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Quantifying Efficient Tax Reform*

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ABSTRACT

This paper quantifies welfare gains from tax policy reform that is both efficient and Pareto improving for an overlapping generations economy, disciplined by administrative panel data for the Netherlands. Households are heterogeneous in their age, marital status, education, and productivity. We first compute remaining lifetime utilities under current policy, which serve as a bound for Pareto improvements. We then solve a planning problem to quantify the Pareto-improving welfare gains, which we decompose into gains from level effects and gains from improved insurance. For our baseline parameterization, we find large gains, on the order of 21 percent of lifetime consumption, which are mostly driven by level effects. We also show that the solution to a utilitarian planning problem, one with educational choices aligned with educational ability, is Pareto-improving.

Keywords: income tax reform

JEL classification: E13, H21

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1. Introduction

This paper quantifies welfare gains from tax policy reform that is both efficient and Pareto improving for a heterogeneous-agent overlapping generations (OLG) economy, disciplined by administrative panel data for the Netherlands. The OLG economy serves as a positive reference point for Pareto improvements: we compute remaining lifetime utilities under current tax policy and then use them as inputs to a planning problem. We solve the planning problem to quantify Pareto-improving welfare gains, which we decompose into gains from level effects and gains from improved insurance.

To model the Netherlands, we use an open economy framework with overlapping generations and households that are heterogeneous in age, marital status, education, and productivity. Fiscal policy in this economy is summarized by tax schedules on incomes and assets and a tax rate on consumption. We compute values under current policy and use them—along with estimates for preferences, technologies, and wage processes—as inputs to our reform problem. In the reform problem, we compute the maximum consumption equivalent gain, which is restricted to be the same for all households. We also compare this gain to results of a utilitarian planning problem with equal Pareto weights on all individuals and constraints that ensure educational choices align with educational ability.

For our baseline parameterization, we find large welfare gains, on the order of 21 percent of lifetime consumption. Optimal consumption allocations are higher and more smooth than allocations under current policy, while leisure allocations are lower and more volatile. To investigate this further, we decompose the total gain into contributions for level effects and contributions for improved insurance—for consumption and leisure. Increasing mean consumption is by far the largest source of gain, although some education groups with high variability in wages also have significant gains in lowering consumption dispersion.[1]

We also compute the solution to a utilitarian planning problem, one with educational choices aligned with educational ability, is Pareto-improving. With equal Pareto weights, we estimate gains for individuals in three educational groups—low, medium, and high—to be 32, 18, and 2 percent, respectively. Thus, all gain and the high-education types are sufficiently productive to produce large gains for the other two groups.

This paper is related to the literature on optimal income taxation. We extend Kapicka (2013), Farhi and Werning (2013), and Golosov, Troshkin, Tsyvinski (2016) to compute Pareto reforms using a baseline matched to the Netherlands with a more general productivity process. Like Hosseini and Shourideh (2019), we compute the set of Pareto improving policy reforms, but we allow for stochastic productivity shocks. We find that allowing for stochastic shocks is quantitatively important for our welfare decomposition.

2. Theory

In this section, we describe the positive economy, with current fiscal policies of an actual economy, that is our baseline for estimating parameters of preferences and technologies. We then describe the associated planning problem used to quantify Pareto reforms of the OLG economy.

[1] We find that the welfare decomposition is quantitatively sensitive to estimates of wage profiles and processes governing shocks to labor productivity. For example, gains from smoothing consumption are particularly sensitive to the parameterizations of life-cycle wage growth and productivity shock variances.

2.1. Positive Economy

In this section, we describe the model economy that will be matched up to administrative data for the Netherlands. The environment is relatively standard with the exception of country-specific fiscal policies. The economy is populated by a continuum of individuals, which form households in an initial period, and perfectly competitive firms that operate a constant-returns-to-scale technology. After their formation, households face uninsurable productivity risks.

Households are formed in an initial period through random meeting of individuals. Individuals of type $k \in \mathcal{K}$ end up in a household type h with probability $\pi_0(h|k)$. In our quantitative analysis we map $\mathcal{K}$ to levels of educational attainment.

Households differ by age j, assets a, and productivity ϵ. They solve the following dynamic program:

$$v_j\left(a,\epsilon;\Omega\right)=\max_{c,n,a'}\left\{U\left(c,\ell\right)+\beta E[v_{j+1}\left(a',\epsilon';\Omega\right)|\epsilon]\right\}$$

subject to the budget constraint

$$a'=\left(1+r\right)a-T^a\left(ra\right)+w\epsilon n-T^n\left(j,w\epsilon n\right)-\left(1+\tau_c\right)c$$

and a lower bound on asset holdings: $a' \geq 0$. The aggregate state vector contains prices and policies:

$$\Omega=\{r,w,G,B,T^a,T^n,\tau_c\},$$

where r is the interest rate, w is the wage rate, G is government consumption, B is external debt, $T^a(\cdot)$ is the tax schedule for financial assets, $T^n(\cdot)$ is the tax schedule for labor income less transfers, and τ_c is the tax rate on consumption.

We assume the economy is open with interest rates r set in international markets. Firm technologies are constant-returns-to-scale functions in capital K and labor N with output Y given by:

$$Y = F(K, N).$$

Thus, knowing r, we also know the aggregate capital-labor ratio K/N and the wage rate w from the firm's optimality conditions. For computations below, we assume that prices and policies are fixed.[2] In a competitive equilibrium, the resource constraint must also hold in all periods:

$$C_t + K_{t+1} - (1-\delta) K_t + G_t + B_{t+1} - RB_t = Y_t.$$

The key outputs obtained from computing equilibrium for the positive economy are the values under current policy, namely

$$\vartheta\left(\epsilon^{j-1}\right) = E\left[v_j\left(a, \epsilon; \Omega\right)|\epsilon^{j-1}\right]$$

for households, and $\vartheta(k) = E[v_1(a, \epsilon; \Omega)|k]$ for future individuals. We want to Pareto improve on these values, and move to the efficient frontier. As an example, consider the two-person case drawn in Figure 1. The allocation the positive economy is the result of calculating the equations above. In the next section, we compute a reform problem that puts households on the efficient frontier (the blue line). The aim is to consider reforms that would narrow the set to Pareto-improving reforms (the red line), for example, at a point with consumption levels higher by the same percentage (the red dot).[3]

[2] This assumption that policies are fixed can easily be relaxed without adding much computational burden as shown by Nishiyama and Smetters (2014).

[3] The ultimate goal is to use the information gleaned from the exercise to study restricted optima along the green line.

2.2. Reform Problem

In this section, we describe the planning problem that we solve to compute Pareto reforms given the initial valuations from the positive economy.

As in the positive economy, the interest rate r is given as we are working with an open economy. Given the production function $F(K, N)$, we can determine the optimal capital-labor ratio K/N and, hence, the marginal product of labor w. We also assume that the planner must finance government spending $\{G_t\}$ and takes the initial assets $B_0 + K_0$ as given.

Given the initial values, the planning problem is to choose a feasible allocation that maximizes excess initial resources so that remaining lifetime values exceed their initial values. Formally, the planning problem is:

$$\max \; F\left(K_0, N_0\right) + RB_0 - C_0 - K_1 + (1-\delta)\, K_0 - G_0 - B_1$$

subject to the laws of motion for capital and the resource constraints for all periods, along with incentive constraints that ensure truthful reporting of households private productivity, and a condition such that remaining lifetime values exceed the initial values. In the appendix, we prove that an allocation is Pareto efficient if and only if it solves the planning problem, taking as given initial values that are generated by this allocation.

The Lagrange function for the planning problem is separable in the allocation of each household and, therefore, we can separately characterize the solution to the planning problem for each household. The planner problem for each household is to choose a household allocation to maximize excess resources subject to the household's incentive constraints. To make this tractable, we assume that only local downward incentive constraints bind at the solution. Assuming that only the local downward incentive constraints bind is a finite type analog for the first-order approach typically adopted in dynamic Mirrlees problems with a continuum of productivity types. (See, for example, Kapicka (2013), Farhi and Werning (2013), and Golosov, Troshkin, and Tsyvinski (2016).) The relaxed component planner problem is formulated by replacing the set of constraints that ensure global incentive compatibility in the component planning problem with the set of constraints that ensure the allocation satisfies all local downward incentive constraints. We write the relaxed component planner problem recursively and then characterize its solution.

This relaxed recursive problem can be formalized as follows. The planner chooses sequences of consumption $c_j(\epsilon)$, labor $n_j(\epsilon)$, promised values $V_j(\epsilon)$ for telling the truth about the productivity type, and threat values $\tilde{V}_j(\epsilon)$ for reporting a productivity type of ϵ while being one level more skilled, which we denote by ϵ^+. The recursive planning problem is given by:

$$\Pi_j\left(V_-, \tilde{V}_-, \epsilon_-\right) \equiv \max \sum_{\epsilon_i \in \mathcal{E}} \pi_j(\epsilon_i|\epsilon_-) \left(w_t \epsilon_i n_j(\epsilon_i) - c_j(\epsilon_i) + \Pi_{j+1}\left(V_j(\epsilon_i), \tilde{V}_j(\epsilon_{i+1}), \epsilon_i\right)/R\right)$$

subject to:

$$U\left(c_j(\epsilon_i), \ell_j(\epsilon_i)\right) + \beta V_j(\epsilon_i)$$
$$\geq U\left(c_j(\epsilon_{i-1}), \ell_j^+(\epsilon_{i-1})\right) + \beta \tilde{V}_j(\epsilon_i),\ \mathit{for}\ i = 2, \ldots, N \tag{2.1}$$

$$V_- = \sum_{\epsilon_i \in \mathcal{E}} \pi_j(\epsilon_i|\epsilon_-) \left(U\left(c_j(\epsilon_i), \ell_j(\epsilon_i)\right) + \beta V_j(\epsilon_i)\right) \tag{2.2}$$

$$\tilde{V}_- = \sum_{\epsilon_i \in \mathcal{E}} \pi_j\left(\epsilon_i|\epsilon_-^+\right) \left(U\left(c_j(\epsilon_i), \ell_j(\epsilon_i)\right) + \beta V_j(\epsilon_i)\right), \tag{2.3}$$

where $\pi_j(\epsilon_i|\epsilon_-^+)$ is the conditional probability over current states ϵ_i for households that were one level more productive in the previous period ϵ_-^+. The first set of constraints in (2.1) ensures that utility is higher under truth-telling, with the leisure arguments given by:

$$\ell_j\left(\epsilon_i\right) = 1 - n_j(\epsilon_i)$$

$$\ell_j^{+}(\epsilon_{i-1}) = 1 - n_j(\epsilon_{i-1})\,\epsilon_{i-1}/\epsilon_i.$$

When calculating the welfare gains of efficient reform for future generations, we replace V_- in the problem above at the initial age with $\vartheta(\epsilon_0) + \vartheta_\Delta$, where $\vartheta(\epsilon_0)$ is the initial value for future generations—that is, $E[v_1(0, \epsilon; \Omega)|\epsilon_0]$ in the positive economy—and the ϑ_Δ is the value corresponding to giving Δ more consumption to households.

To determine the consumption equivalent gain Δ for different households as implied by identical welfare gains for future individuals, we maximize resources at the initial stage given utilities V^i for individual i:

$$\Pi_0\left(\{V^i\}\right) = \max \sum_h \pi_0\,(h)\,\Pi_0\left(V^h, -, \epsilon_0; h\right),$$

subject to $V^i \leq \sum \pi_0(h|i)V^h$ for all i, where $\pi_0(h)$ is the mass of households of type h consistent with the conditional probability distribution $\pi_0(h|i)$.

3. Data and Estimation

In this section, we discuss the administrative data from the Netherlands and estimation methods used to parameterize the model. We start with aggregated data from the national accounts, flow of funds, population censuses, and tax authorities. We then discuss the micro data on earnings, hours, and education.

3.1. Aggregate Data

The main data source for the aggregate data is the Dutch Bureau of Statistics. These data are publicly available.

3.1.1. *National accounts*

The primary data source for national income and product accounts is the *nationale rekeningen*. Table 1 splits national income by factor of production. Labor income includes compensation of employees and 70% of proprietors' income. All other income is categorized as capital income, which we adjust in three ways. First, we subtract product-specific taxes as measured in the government's income and expenditure accounts. We make this correction because we are interested in production at producer prices rather than at consumer prices. Second, we impute capital services for consumer durables—which we treat as investment—and government capital. The imputed services are assessed to be 4 percent of the current-cost net stock of consumer durables and government fixed assets. Government fixed assets as well as consumer durables are recorded as non-financial balances. Finally, we impute depreciation of consumer durables. Since our data do not include the equivalent of the United States flow of funds, we assume the ratio of consumer durable depreciation to consumer durable goods to be identical to the United States.[4] This implies consumer durable depreciation of 5 percent.

On the product side, revisions must also be made with regard to sales taxes, capital services and consumer durables depreciation. The sales taxes are assumed to primarily fall on personal consumption expenditures. We assume pro rata shares when assessing how much of the taxes are on durables, non-durables and services. We include nondurables and services with consumption and durable goods with tangible investment. Therefore, we subtract sales taxes from both product categories. Imputed capital services only affect our consumption measure, which combines personal and government consumption from

[4] See Table 1 in McGrattan and Prescott (2017).

the national accounts. The consumption of consumer durables depreciates the outstanding stock of durables, which motivates us to classify consumer durables depreciation as consumption.

Fixed assets and other capital stocks used in our analysis are shown in Table 2 with averages for 2000-2010. As in the case of national accounts, we divide all estimates by adjusted GDP. We add the stock of consumer durables. The data are separated for businesses, households, and the government. We also include the value of land, which is much higher than estimates reported by McGrattan and Prescott (2017) for the United States. In fact, the data show that the value of residential land exceeds the value of structures by roughly 12 percent, likely due to strict land-use regulation. Since the oil and gas sector is so significant for the Netherlands, we include reserves. Related to fixed assets are the valuations in flow of funds data which we report in Table 3. Here, we report estimates for household net worth and government debt relative to GDP averaged over the sample 2000-2010.

Finally, in Table 4, we report aggregates on population and hours, which we use to parameterize preferences and to check aggregated micro data. Averaging data between 2000 and 2010, we estimate that the Dutch population worked 12,243 million hours, implying average annual hours of 1,135 for every individual between ages 16 and 64.

The data from the national accounts and population census are used to parameterize the discount factor, the capital share, the depreciation rate, the weight on leisure in preferences, the length of working life, and the length of retirement.

3.1.2. Fiscal Policy

In Figure 2, we plot the income tax schedule for the Netherlands during our sample period. The figure shows three marginal tax rates, namely, 34, 42 and 52 percent for working age households, with cutoff levels of 20,000 and 59,000 Euro. Marginal tax rates are reduced for retirees with incomes below 35,000 Euro. Specifically, the marginal tax rate is 17 percent for incomes below 20,000 Euro and 24 percent for incomes below 35,000 Euro. In Figure 3, we show the tax schedule for financial assets. Below 46,000 Euro, the tax rate is 0. Above this level, the rate of taxation is 1.2 percent. Finally, we assume an effective tax rate on consumption of 13.4 percent, which is the weighted average VAT for a basket of goods in the Netherlands. These schedules and rates are used to parameterize T^a, T^n, and τ_c.

3.2. Micro Data

We use linked administrative records between 2006 and 2014 from Statistics Netherlands for the information on education, earnings, and hours—series that we need to estimate productivity processes $\{\epsilon\}$ and wage profiles $\{\zeta\}$ over the life cycle for different education groups.

3.2.1. Merged datasets

We start with a representative subsample of all Dutch households selected by Statistics Netherlands. The sample consists of roughly 95 thousand households per year, which is 1.3 percent of the population of households, covering a total of over 275 thousand individuals. For all analyses, we weight households with the provided sample weights. We consider all households with heads of household above age 25. Income is measured by employer-provided earnings records. We construct an individual's annual taxable labor earnings, which includes the employer's health insurance contribution, by adding all earnings reports within a given calendar year. To construct an hourly wage rate, we merge the earnings dataset with a dataset on employer-reported hours worked, dividing taxable labor earnings by hours of work. Because the model features a single decision maker for each household, we define the household wage rate for married and cohabitating households as the average individual wage rate weighted by the hours worked of each partner. For single households, the individual wage rate is the household wage rate. Household non-market time is given by average individual non-market time which is discretionary time minus individual hours worked. We set an individual's discretionary time equal to 16 hours a day for 365 days.

We merge the datasets for earnings and hours with another that provides education levels for our sample. We need this information because we assume that there is ex-ante heterogeneity in productivity and wage profiles based on the highest educational degree earned. We classify every degree as a low, a medium, or a high level of education. The low education level is a high school degree or a practical degree, the medium level is a degree from a university of applied sciences, and the high level is a university degree. We consider six household education types, which are unordered pairs of the degree of each partner. Singles are grouped with couples in which both partners have obtained the same level of education.[5] Meeting probabilities in the initial stage are set consistent with the observed conditional probabilities in the data.

We should note here that there are significant advantages to the merged data available in the Netherlands relative to what is available in most other countries. For example, in the case of the United States, we only have administrative data for earnings whereas in the Netherlands we have earnings and hours linked and available for all members of the

[5] In our sensitivity analysis, we also explore conditioning on head of household, which is more common in the literature.

household. We also have detailed data on education, which is not available in the United States.

3.2.2. *Estimated wage processes*

We estimate the parameters that govern the residual wage process using the minimum distance estimator (Chamberlain (1984)). We first regress logarithmic wages on as follows:

$$\log W_{ijt} = A_t + X_{ijt} + \omega_{ijt},$$

where the household index is i, age is j, and the period is t. The right-hand-side variables are time effects A_t and household observables X_{ijt}. The observables include a set of dummy variables for the age of the household head, the coefficient of which is our estimate of the lifecycle profile ζ_j.

The second step is to estimate components of the residual wage after pooling across cohorts. More specifically, we use the method of simulated moments approach to estimate parameters ρ, σ_u^2, σ_η^2, $\sigma_{\epsilon_0}^2$ for the standard permanent-transitory process:

$$\omega_{ij} = \epsilon_{ij} + \eta_{ij}$$

$$\epsilon_{ij} = \rho\epsilon_{ij-1} + u_{ij}$$

with the persistent component of the residual wages given by ϵ_{ij} and the transitory component given by η_{ij}. The error processes and initial conditions are assumed to be distributed normally, that is $\eta_{ij} \sim \mathcal{N}(0, \sigma_\eta^2)$, $u_{ij} \sim \mathcal{N}(0, \sigma_u^2)$, and $\epsilon_{i0} \sim \mathcal{N}(0, \sigma_{\epsilon_0}^2)$.

The moments we use to identify the parameters are the variances and first-order autocovariances. These moments can be written in closed form as follows:

$$\mathrm{var}\,(\omega_{ij}) = \rho^{2j}\sigma_{\epsilon_0}^2 + \frac{1-\rho^{2j}}{1-\rho^2}\sigma_u^2 + \sigma_\eta^2$$

$$\text{cov}\left(\omega_{ij}, \omega_{ij-k}\right) = \rho^k \frac{1-\rho^{2(j-k)}}{1-\rho^2}\sigma_u^2 + \rho^{2j-k}\sigma_{\epsilon_0}^2.$$

These expressions are functions of (j, k) and the four parameters.

The estimation of the wage process uses the minimum distance estimator introduced by Chamberlain (1984), which minimizes a weighted squared sum of the differences between each moment in the model and its data counterpart. Let $m(\Lambda)$ be the vector of theoretical covariances and Λ be the parameter vector. The data counterpart is given by $\hat{m}$. In this case, the estimator solves:

$$\min_{\Lambda} \; \left(\hat{m} - m\left(\Lambda\right)\right)' W \left(\hat{m} - m\left(\Lambda\right)\right),$$

where W is a weighting matrix. For our baseline parameterization, we use the identity matrix for W. To compute confidence intervals, we bootstrap using 1,000 replications. Given the closed form expressions for the theoretical moments, the objective function is efficiently evaluated.

We use the estimated parameters ρ and σ_u^2 to parameterize the residual wage process in the model.[6] The results of our estimation procedure are reported in Table 5. We find the parameters are precisely estimated with estimates for $\hat{\rho}$ in the range of 0.95 to 0.97 across education groups. If we construct estimates of variation for the residual wages, that is, $\hat{\sigma}_u^2/(1-\hat{\rho}^2)$, we find that households with a low and high member and those with two high members are close to twice as variable as the others.

In Figure 4, we report the life-cycle wage profiles (ζ_j) for the 6 education groups. The right side of the figure shows the population for each group. For example, the low-low group is the largest with 43 percent of the working population. We have normalized these

[6] We assume η is a shock that households can insure against, and we use the ergodic distribution based on ρ and σ_u^2 to parameterize the initial distribution of productivities.

estimates by dividing each profile using the average wage rate for the entire population. Not surprising, we find a steep rise between ages 25 and 45 for all groups, with the lowest higher by roughly 40 percent and the highest by roughly 200 percent.

3.3. Computation

When we compute equilibria for our positive economy and our reform problem, we approximate labor productivity shocks by a Markov chain with 20 types. For both problems we assume that baseline preferences are logarithmic, that is,

$$U(c, \ell) = \gamma \log c + (1 - \gamma) \log \ell. \tag{3.1}$$

Both problems are parallelizable and thus we can solve them quickly on most modern computer clusters. As a check on these choices, we will recompute results for a 40-type case and for different preferences.

4. Results

In this section, we report our main findings. The main deliverables are labor wedges and welfare gains. We compute labor wedges for each household type. These wedges represent distortions used by the planner to incentivize individuals and to provide insurance across time and across types. We then report consumption-equivalent welfare gains and their decomposition into gains from increasing the level of consumption, gains from reducing dispersion in consumption, gains from increasing the level of leisure, and gains from reducing the dispersion in leisure. Finally, we compare consumption-equivalent gains to that found by a utilitarian planner.

The labor wedges are defined as follows:

$$\tau_n\left(\epsilon^j\right) = 1 - \frac{1}{w}\frac{U_\ell\left(c\left(\epsilon^j\right), \ell\left(\epsilon^j\right)\right)}{U_c\left(c\left(\epsilon^j\right), \ell\left(\epsilon^j\right)\right)} \tag{4.1}$$

and computed for each education group. Equation (4.1) tells us that in the optimal allocation there is a wedge between the wage rate w and the marginal rate of substitution between consumption and leisure. We report these wedges for the baseline model in Figure 5. The highest wedge is not that of the high-high group, but rather the low-high group. The reason is that the low-high group has the most variable wage process. The greater the dispersion in productivities, the greater are gains from insurance and higher is $\tau_n(\epsilon^j)$. In fact, if we were to take averages, we would find a positive correlation between the total variance $\hat{\sigma}_u^2/(1-\hat{\rho}^2)$ and the wedge across education groups. This information is useful for the reform of current policy.

In Table 6, we report the welfare gains and its decomposition for our baseline parameterization. We find a total gain of 21 percent for an efficient reform in which all individuals are made better off by the same percentage. Building on Floden (2001) and Benabou (2002), we decompose this total gain into the gain from increasing consumption, the gain from smoothing consumption, the gain from increasing leisure, and the gain from smoothing leisure. That is, we take the total consumption-equivalent gain Δ and compute:

$$\begin{aligned}\log\left(1-\Delta\right) = \log&\left(\left(1-\Delta_c^L\right)\left(1-\Delta_c^D\right)\right)\\ &+\left(1-\gamma\right)\log\left(\left(1-\Delta_\ell^L\right)\left(1-\Delta_\ell^D\right)\right)/\gamma.\end{aligned}$$

Let x be the allocation in the planner problem and $\hat{x}$ be the allocation in the positive economy. Then we define the gain due to a level increase in $x = \{c, \ell\}$ as

$$1-\Delta_x^L = \frac{\sum \pi\left(\epsilon^j\right)\hat{x}\left(\epsilon^j\right)}{\sum \pi\left(\epsilon^j\right)x\left(\epsilon^j\right)}.$$

We define the gain due to a reduction in dispersion in $x = \{c, \ell\}$ as:

$$1 - \Delta_x^D = \sum \beta^j \pi\left(\epsilon^j\right) \log\left(\frac{\hat{x}\left(\epsilon^j\right)}{\sum \pi\left(\epsilon^j\right) \hat{x}\left(\epsilon^j\right)}\right)$$
$$- \sum \beta^j \pi\left(\epsilon^j\right) \log\left(\frac{x\left(\epsilon^j\right)}{\sum \pi\left(\epsilon^j\right) x\left(\epsilon^j\right)}\right)$$

The results of the decomposition are shown in Table 6. First, note that the summing across rows yields the total gain of 21 percent (and may be off because of rounding). Second, note that there are large gains for increasing and smoothing consumption, but the optimal plan calls for lower and more dispersed leisure than in the positive economy. The gains from increasing consumption are the most significant. For example, level gains for individuals in education groups exceed 21 percent. The gains from smoothing consumption are relatievely modest for individuals in the lower education groups and close to 7 percent for the highly educated that have the highest variation in wages. In terms of leisure, we find lower levels on average for all groups in the planning problem relative to the positive economy and negative contributions to the overall gains. For leisure, the relevant margin is dispersion: those in the highest education group gain roughly the same percentage for smoothing consumption and as for smoothing leisure.

If we consider these results in light of more simple models—say, static models with and without insurance—we find that our results are in line with the simpler models. For example, consider the case in which there is no insurance and households maximize (3.1) subject to a budget constraint that consumption is less than or equal to after-tax labor earnings. The optimal plan in that case calls for variation in consumption but constant leisure. If instead there was full insurance, a planning problem would call for constant consumption and variation in leisure. The positive economy is closer to the no-insurance case and the reform problem is closer to the full-insurance case.

In Figure 6, we show the allocations of (log) consumption and leisure along with their variances for those in the low-low households. While the magnitudes are different for different household groups, the patterns are the same. In the upper left panel of the figure, we have plotted consumption for ages 25 to 64. We see from the figure that the planner can completely smooth mean consumption, which is not possible under current policy due to the borrowing constraint. In the upper right panel of the figure, we have plotted the variance of consumption. Dispersion is lowered in early years, but is higher than the positive economy later in life. In the lower panels, we plot the results for leisure. As predicted, leisure is lower in the reform problem than the positive economy for most years. while the variance is higher.

Next, we consider an alternative calculation of welfare gains, using equal Pareto weights. Here, we impose constraints that ensure the educational choices alight with educational ability. That is, we assume that the lifetime utility values of the highly educated are at least as high as values for the medium group and, similarly, that the values of the medium group are at least as high as values for the lowest group. Otherwise, the highly educated would be tempted lie about their true ability. In Table 7, we compare the welfare gains in this case—with equal Pareto weights ω set equal to 1—to the consumption-equivalent gain (Δ) of 21 percent. We also report the implied Pareto weights for the three education groups if we equalize consumption gains. As we see from the table, the Pareto weights with equal consumption gains range from 0.8 for the low group to 1.2 for the high group. If these weights are equated, we still find a Pareto improvement, although the high group in this case has only 1.6 percent consumption gains. Because this group is so highly productive, the utilitarian planner can generate gains of 32 and 18 percent for the low and medium groups, respectively.

5. Summary

In this paper, we computed efficiency gains of Pareto reforms in an environment with policies constrained due to private information about shocks to household labor productivity. Using administrative data for the Netherlands, we found the gains to be large. As a next step, the results in Figures 4–5 and Tables 5–7 can be used to inform a policy redesign in our positive economy—for example, in this case in the Netherlands. We found average tax wedges that are less than half the values of current labor tax rates. We found most gains arising from increasing consumption levels for the young and descreaing leisure for the old. We found only modest gains from smoothing consumption or leisure.

Appendix

In the main text we present a planning problem and discuss how we characterize its solution using relaxed and recursive household planning problems. In this appendix we describe the intermediate steps. We start with a general specification of the planning problem to be solved and our notion of efficiency. We then describe steps to be taken to compute a solution. Our discussion closely follows Boerma (2019).

The problem for the planner is to maximize the present value of aggregate resources subject to incentive constraints and meeting minimum bounds on lifetime utility for all households. A household i is identified by a birth year b and a history of shocks to productivities ϵ^{j-1} at the time of the reform, that is, $i \equiv (b, \epsilon^{j-1})$. The set of households considered by the planner at the time of the reform includes those currently alive and those that will be born in future periods. In period 1, this set is:

$$\mathcal{I} \equiv \left\{ \left\{ \left(1-j, \epsilon^{j-1}\right) \right\}_{j=1}^{J}, \left\{ (b, \epsilon_0) \right\}_{t=1}^{\infty} \right\}.$$

We use the notation $x(i)$ for household $i = (t, \epsilon^{j-1})$'s allocation of consumption and labor:

$$x\left(i\right) \equiv \left\{ x_{b+s}\left(\epsilon^s\right) \right\}_{s=1}^{J},$$

where $x_{b+s}(\epsilon^s) = (c_{b+s}(\epsilon^s, n_{b+s}(\epsilon^s)$. We use the notation x to summarize both the allocations of all households and the aggregate quantities of consumption C_t, hours N_t, end-of-period holdings of foreign assets B_{t+1}, and end-of-period capital K_{t+1}:

$$x \equiv \left\{ \left\{ x\left(i\right) \right\}_{\mathcal{I}}, \left\{ \left(C_t, N_t, B_{t+1}, K_{t+1}\right) \right\}_{t=1}^{\infty} \right\}.$$

We study an open economy and assume the returns on assets are given by rate R and that capital depreciates at rate δ, with the aggregate resource constraint given by:

$$C_t + K_{t+1} - \left(1-\delta\right) K_t + G_t + B_{t+1} \leq F\left(K_t, N_t\right) + RB_t.$$

The aggregate consumption and hours can be written as:

$$C_t = \sum_{j=1}^{J} \int_{\mathcal{E}^j} c_t\left(\epsilon^j\right) \mathrm{d}\mu_j\left(\epsilon^j\right)$$
$$N_t = \sum_{j=1}^{J} \int_{\mathcal{E}^j} \epsilon_j \zeta_j n_t\left(\epsilon^j\right) \mathrm{d}\mu_j\left(\epsilon^j\right),$$

where ζ_j is the deterministic age profile of productivity.

Households have private information about the history of productivity shocks, so we need to specify the information sets and the reporting strategies of households. Here, we assume that households make a report $m_j \in \mathcal{E}_j$ at age j about their type ϵ_j, where $\mathcal{E}_j$ is the set of all possible productivities at age j. A strategy specifies a report for every productivity history, $\sigma = \{\sigma_j(\epsilon^j)\}_{\epsilon^j, j}$, where σ_j maps the history of shocks to the current message, that is, $\sigma_j : \epsilon^j \to m_j$. The history of reports is summarized as:

$$\sigma^j\left(\epsilon^j\right) = \left(\sigma_1\left(\epsilon^1\right), \ldots, \sigma_j\left(\epsilon^j\right)\right).$$

The maximization problem for the planner is:

$$\max_x \sum_{t=1}^{T} R^{-t}\left(wN_t - C_t\right) + K_0 + B_0 - \sum_{t=1}^{T} G_t / R^t$$

subject to the following constraints for all i, j_i, and all reporting strategies σ:

$$\sum_{j=j_i}^{J} \beta^{j-j_i} \int_{\mathcal{E}^j} U\left(c_t\left(\epsilon^j\right), n_t\left(\epsilon^j\right)\right) \geq \sum_{j=j_i}^{J} \beta^{j-j_i} \int_{\mathcal{E}^j} U\left(c_t\left(\sigma^j\left(\epsilon^j\right)\right), n_t\left(\sigma^j\left(\epsilon^j\right)\right)\right) \tag{5.1}$$

$$\sum_{j=j_i}^{J} \beta^{j-j_i} \int_{\mathcal{E}^j} U\left(c_{b+j}\left(\epsilon^j\right), n_{b+j}\left(\epsilon^j\right)\right) \mathrm{d}\mu_j\left(\epsilon^j | \epsilon^{j_i}\right) \geq v_0\left(i\right), \tag{5.2}$$

where the marginal product of labor w and promised values $v_0(i)$, all i, are given, and j_i is the age for currently-alive households i at the time of the reform and j_i is 1 for all future households.

We are interested in allocations that are efficient in the sense that there is no alternative incentive and resource feasible allocation that makes all households weakly better off and some strictly better off.

Proposition. Let $v_0(i)$ be:

$$v_0\left(i\right) = \sum_{j_i}^{J} \beta^{j-1} \int_{\mathcal{E}^j} U\left(c_{b+j}\left(\epsilon^j\right), n_{b+j}\left(\epsilon^j\right)\right) \mathrm{d}\mu\left(\epsilon^j | \epsilon^{j_i}\right), \tag{5.3}$$

where the c and n are consumption and hours in allocation x. Then, allocation x is efficient if and only if it solves the planner problem with a maximum of zero, given the promised values in (5.3).

Proof. We show both directions by contradiction. $\Rightarrow$ If an allocation x is efficient it solves the planner problem given $v_0(i)$ for all $i \in \mathcal{I}$ with a maximum of zero. Suppose x does not solve the planner problem and let $\hat{x}$ denote a solution to the planner problem. Because x is feasible, the allocation $\hat{x}$ generates strictly excess resources in the first period. Construct an alternative allocation $\tilde{x}$ identical to $\hat{x}$ but increase initial consumption such that the incentive constraints in (5.1) are satisfied. The allocation $\tilde{x}$ strictly Pareto dominates x, which is a contradiction.

$\Leftarrow$ If an allocation x solves the planner problem given $v_0(i)$ for all $i \in \mathcal{I}$ with a zero maximum, then it is efficient. Suppose that x is not efficient, then there exists an alternative feasible allocation $\hat{x}$ such that all households are better off, with some household i strictly better off. Since $\hat{x}$ is feasible and delivers at least $v_0(i)$ for all $i \in \mathcal{I}$, $\hat{x}$ is a candidate solution to the planner problem. Construct an alternative allocation $\tilde{x}$, which is equal to $\hat{x}$ but reduce initial consumption for household i that is strictly better off under $\hat{x}$ (such that the incentive constraints are satisfied). Alternative allocation $\tilde{x}$ is feasible and generates excess resources in the initial period. This contradicts that x is a solution to the planner problem. ∎

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FIGURE 1. PARETO EFFICIENT FRONTIER

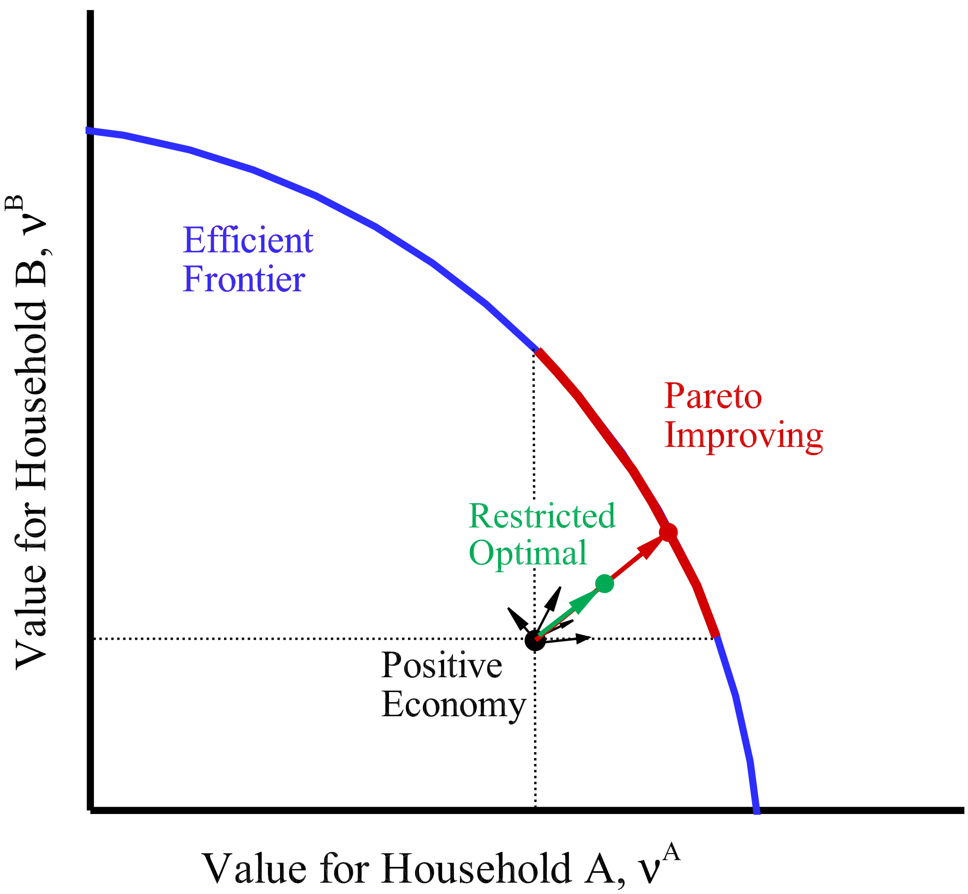


Figure 2. Income Tax Schedule

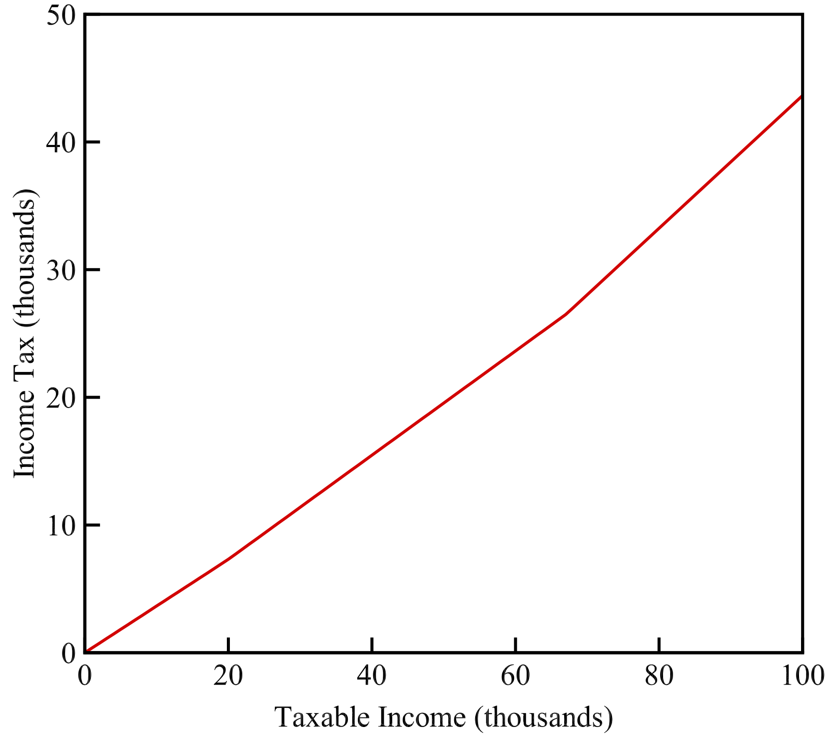


Figure 3. Financial Asset Tax Schedule

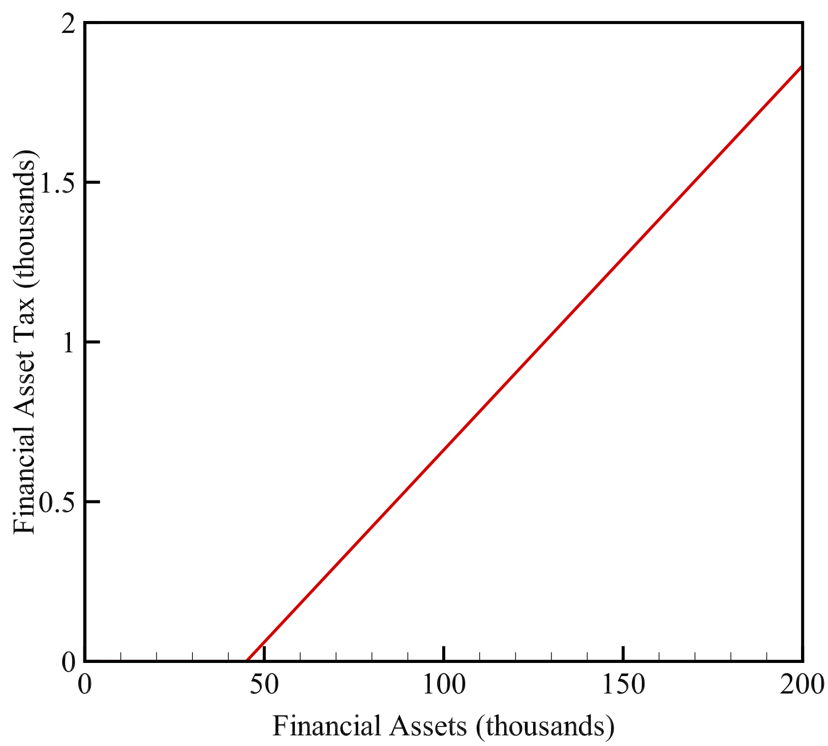


Figure 4. Wage Profiles

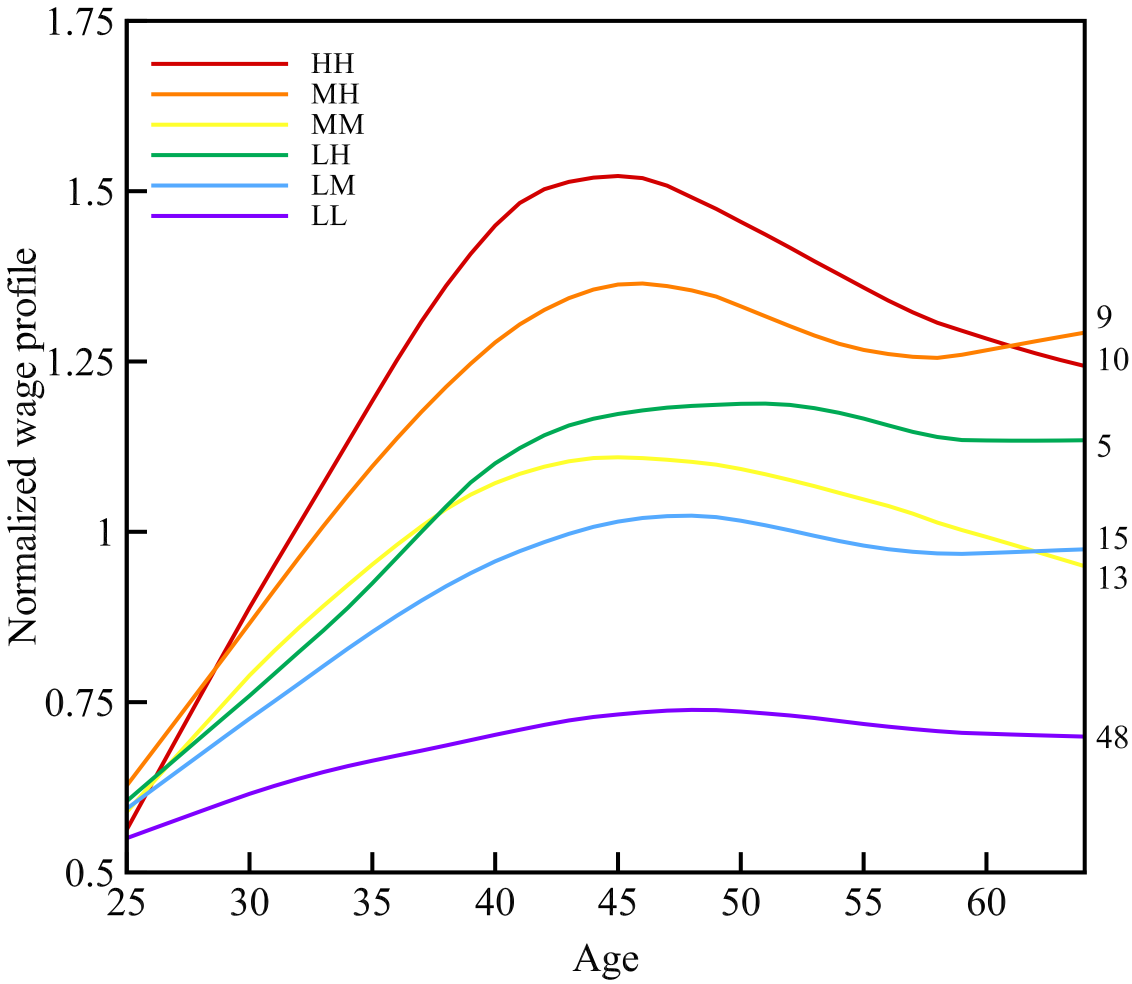


Figure 5. Labor Wedges: Baseline Model

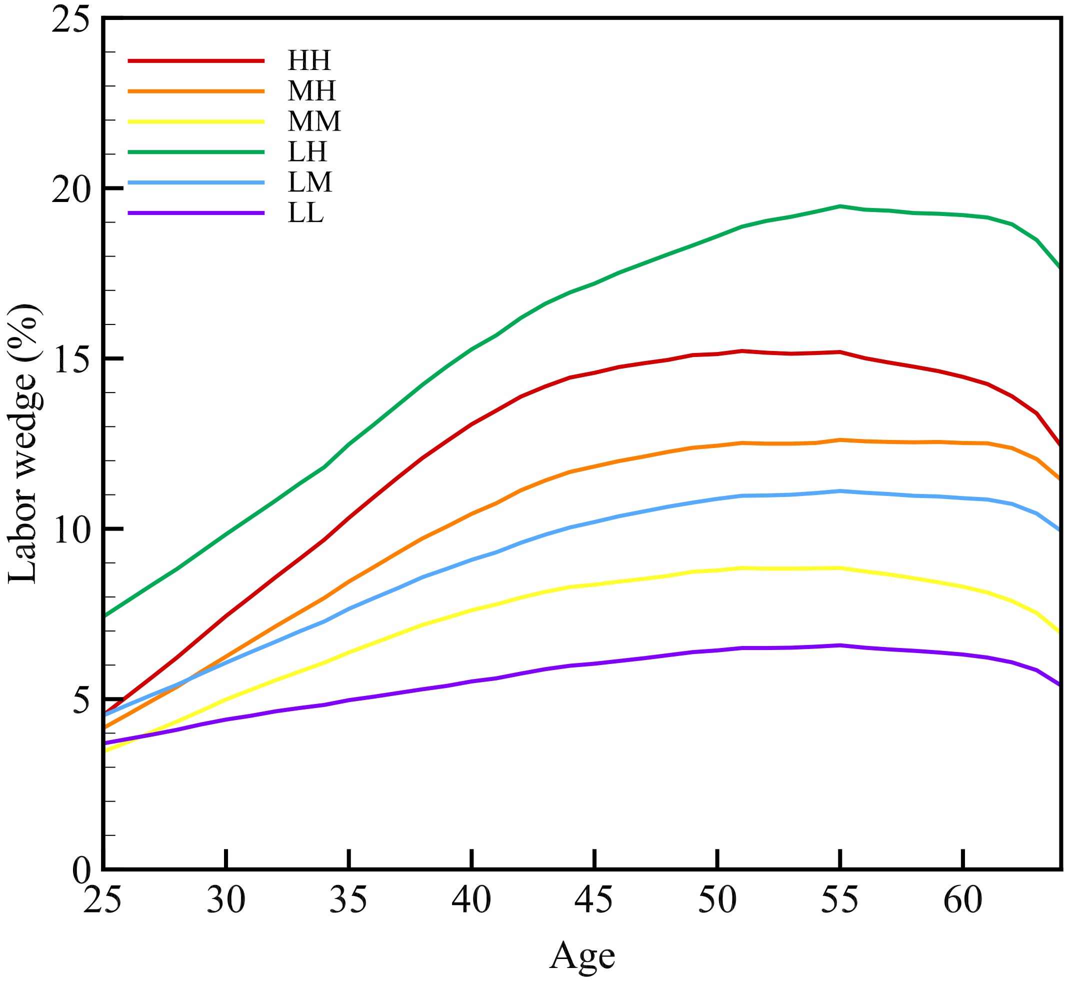
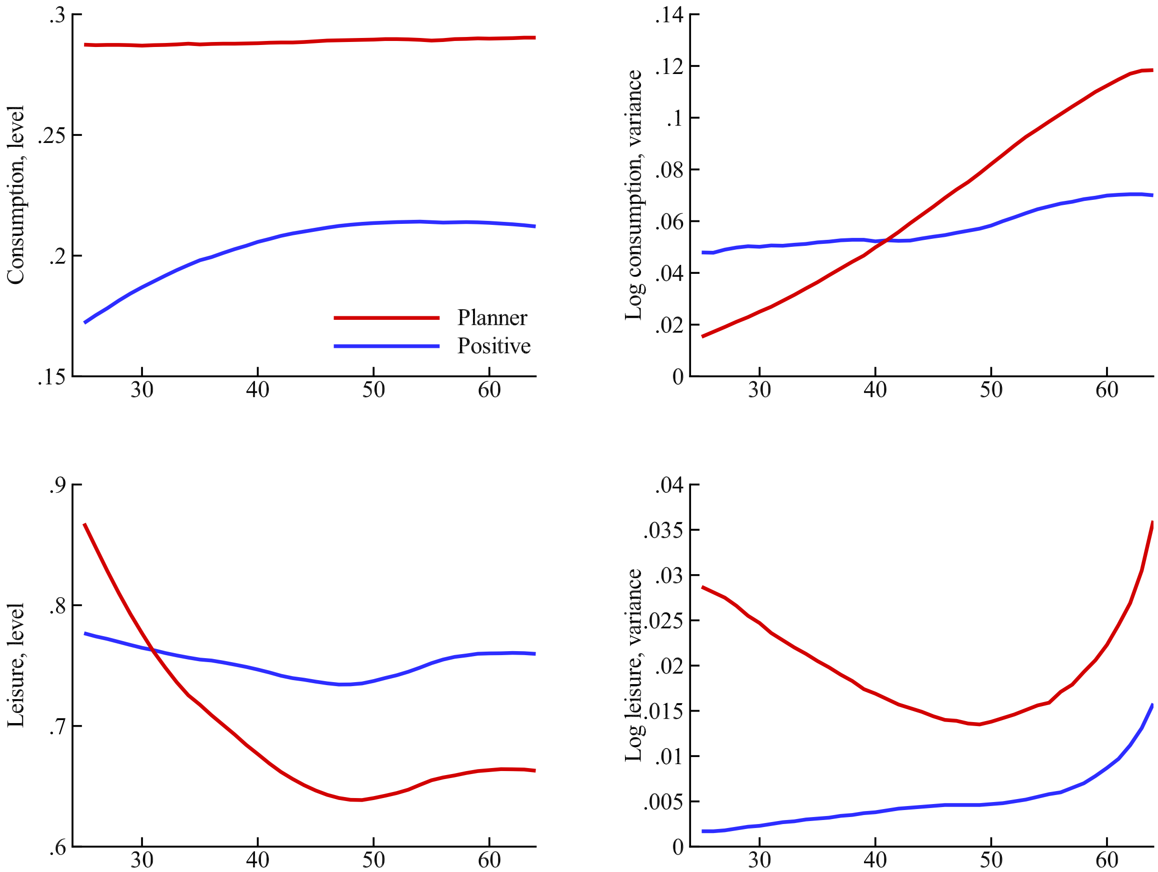


Figure 6. Allocation Levels and Dispersion for LL



Note: Results for the positive economy are shown in blue and results for the reform problem are shown in red.

Table 1. Revised National Income and Product Accounts
Averages Relative to Adjusted GDP, 2000–2010

Total Adjusted Income	1.000
Labor Income	.566
Compensation of employees	.502
Wages and salary accruals	.397
Supplements to wages and salaries	.105
70% of proprietors' income	.064
Capital Income	.434
Profits	.156
30% of proprietors' income	.027
Indirect business taxes	.105
Less: Sales tax	.103
Consumption of fixed capital	.165
Consumer durable depreciation	.050
Imputed capital services	.035
Consumer durable services	.012
Government capital services	.023

See footnotes at the end of the table.

Table 1. Revised National Income and Product Accounts Averages Relative to Adjusted GDP, 2000–2010 (Cont.)

Total Adjusted Product	1.000
Consumption	.635
Personal consumption expenditures	.484
Less: Consumer durable goods	.068
Less: Imputed sales tax, nondurables and services	.088
Plus: Imputed capital services, durables	.012
Government consumption expenditures, nondefense	.222
Plus: Imputed capital services, government capital	.023
Consumer durable depreciation	.050
Tangible investment	.351
Gross private domestic investment	.177
Consumer durable goods	.068
Less: Imputed sales tax, durables	.014
Government gross investment, nondefense	.041
Net exports of goods and services	.079
Defense spending	.014

Note: The data source for national income statistics is the Dutch Bureau of Statistics. Imputed capital services are equal to 4 percent times the current-cost net stock of government fixed assets and consumer durable goods.

Table 2. Revised Fixed Asset Tables with Stocks End of Period, Averages Relative to Adjusted GDP, 2000–2010

Total Capital	5.657
Fixed assets	3.068
Businesses	1.261
Government	0.571
Households	1.236
Consumer durables	.301
Inventories	.142
Businesses	.129
Households	.013
Land	1.905
Agricultural and productive land	.420
Residential land	1.485
Oil and gas	.241

Note: The data source for national income statistics is the Dutch Bureau of Statistics.

Table 3. Household Net Worth and Government Debt Averages Relative to Adjusted GDP, 2000–2010

Household Net Worth, end of period	3.895
Assets	5.130
Tangible	2.466
Financial	2.664
Liabilities	1.236
Government Debt, end of period	.556

Note: The data source for national income statistics is the Dutch Bureau of Statistics.

Table 4. Population, Employment, and Hours

Averages, 2000–2010

Population in millions	
All ages	16.3
Ages 16 to 64	10.8
Population growth (%)	
All ages	0.5
Ages 16 to 64	0.3
Annual hours per population 16-64	1,135

Note: The data source for national income statistics is the Dutch Bureau of Statistics.

Table 5. Estimated Wage Process Parameters

	Persistence		Innovation Variance	
Education Group	$\hat{\rho}$	Confidence	$\hat{\sigma}_u^2$	Confidence
Low, Low	.9542	(.9515,.9575)	.0096	(.0093,.0102)
Low, Medium	.9660	(.9610,.9692)	.0087	(.0083,.0096)
Low, High	.9673	(.9628,.9710)	.0162	(.0153,.0176)
Medium, Medium	.9570	(.9536,.9612)	.0099	(.0091,.0103)
Medium, High	.9616	(.9520,.9782)	.0109	(.0082,.0124)
High, High	.9564	(.9501,.9582)	.0172	(.0164,.0184)

Table 6. Welfare Gain Decomposition

	Consumption		Leisure	
Education group	Δ_c^L	Δ_c^D	Δ_ℓ^L	Δ_ℓ^D
Low	27.2	2.1	−13.1	4.8
Medium	26.1	3.6	−15.5	6.7
High	21.3	6.7	−14.4	7.3

Table 7. Equal Consumption Gains versus Pareto Weights

	Equal Gains		Equal Weights	
Education group	Δ	ω	Δ	ω
Low	21.0	0.8	32.1	1.0
Medium	21.0	1.0	18.4	1.0
High	21.0	1.2	1.6	1.0