogenous welfare weights (Tables 18 and 19 below) are qualitatively similar to the ones obtained using endogenous welfare weights (Tables 17 and 18 in the paper). Quantitatively, the main difference is that, with exogenous weights, the level of inequality aversion needed for the planner to find it optimal to tax durables instead of subsidizing them and to redistribute towards the less wealthy group is higher than in the case of endogenous weights. al to tax luxuries more than necessities is lower than in the case of endogenous weights.

Table 18: Optimal tax rates and welfare effects, $\{\tau^{n1}, \tau^{n2}, \tau^{d}, \lambda\}$

Inequality Aversion	Optimal tax rates						$\Delta EV(\%)$		
$1-\epsilon$	τ^{n1}	τ^{n2}	τ^{d}	λ	MTR	ATR	Secondary	High School	College
0	22	18	-22	2.4849	32	24	-1.46	1.35	4.57
-2	8	9	-8	2.3452	36	28	0.64	2.04	3.45
-4	3	15	-23	2.3213	37	29	-0.89	1.43	3.81
-20	0	10	23	2.3704	36	27	0.08	-0.12	-0.35

Notes: $\tau^{n1}, \tau^{n2}, \tau^{d}$ expressed in %. MTR and ATR computed at mean gross earnings.

Table 19: Optimal tax rates and welfare effects, $\{\tau^{n1}, \tau^{n2}, \tau^{d}, \tau^{y}\}$

Inequality Aversion	Optimal tax rates						$\Delta EV(\%)$		
$1-\epsilon$	τ^{n1}	τ^{n2}	τ^{d}	τ^{y}	MTR	ATR	Secondary	High School	College
0	22	19	-21	0.1103	32	23	-1.75	1.30	4.65
-2	10	15	-21	0.1151	35	27	-0.82	1.59	4.19
-4	17	23	-22	0.1097	31	23	-1.66	1.25	4.52
-20	0	0	23	0.1214	40	32	0.55	-0.03	-0.67

Notes: $\tau^{n1}, \tau^{n2}, \tau^{d}$ expressed in %. MTR and ATR computed at mean gross earnings.

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