

Optimal Progressive Labor Income Taxation and Education Subsidies When Education Decisions and Intergenerational Transfers are Endogenous*

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We quantitatively characterize the optimal mix of progressive income taxes and education subsidies in a large-scale overlapping generations model with endogenous human capital formation, borrowing constraints, income risk, intergenerational transmission of wealth and ability and incomplete financial markets. Progressive labor income taxes provide social insurance against idiosyncratic income risk and redistribute after-tax income among ex-ante heterogeneous households. Furthermore, in addition to the standard distortions of labor supply progressive labor income taxes also reduce the incentives to acquire higher education, generating a non-trivial quantitative trade-off for the benevolent utilitarian government. The latter distortion can potentially be mitigated by an education subsidy which then becomes part of the optimal fiscal constitution.

We find that the welfare-maximizing fiscal policy is characterized by a substantially progressive labor income tax code and a sizeable subsidy for college education. Both the degree of tax progressivity and the education subsidy are larger than under current U.S. status quo policy.

This paper lies at the intersection of two strands of the literature on optimal labor income taxation. Previous work (see e.g. Conesa and Krueger (2006) and Conesa, Kitao and Krueger, 2009) characterized the optimal degree of labor income tax progressivity within parametric classes of tax functions in quantitative OLG models with idiosyncratic uninsurable wage risk, but took wages over the life cycle as exogenously given. In this paper instead households *choose*, by deciding on whether to go college, the life cycle wage profile they will face during their working years. Second, a primarily theoretical literature has characterized the optimal combination of progressive labor income taxes and education subsidies in models that abstract from uninsurable income risk and precautionary asset accumulation (see Benabou (2002), Jacobs and Bovenberg (2010) and Bovenberg and Jacobs, 2005). The latter paper highlights how an education subsidy can mitigate the distortions of progressive labor income taxes (motivated by redistributive societal concerns) on household education decisions. Finally, Guvenen, Kuruscu and Ozkan (2011) present a positive quantitative analysis of the effects of progressive income taxation on human capital accumulation.

This paper follows the Ramsey tradition in that, to characterize optimal taxation in large-scale OLG models with uninsurable idiosyncratic risk and endogenous education choices, we restrict the choices of the government to simple, easily implementable tax policies. Thus the paper is subject to the critique of this approach by the New Dynamic Public Finance literature. See Bohacek and Kapicka (2008), Kapicka (2011) and Findeisen and Sachs (2012) for the analysis of models with endogenous human capital accumulation and education subsidies following the NDPF approach.

I. Elements of the Model

I.A. Firms and Production

In this paper we only highlight the crucial model elements, leaving the details to our companion paper, Krueger and Ludwig (2013). The production side of the model is completely neoclassical and features perfect substitutability between college-educated (*skilled* henceforth) labor L_c and unskilled labor L_n , both measured in efficiency units, $Y = K^\alpha [L_n + L_c]^{1-\alpha}$ where Y is the output of the final consumption good produced by the representative firm, K is the capital stock in the economy and α is the capital share.

I.B. Household Preferences, Endowments and Decisions

Households are the key determinants of dynamics in our model and undergo a meaningful life cycle. In every period a continuum of new individuals is born whose measure increases at the constant and exogenous population growth rate $\chi > 0$. Children remain with their parents until age j_a and make no economic decisions. At age j_a the economically meaningful part of life commences as the new adult household forms. It draws an ability level $e \sim N(\mu_{sp}, \sigma_e^2)$ from a Normal distribution whose mean depends

on the skill level $s_p \in \{n, c\}$ of its parents and that is truncated to $e \in [0, 1]$. It then receives an inter-vivos transfer a and draws an idiosyncratic productivity shock $\eta \sim \Pi_n(\eta)$.

Given the initial state $z = (j_a, e, \eta, a)$ at age j_a the educational decision $s \in \{n, c\}$ is made. Going to college (denoted as $\mathbf{1}_s = 1$) requires a fraction $0 < \xi(e) < 1$ of time between the ages of j_a and graduation age j_c . The time cost takes the form $\xi(e) = 1 - e$ and is declining in household ability e . It also incurs a resource cost κw_c that is proportional to the skilled wage. The government covers a share θ of this cost, and households can borrow a fraction ϕ of the remainder. The main benefit of going to college is a higher wage after college completion. After the education decision has been taken but prior to college completion at age j_c all households work for non-college wages. Wages are given by $w_n \epsilon_{j,n} \gamma_n(e) \eta$ where $\{\epsilon_{j,n}\}$ is the deterministic mean age-wage profile of low-skilled workers, $\gamma_n(e)$ is a fixed ability-dependent component and the stochastic part of wages η evolves according to the Markov transition function $\pi_n(\eta'|\eta)$. Households can buy one-period risk-free bonds but explicit insurance markets against idiosyncratic η -shocks are absent by assumption. They then choose sequences of consumption, labor supply and assets $\{c_j, l_j, a'_j\}$, and their period utility function is given by $[c^\mu (1 - \mathbf{1}_s \xi(e) - l)]^{1-\sigma} / (1 - \sigma)$ where μ is the consumption elasticity and $1/\sigma$ is the inter-temporal elasticity of substitution. Households discount the future with effective time discount factor $\varphi_j \beta$, where β is the raw time discount factor and φ_j is the probability of survival between age j and $j + 1$. A typical household's budget constraint reads as

$$(1) \quad (1 + \tau_c)c + a' + \mathbf{1}_s(1 - \theta)\kappa w_c + T(y) = (1 + (1 - \tau_k)r)(a + Tr_j) + (1 - \tau_{ss})w_n \epsilon_{j,n} \gamma_n(e) \eta l$$

where $y = (1 - 0.5\tau_{ss})w_n \epsilon_{j,n} \gamma_n(e) \eta l$ and $T(y) = \max\{0, \tau_l(y - Z)\}$

Here r is the pre-tax return on assets, Tr_j are age-specific accidental bequests from deceased parents, y is taxable labor income (which excludes the share of social security payroll taxes paid by the employer), and $(\tau_c, \tau_k, \tau_{ss}, \tau_l, Z)$ are policy parameters. Specifically, the labor income tax is linear for income above the exemption Z , whose size controls the progressivity of the system.

At age $j = j_c + 1$ college-educated households ($s = c$) first redraw their idiosyncratic shock $\eta \sim \Pi_c(\eta)$ which from then on evolves according to the transition function $\pi_c(\eta'|\eta)$ for college-educated households. They don't incur the college time cost anymore and now face wages $w_c \epsilon_{j,c} \gamma_c(e) \eta$. The Markov processes π_s are two-state approximations of education-specific $AR(1)$ processes estimated from PSID data and the fixed effects take the form $\gamma_s(e) = \vartheta_{0s} + \vartheta_{1s}e$ for $s \in \{n, c\}$. At age j_f households have $f > 1$ children. After this exogenous advent it is *per capita consumption* $c/(1 + \zeta f)$ that enters the period utility function, where the parameter ζ measures the adult-equivalent consumption requirements of each child. Then at age $j_a + j_f$ children leave the household and the adjustment factor $1 + \zeta f$ in the utility function disappears. In addition, at this time (and this time only) the household has the chance of transferring wealth $b(e') \geq 0$ to each of their f children, after the ability e' of the children has been realized. These transfers are altruistically motivated as parents value the lifetime utility of their children with parameter ν , and they form the initial asset holdings a of newly formed households described above. Finally, at age j_r households retire and receive social security benefits $p_j(e, s)$ that depend on their past earnings through their education level and ability. Households die stochastically but with probability 1 at maximum age J .

I.C. Government Policies, Objective, and the Thought Experiment

Fiscal policy in the model is determined by government spending G , tax rates/parameters $(\tau_c, \tau_k, \tau_l, Z)$, the social security system $(\tau_{ss}, p_j(e, s))$, the education subsidy θ and government debt B . The objective of this study is to characterize the optimal labor income tax and education subsidy reform, so we will take the part $(G, \tau_c, \tau_k, \tau_{ss}, p_j(e, s))$ of fiscal policy as exogenously given (and calibrate it to the data) and let

the government optimize over the remaining part (τ_l, Z, θ, B) . For calibration purposes it is useful to relate the deduction $Z = d\bar{y}$ to average income \bar{y} in the economy and treat d as the policy parameter.

The thought experiment proceeds in two steps. First we calibrate the model parameters, including *all fiscal policy parameters*, such that the stationary equilibrium of our model matches selected observations from U.S. data. We call the resulting fiscal policy the *status quo*. In a second step we determine the *optimal fiscal policy* reform $\{\tau_{l,t}, d_t, \theta_t, B_t\}_{t=1}^{\infty}$, keeping the other components of fiscal policy constant. For that we assume that any given policy reform is unexpected, and then compute the transition path of the economy induced by this policy reform towards a new stationary equilibrium. Two important aspects of the optimal tax analysis remain to be discussed. First, even within the functional forms already imposed on the labor income tax functions and education subsidies, it is infeasible to optimize over unrestricted policy sequences $\{\tau_{l,t}, d_t, \theta_t, B_t\}_{t=1}^{\infty}$, since for each such policy sequence the entire economic transition has to be computed to evaluate social welfare. Thus, in addition to the restrictions that the policies satisfy the sequence of government budget constraints and lead to a stationary debt to output ratio in the long run, the government is restricted to tax reforms of the form $\tau_{l,t} = \tau_{l,1}$ and $d_t = d_1$ and $\theta_t = \theta_1$ for all $t > 1$. Thus the government chooses the optimal once-and-for-all tax reform $(\tau_{l,1}, d_1, \theta_1)$ and then holds taxes constant at that level. Government debt adjusts to satisfy the sequence of government budget constraints as the economy converges to its new long run stationary equilibrium. We assume that the government maximizes Utilitarian social welfare over all households alive at the time of the reform by choice of $(\tau_{l,1}, d_1, \theta)$.

II. Mapping the Model to the Data

The model is parameterized such that the stationary equilibrium of the model matches selected observations from the U.S. economy on macroeconomic aggregates, wage processes as well as education allocations. For a detailed justification and calculation of these targets and resulting parameters we refer the reader to Krueger and Ludwig (2013). As point of comparison the status quo policy is given by a marginal labor income tax rate of $\tau_l = 17.5\%$, a deduction of $d = 14\%$ and a college subsidy rate of $\theta = 38.8\%$.

III. The Optimal Policy

Relative to the status quo, the optimal policy as defined above is characterized by a significantly more progressive tax system with a marginal tax rate of $\tau_l = 24.1\%$ and a deduction of $d = 32\%$ of average household income. The associated optimal education policy subsidizes the resource cost of going to college at a rate of $\theta = 70\%$, close to doubling the subsidy. The resulting welfare gain from the policy reform is equivalent to a uniform increase in consumption (over time, states of the world and households) of approximately 1.2%. In the next two subsections we characterize the long run and then transitional consequences of this fundamental tax reform, before turning to an interpretation of the welfare gains in section III.C.

III.A. Comparison of Initial and Final Steady States

In the next table we summarize the impact of the policy reform on macroeconomic aggregates in the long run, by comparing stationary equilibria under the status quo and the dynamically optimal policy. From the table we observe that the increase in the progressivity of the tax code and simultaneous rise in education subsidy triggers a significant decline in hours worked, by 1.3%. Furthermore, the expansion of government debt along the transition (see next subsection) crowds out physical capital accumulation, so that the steady state capital stock is now 1% lower than in the status quo and the capital-labor ratio falls by 3.3%.

Variable	Status Quo	Opt. Pol.	Change
Y	0.612	0.620	1.3%
D/Y	60.0%	76.8%	16.8%p.
K	0.406	0.402	-1.0%
L	1.139	1.166	2.4%
K/L	0.542	0.524	-3.3%
$hours$	33%	31.7%	-3.9%
C	0.398	0.405	1.9%
college share	43.9%	57.8%	13.9%p
$Gini(c)$	0.309	0.286	-0.023
$Gini(a)$	0.607	0.581	-0.026

However, the policy does not lead to a substantial decline in per capita output, as one might suspect from the decline in capital and hours worked; in fact GDP per capita increases by 1.3%. Key to this finding is the increase in the share of households attending college and thus the share of workers with a college degree, which is up by 14 percentage points. The doubling of the college subsidy rate more than offsets the reduced incentives to acquire human capital due to a more progressive tax system. The improved skill distribution in the population in turn results in a larger effective labor supply in the new steady state, despite the fact that average hours are significantly down. Aggregate consumption in turn rises by 1.9% in the long run. On the distributional side, consumption and wealth inequality fall on account of a more redistributive labor income tax schedule. Overall, the significant reduction in hours worked and increase in aggregate consumption as well as a more equal distribution of resources indicates substantial welfare gains from this policy reform.

III.B. Transitional Dynamics

However, this discussion ignores the fact that it takes time and resources to build up a more skilled workforce, suggesting that an explicit consideration of the transition path is important. At any point in time, the youngest cohort constitutes just a small share of the overall workforce, so even if the education decision of this cohort changes drastically on impact in favor of more college education, it takes decades until the skill composition of the entire workforce is altered significantly as older, less skilled cohorts retire and younger, more skilled cohorts take over. In figure 1 we plot the evolution of the key macroeconomic variables along the policy-induced transition path. The upper left panel which displays both the share of the youngest cohort going to college as well as the overall fraction of the population highlights the observation described above. Whereas the share of the youngest cohort going to college moves strongly on policy impact, it takes approximately 60 years until the overall skill distribution has reached a level close to its new steady state value. It is this dynamics that a restriction to a steady state policy analysis would miss completely.

That this omission has profound consequences is seen from the upper right and the lower left panel of figure 1 which show the evolution of GDP per capita (and that of capital and effective labor supply), and of consumption (together with average hours worked). The graphs show that while hours worked respond significantly on impact and then remain fairly flat, effective labor supply falls early on but then recovers as the skill composition of the population changes. Consequently the drop in GDP and consumption per capita is substantial early on (in the order of 2-3%), prior to education-driven transitional growth setting in. The dynamics of government debt (which is mechanically determined, through the sequence of

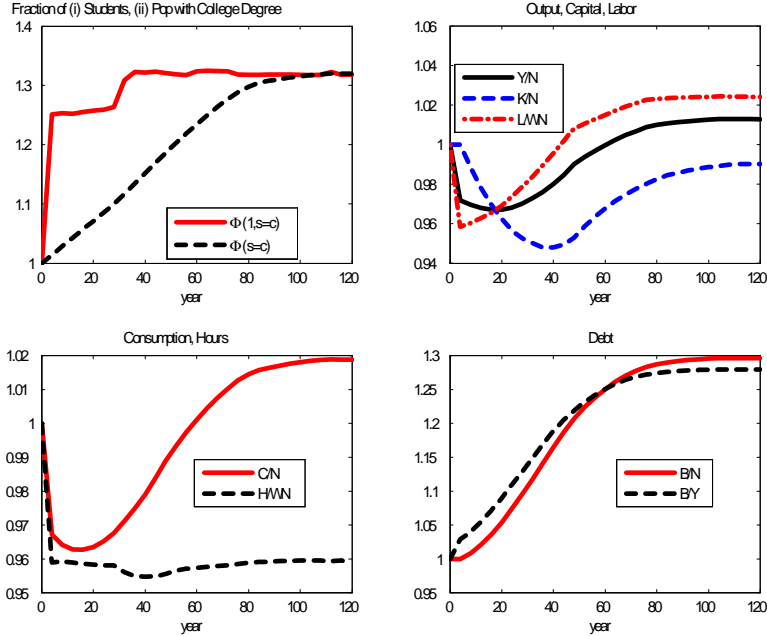


Figure 1: Evolution of Macroeconomic Aggregates

government budget constraints, given its initial level and the tax and education policies) mirrors that of GDP per capita, as the lower right panel of figure 1 displays. During the transitional years of low economic activity the government accumulates debt and the debt to GDP ratio rises from its initial 60% level. As the economy recovers the debt-to-GDP ratio stabilizes at its higher steady state level of 77%.

III.C. Interpreting the Optimal Policy and Welfare Results

Despite the previous discussion, the tax reform *does* increase social welfare significantly (in the order of 1.2% of consumption) even when the transitional cost of the policy is fully taken into account. An important element of these gains stems from a more equal distribution of consumption (and also leisure). The substantial increase in labor income tax progressivity induces a gradual reduction, over time, in earnings, consumption and wealth inequality. The cross-sectional dispersion of leisure, on the other hand, changes relatively little. Thus the aggregate welfare gains documented above stem primarily from two sources, a decline in aggregate hours worked and resulting increase in leisure for the typical household, and from a more equal consumption distribution. They are significantly mitigated by the decline in aggregate output and thus consumption that the policy brings about *in the short run*, due to lower incentives to work and the crowding out of physical capital by government debt. Finally note that, relative to the status quo, the optimal policy mix induces a substantial increase in college attendance (and thus, over time, a rising share of high-skilled households) despite the fact that the incentives from the labor income tax side for acquiring a college degree have substantially weakened. The optimal choice of $\theta = 0.7$ is crucial for this finding, and points to the important interaction of progressive taxes and education subsidies that Bovenberg and Jacobs (2005) stressed. In fact, had θ remained constant at its status quo value of 0.388, a change in the progressivity of the labor income tax alone (to $d = 32\%$) would have led to a decline in the share of the young cohort going to college by 3% in the short run and 6% in the long run and welfare gains of only 0.3% of consumption.

IV. Conclusion

We have argued that a substantially progressive labor income tax and a positive education subsidy constitute part of the optimal fiscal constitution once household college attendance decisions are endogenous. Both the degree of tax progressivity and the education subsidy are larger than under current U.S. status quo policy. We took the tax on capital income and the relative wages of skilled and unskilled workers as exogenously given. Future work will determine whether these conclusions remain robust once the government also chooses the optimal mix between capital and labor income taxes, and when relative wages respond to the skill composition of the population.

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