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On the Optimality of Age-Dependent Taxes and the Progressive U.S. Tax System

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Abstract

In life-cycle economies, where an individual's optimal consumption-work plan is almost never constant, the optimal marginal tax rates on capital and labor income vary with age. Conversely, the progressivity imbedded in the U.S. tax code implies that marginal tax rates vary with age because tax rates vary with earnings and earnings vary with age. Using numerical simulations, this paper shows that if the tax authority is prevented from conditioning tax rates on age, some degree of progressivity is desirable as progressive taxation better imitates optimal age-dependent taxes than an optimal age-independent tax system. This role for progressive taxation emanates from efficiency reasons and does not rely on any insurance nor re-distribution arguments.

Journal of Economic Literature Classification Numbers: E62; H21
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1 Introduction

Since the seminal work of Mirrlees (1971), the trade off between equity and efficiency of progressive tax systems has received considerable attention (see Boadway and Keen (2000) for a review). On the one hand, progressive taxation is thought to give rise to more equitable allocations, but it does so at the cost of distorting the labor supply decision. Other authors have cast the trade off in terms of the implicit insurance provided by progressive taxation relative to its distortionary impact on labor/leisure and savings decisions—see Conesa and Krueger (2005) and Conesa et al. (2009). In this paper, I argue that progressive taxation may have a role purely on efficiency grounds, without relying on any re-distribution arguments: A certain degree of progressivity in the tax system implies tax rates that are closer to optimal age-dependent tax rates. Thus, in a world in which the fiscal authority cannot condition tax rates on age, as is the case in the U.S., the optimal tax code involves progressive taxation.

In life-cycle economies both capital and labor income taxes are generally used by an optimizing government, even in the long run. Erosa and Gervais (2002) show that when the government has access to a full set of proportional, age-conditioned, tax rates on capital and labor income, the optimal tax rates vary over the lifetime of individuals, that is, the optimal (marginal) tax rates are age-dependent. Likewise, because of the progressivity of the U.S. tax system, the marginal tax rates that individuals face vary with earnings. Since earnings vary over the lifetime of individuals, a progressive tax system implies that the marginal tax rates faced by the average U.S. tax payer also vary with age. As such, progressive taxation may provide a way for the government to imitate optimal age-based taxes without explicitly conditioning tax rates on individuals' age.

As is well known, however, progressive taxation introduces a wedge between marginal and average tax rates that is not present under age-dependent proportional taxes. I evaluate the cost of this wedge by computing equilibria of the life-cycle model under different specifications of progressive tax systems. I compare the allocations obtained under these tax systems to a benchmark allocation taken to be the solution to a Ramsey problem in which the government is forced to pick age-independent (proportional) tax rates—a feasible alternative when the government cannot condition tax rates on age.

The desirability of progressive taxation naturally depends on the level and shape of the lifetime profiles of consumption and leisure induced by the tax system. While a progressive tax system in which the tax base is total income induces flatter profiles, it also lowers the level of the profiles, leaving individuals to prefer the tax system with flat proportional taxes. However, a progressive tax on labor income together with a fairly high (40%) proportional tax on capital income strikes the right balance between the shape and the level of the consumption and leisure profiles, making individuals prefer this tax system to the best tax system with flat proportional taxes. Unlike Conesa et al. (2009), these results are based on a representative agent (or generation) model with complete markets and without uncertainty. As such, the desirability of progressive taxation emanates solely from efficiency reasons.

The rest of the paper is organized as follows. Section 2 presents the economic environment, formulates a Ramsey problem and presents optimal age-dependent taxes generated by a parameterized version of the model. The shape of these profiles suggest a potential role for progressive taxation, which is the subject of section 3. In that section, allocations under various progressive tax systems are compared to allocations derived from a Ramsey problem which imposes age-independent tax rates. A brief conclusion is offered in section 4.

2 Economic Environment and Ramsey Taxes

Consider an economy populated by overlapping generations of individuals with finite lives along the lines of Auerbach and Kotlikoff (1987). Individuals make consumption and labor/leisure choices in each period so as to maximize their lifetime utility. Firms operate a neoclassical production technology: factors are paid their marginal products. The payments received by individuals on their factors (capital and labor) are subject to proportional taxes which can be conditioned on age.[1] The government uses the revenues from taxation to finance an exogenously given stream of government purchases. Note that for any given fiscal policy, individual behavior (by consumers and firms) implies a particular allocation. The Ramsey problem consists of choosing, among all those allocations, the one that maximizes a particular utilitarian welfare

[1] Age-dependent taxation will be ruled out in section 3.

function. This problem, the Ramsey problem, will be formally defined once the basic economic environment is introduced.

2.1 Economic Environment

Households Individuals live $(J+1)$ periods, from age 0 to age J. At each time period a new generation is born and is indexed by its date of birth. At date 0, when the change in fiscal policy occurs, many generations are already alive. To account for these initial generations, born in periods $t = -J, -J+1, \ldots, 0$, it is convenient to denote by $j_0(t)$ the age of these individuals at date 0. For all other generations, $j_0(t) = 0$, so that for any generation t, $j_0(t) = \max\{-t, 0\}$. One can thus think of $j_0(t)$ as the first period of an individual's life which is affected by the date zero switch in fiscal policy. The population is assumed to grow at constant rate n per period, and μ_j represents the (time-invariant) share of age-j individuals in the population. The labor productivity level of an age-j individual is denoted z_j.

Let $c_{t,j}$ and $l_{t,j}$, respectively, denote consumption and time devoted to work by an age-j individual who was born in period t. Note that $c_{t,j}$ and $l_{t,j}$ actually occur in period $(t+j)$. Similarly, the after-tax prices of labor and capital services are denoted $w_{t,j}$ and $r_{t,j}$, respectively. Given a fiscal policy π, which specifies capital and labor tax rates at each age for each generation as well as government debt at each date, the problem faced by an individual born in period $t \geq -J$ is to maximize lifetime utility subject to a sequence of budget constraints:

$$U^t(\pi) \equiv \max \sum_{j=j_0(t)}^{J} \beta^{j-j_0(t)} U(c_{t,j}, 1-l_{t,j}), \tag{1}$$

$$\text{s.t.} \quad c_{t,j} + a_{t,j+1} = w_{t,j} z_j l_{t,j} + (1+r_{t,j}) a_{t,j}, \quad j = j_0(t), \ldots, J, \tag{2}$$

where $\beta > 0$ is a discount factor and $a_{t,j}$ denotes total asset holdings by an age-j individual who was born at date t. Initial asset holdings, $a_{t,j_0(t)}$, are taken as given for initial generations and are equal to zero for all other generations. In equation (1), $U^t(\pi)$ denotes the indirect utility function of a generation-t individual, that is, the maximum lifetime utility an individual obtains under fiscal policy π. The budget constraint (2) expresses that individuals allocate their income, composed of labor and (gross) interest income net of taxes, to consumption and saving.

Technology and Feasibility The production technology is represented by a production function with constant returns to scale, $q_t = f(k_t, l_t)$, where q_t, k_t and l_t denote the aggregate (per capita) levels of output, capital, and effective labor, respectively. Capital and labor services are paid their marginal products: before-tax prices of capital and labor in period t are given by $\hat{r}_t = f_k(k_t, l_t) - \delta$, where $0 < \delta < 1$ is the depreciation rate of capital, and $\hat{w}_t = f_l(k_t, l_t)$.

Feasibility requires that total (private and public) consumption plus investment be less than or equal to aggregate output

$$c_t + (1+n)k_{t+1} - (1-\delta)k_t + g_t \leq q_t, \tag{3}$$

where c_t and g_t respectively denote aggregate (per capita) private and government consumption at date t. Note that tomorrow's per capita stock of capital needs to be multiplied by $(1+n)$ to account for population growth. Also, the date-t aggregate levels of consumption and labor input, the latter being expressed in efficiency units, are obtained by adding up the weighted consumption and effective labor supply of all individuals alive at date t, where the weights are given by the fraction of the population that each individual represents:

$$c_t = \sum_{j=0}^{J} \mu_j c_{t-j,j}, \tag{4}$$

$$l_t = \sum_{j=0}^{J} \mu_j z_j l_{t-j,j}. \tag{5}$$

The Government To finance a given stream of government expenditures, the government has access to a set of fiscal policy instruments and a commitment technology to implement its fiscal policy. The set of instruments available to the government consists of government debt and proportional, age-dependent taxes on labor income and capital income. The date-t tax rates on capital and labor services supplied by an age-j individual (born in period $(t-j)$) are denoted by $\tau^k_{t-j,j}$ and $\tau^w_{t-j,j}$, respectively. In per capita terms, the government budget constraint at date $t \geq 0$ is given by

$$(1+\hat{r}_t)b_t + g_t = (1+n)b_{t+1} + \sum_{j=0}^{J} (\hat{r}_t - r_{t-j,j})\mu_j a_{t-j,j} + \sum_{j=0}^{J} (\hat{w}_t - w_{t-j,j})\mu_j z_j l_{t-j,j}, \tag{6}$$

where $w_{t,j} \equiv (1-\tau^w_{t,j})\hat{w}_{t+j}$, $r_{t,j} \equiv (1-\tau^k_{t,j})\hat{r}_{t+j}$, and b_t denotes government debt issued at date t.[2] Equation (6) expresses that the government pays its expenditures, composed of outstanding government debt payments (principal plus interest) and other government outlays, either by issuing new debt (adjusted for population growth), by taxing interest income, or by taxing wage income.

In the spirit of Ramsey (1927), the government takes individuals' optimizing behavior as given and chooses a fiscal policy to maximize social welfare, where social welfare is defined as the discounted sum of individual lifetime welfares (Samuelson (1968) and Atkinson and Sandmo (1980)). In other words, the government chooses a sequence of tax rates in order to maximize

$$\sum_{t=-J}^{\infty} \gamma^t U^t(\pi), \tag{7}$$

where $0 < \gamma < 1$ is the intergenerational discount factor and $U^t(\pi)$ was defined earlier as the indirect utility function of generation t as a function of the government policy π.

2.2 The Ramsey Problem

The Ramsey problem consists of choosing a set of tax rates so that the resulting allocation, when prices and quantities are determined in competitive markets, maximizes a given welfare function. Alternatively, a Ramsey problem where the government chooses allocations rather than tax rates can be formulated.[3] This is done by constructing a sequence of implementability constraints which guarantee that any allocation chosen by the government can be decentralized as a competitive equilibrium. The implementability constraints are obtained by using the consumers' optimality conditions to substitute out prices from the consumer's budget constraints (2). After adding up these budget constraints, the resulting implementability constraint associ-

[2]Note that in overlapping generations economies, the present value of taxes collected need not equal the present value of expenditures. However, since debt per capita is bounded, there is no need to impose a limit on government debt.

[3]This is the formulation of the Ramsey problem generally used to study optimal taxation in infinitely-lived agent models. See Chari and Kehoe (1999) for a review.

ated with the cohort born in period t is given by

$$\sum_{j=j_0(t)}^{J} \beta^{j-j_0(t)}(U_{c_{t,j}} c_{t,j} + U_{l_{t,j}} l_{t,j}) = A_{t,j_0(t)}, \tag{8}$$

where $A_{t,j_0(t)} = U_{c_{t,j_0(t)}}(1 + r_{t,j_0(t)})a_{t,j_0(t)}$. It is important to note that these implementability constraints rely on the existence of age-dependent tax rates. Since factors are paid their marginal products, before-tax prices do not depend on age. It follows that after-tax prices can only depend on age if the government has access to age-dependent tax rates: additional restrictions, which involve marginal rates of substitution over the lifetime of individuals, need to be imposed for an allocation to be implementable with age-independent taxes. In other words, the set of allocations from which the government can pick depends crucially on the instruments available to the government.

Since these implementability constraints are constructed from the optimality conditions of the consumers' problem, it is clear that any competitive equilibrium allocation satisfies (8). Conversely, one can show that if an allocation satisfies the implementability constraints (8) as well as the feasibility constraint (3), then there exists a fiscal policy for which the allocation is a competitive equilibrium.[4] This equivalence allows one to set up a Ramsey problem in which the government chooses quantities rather than tax rates.

This Ramsey problem consists of choosing an allocation to maximize the discounted sum of successive generations' utility subject to each generation's implementability constraint as well as the feasibility constraint, that is,

$$\max_{\left\{\{c_{t,j},l_{t,j}\}_{j=j_0(t)}^{J},k_{t+J+1}\right\}_{t=-J}^{\infty}} \sum_{t=-J}^{\infty} \gamma^t W_t \tag{9}$$

subject to feasibility (3) for $t = 0, 1, \ldots$. The function W_t is defined to include generation t's implementability constraint in addition to generation t's lifetime utility, where lifetime utility now refers to the direct utility function. Letting $\gamma^t \lambda_t$ be the Lagrange multiplier associated with generation t's implementability constraint (8),

[4]For details, see Atkeson et al. (1999) or Erosa and Gervais (2002).

the function W_t is defined as

$$W_t = \sum_{j=j_0(t)}^{J} \beta^{j-j_0(t)} \left[U\left(c_{t,j}, 1 - l_{t,j}\right) + \lambda_t (U_{c_{t,j}} c_{t,j} + U_{l_{t,j}} l_{t,j}) \right] - \lambda_t A_{t,j_0(t)}. \tag{10}$$

It should be noted that since government debt is unconstrained, the government budget constraint (6) need not be imposed on the Ramsey problem. It can be shown that the government budget constraint holds if the implementability constraint (or the present value budget constraint of individuals) and the feasibility constraint are satisfied. Once a solution is found, the government budget constraint can be used to back out the level of government debt.

2.3 Simulating Ramsey Taxes

It is assumed that individuals live for 55 years ($J = 54$) and the population grows at one percent per annum ($n = 0.01$). In this setting, one can think of individuals as beginning their economic life at age 21, which corresponds to model age 0, and living until real age 75. The labor productivity profile is taken from Hansen (1993) and normalized so that labor productivity is equal to one in the first year ($z_0 = 1$).[5] The utility function is specified as follows:

$$U\left(c_j, 1 - l_j\right) = \frac{c_j^{1-\sigma}(1 - l_j)^{\eta}}{1 - \sigma}, \tag{11}$$

where $\eta = \theta(1 - \sigma)$. Here, $1/\sigma$ is the intertemporal elasticity of substitution and θ reflects the intensity of leisure in individuals' preferences. I set the intertemporal elasticity of substitution equal to 0.5 ($\sigma = 2$) and the discount rate to 1.5 percent per year ($\beta = (1 + 0.015)^{-1}$). The parameter determining the intensity of leisure is set such that aggregate working time represents a third of total time ($\theta = 1.47$).

The production function is given by $f(k, l) = k^{\alpha} l^{1-\alpha}$. The capital share of output is set to 36 percent ($\alpha = 0.36$) and capital depreciates at a rate of 6.5 percent per year ($\delta = 0.065$).

[5] I actually use a smoothed version of the profile. The equation generating the productivity profile is $z_j = 0.4817 + 0.0679(j + 1) - 0.0013(j + 1)^2$ for $j = 0, \ldots, 54$, which is then normalized so that $z_0 = 1$.

The level of (per capita) government spending is set so that it represents 19 percent of steady state output. Simultaneously, the value of the intergenerational discount factor (γ) is chosen to make government debt equal to zero in the final steady state.[6] The value of γ which accomplishes this goal is 0.948, which implies a pre-tax interest rate equal to 6.5 percent and a steady state capital-output ratio equal to 2.76.

Figure 1 illustrates how taxes vary with age under this parametrization of the model. It shows that capital income taxes are positive (negative) when the labor supply is decreasing (increasing), and labor income taxes follow the shape of the labor supply.[7] By taxing or subsidizing capital, the government makes consumption and leisure in the future more or less expensive than today.[8] The government thus uses capital income taxes to smooth individuals' leisure and consumption profiles over their lifetime. When leisure is high tomorrow relative to today, the government taxes the return on today's savings at a positive rate tomorrow. Doing so, the government gives individuals an incentive to consume more and to save less today, and thus to consume less tomorrow. Since leisure is constant during retirement—which is endogenous—capital income is not taxed while individuals are retired. Notice, however, that consumption and leisure during retirement are taxed indirectly by taxing the return on savings prior to retirement.

3 Alternatives without Age-Dependent Taxes

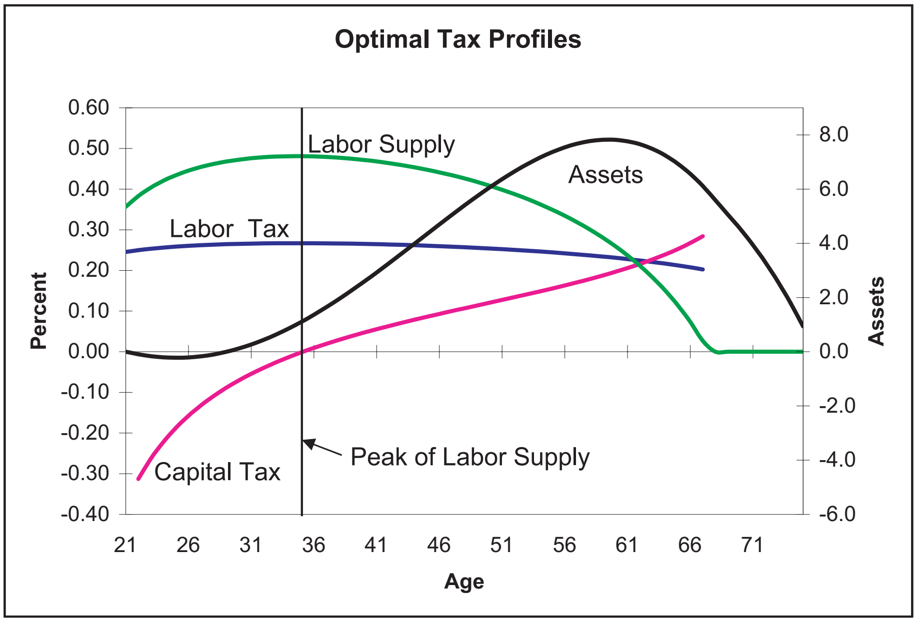
When the tax authority is precluded from using age-based taxation, one alternative is to resort to proportional age-independent capital and labor income tax rates, which can of course be chosen optimally. In this section, I take the allocation that obtains under this optimal age-independent tax code as a benchmark, and compare it to

[6]Note that different values of γ influence the level of the labor and capital tax profiles more than their shape: higher values of γ lead to lower government debt and lower tax rates in the long run.

[7]The fact that the tax on labor income peaks at the same age as the labor supply follows from the specification of the utility function, which assumes a unitary intratemporal elasticity of substitution between consumption and leisure. When the elasticity of substitution between consumption and leisure is below (above) one, the labor income tax profile peaks before (after) the labor supply profile peaks.

[8]It is generally known that taxing capital income is equivalent to taxing consumption tomorrow more than today. It is less often pointed out that the same holds true for leisure: taxing capital is also equivalent to taxing leisure tomorrow more than today.

Figure 1: Optimal tax rates over the lifetime of individuals



allocations obtained under various specifications of progressive tax systems.[9,10] This focus on allocations rather than on tax rates themselves is motivated by the fact that even if progressive taxation could perfectly imitate optimal age-dependent tax rates, the progressivity of the tax code caries additional distortions as it introduces a wedge between average and marginal tax rates that is not present under an age-dependent tax system. Before presenting simulation results, I first specify the tax function that will be used in those simulations.

[9]It should be clear that any progressive tax rates can replicated by some age-dependent tax system that is less distortionary. Similarly, an age-dependent tax system cannot do worse than an age-independent tax system. As such, the most interesting comparisons are between progressive tax systems and the age-independent tax system, which is the focus of this section. Some comparisons between age-dependent and age-independent tax systems can be found in Erosa and Gervais (2002).

[10]Only stationary allocations are considered. One advantage of doing so is that there is no need to discuss how the results depend on the intergenerational discount factor (γ): as long as government debt is the same in all steady states, allocations can be meaningfully compared. Of course, these steady state comparisons are subject to the usual drawbacks.

3.1 Average and Marginal Tax Functions

To specify a functional form for the tax function, I use tax rates imputed using the NBER TAXSIM model on data from the Current Population Survey (CPS) of the 1995 US Census.[11] Given the information available in the CPS data, the TAXSIM model calculates the tax liability that each individual in the sample faced under the 1995 U.S. tax code.[12] For each individual, the average tax rate is equal to the ratio of tax liability to adjusted gross income. The data used consist of the mean average tax rates for individuals in various 5-year age groups.[13] Figure 2 depicts the average tax rates as a function of income. Although many different functional forms could be used to approximate the progressivity of the U.S. tax code, the simplest one is perhaps a log-linear function, also shown on Figure 2.[14]

3.2 Simulations

I now solve for optimal proportional tax rates and use the allocation it induces as a benchmark for comparison with allocations obtained under various progressive tax systems.

Age-Independent Optimal Taxation In order to simulate optimal age-independent taxes, I use the same parameter values as in section 2.3, except for per capita

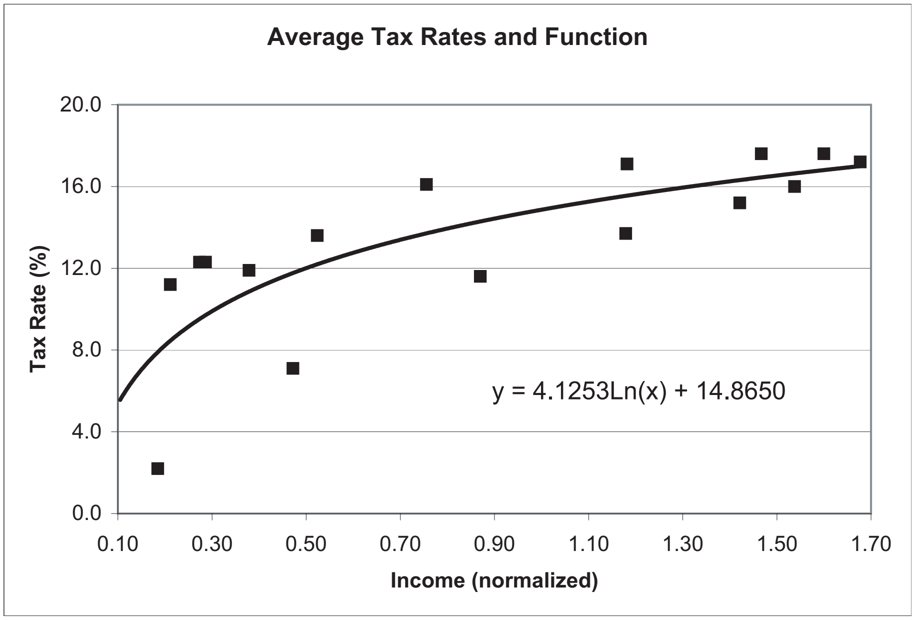
[11]For more information about the TAXSIM model, see Feenberg and Coutts (1993).

[12]It should be noted that the CPS is not an ideal source of property income data. In particular, it is assumed that all individuals are given only the standard deduction. This assumption may make the tax code appear more progressive than it is in reality. On the other hand, the information available in the CPS corresponds closely to the model, which also abstract from housing, the main component of itemized deductions.

[13]TAXSIM can also computes marginal tax rates, but since average tax rates are likely more reliable than marginal tax rates—and they need not be consistent with one another—I use the average tax data to estimate an average tax function from which the marginal tax function is derived.

[14]The tax function estimated by Gouveia and Strauss (1994)—which has been used by Sarte (1997), Castañeda et al. (2003), Conesa and Krueger (2005) and Conesa et al. (2009)—has the same shape as the log-linear tax function over the relevant range of income. Although the log-linear tax function is much easier to use, it does not have some of the nice properties that the Gouveia-Strauss tax function has. In particular, the tax rate at zero income is not zero, and the distance between the average and marginal tax functions does not converge to zero as income gets large.

Figure 2: Average Tax Rates from the Data



government spending (g) and the leisure preference parameter (θ).[15] I re-set these parameters such that the resulting equilibrium under optimal age-independent tax rates features a ratio of government spending to output equal to 19 percent, and is such that aggregate working time represents a third of total available time ($\theta = 1.427$). Of course, these parameters will be kept fixed for the rest of the analysis. The resulting optimal tax rates on labor and capital income are, respectively, 26.8 percent and 9.9 percent. The interest rate is equal to 6.78 percent and the capital to output ratio is equal to 2.71.

Progressive Taxation of Total Income Under a progressive tax system where the tax base is total income, the problem that individuals face is the maximization of

$$\sum_{j=0}^{J} \beta^j \, \frac{c_j^{1-\sigma}(1-l_j)^\eta}{1-\sigma},$$

$$\text{s.t.} \quad c_j + a_{j+1} = (1 - \bar{\tau}(y_j))y_j + a_j, \quad j = 0, \ldots, J,$$

[15]There is no need to discuss the intergenerational discount factor γ in this context. Nevertheless, there does exist a value of this parameter such that the solution to a Ramsey problem appropriately defined to account for age-independent tax rates converges to the allocation discussed below.

where

$$y_j = \hat{w} z_j l_j + \hat{r} a_j,$$

and the average and marginal tax functions are respectively given by

$$\bar{\tau}(y) = \pi_0 + \pi_1 \log y,$$
$$\tau(y) = (\pi_0 + \pi_1) + \pi_1 \log y,$$

with $\pi^1 = 4.1253$ (as shown in Figure 2) and π_0 set to raise a particular amount of tax revenues. The optimality conditions, although standard, are key to understand the results of this section:

$$-U_{c_j} + \beta U_{c_{j+1}}[1 + (1 - \tau(y_{j+1}))\hat{r}] = 0,$$
$$U_{l_j} + U_{c_j}(1 - \tau(y_{j+1}))\hat{w} z_j \leq 0, \quad \text{with equality if } l_j > 0.$$

The distance between the tax function $\bar{\tau}()$ and $\tau()$ thus determines how costly it is for the government to collect a certain amount of tax revenues, that is, it determines the wedge between the average and the marginal tax rates: whereas $\bar{\tau}()$ in the budget constraints measures the resources lost by the individual to the tax authority, $\tau()$ in the optimality conditions measures how costly it is to collect these taxes at the margin.

To compare the allocations under progressive taxation to that under age-independent taxes, the economies need to be parameterized so that they are indeed comparable. In particular, per capita government spending is maintained at the same level across all economies, and government debt is always equal to zero. I adjust the parameter π_0 from the tax functions in order for the latter requirement to hold in all economies. All other parameters of the model are held constant.

The results are shown in Table 1. The second column presents the results from the optimal age-independent tax code, and the third column presents results under a progressive tax system in which the tax base is total income. The last row of table 1 gives the percentage by which consumption would need to be increased/decreased in each period of one's life for that individual to be indifferent between the allocation obtained under the optimal age-independent tax code and some other given allocation. In other words, suppose that country A operates under the optimal age-independent tax code and country B operates under some progressive tax system. Then *ccomp*

Table 1: Progressive Taxation vs Optimal Proportional Taxation

	Age-Independent Taxes	Progressive Taxation of Total Income
q	1.000	0.946
c	0.607	0.576
i	0.203	0.180
k	2.711	2.398
l	0.571	0.560
ccomp (%)	0.000	−0.421

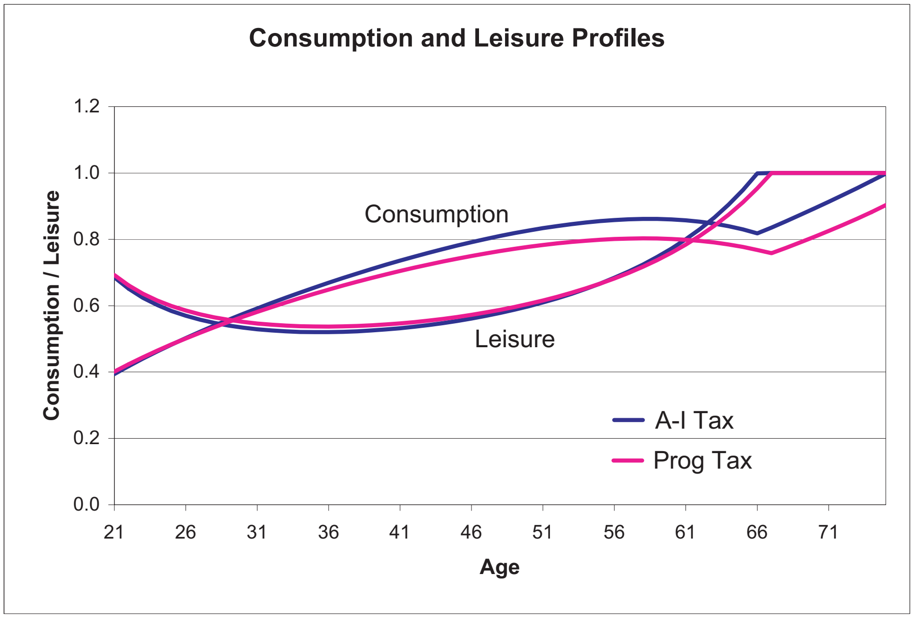
gives the percentage by which consumption at each age for an individual living in country A would need to be increased/decreased in order for that individual to be indifferent between being born in either country.

Table 1 indicates that capital and labor are respectively 11 and 2 percent lower under the progressive tax system with income as the tax base relative to their levels under the optimal age-independent tax code. These lower levels of inputs translate into a 5.4 percent reduction in output. Figure 3 shows that the consumption profile is lower under progressive taxation than under proportional tax rates while the leisure profile is higher except for a few years prior to retirement, which occurs later under progressive taxation. It is important to note that the consumption and leisure profiles are much flatter under progressive taxation than under proportional taxes, as effective after-tax interest rates are generally lower—except for the last two periods of life—under the progressive tax system. The benefits of progressive taxation (flatter profiles, and higher leisure), however, do not outweigh its costs (lower consumption) in this case, as individuals would have to forgo 0.42 percent of their consumption in every period under the age-independent tax system in order to be indifferent between the two tax systems under consideration.

I now investigate the extent to which the above results are affected by the tax treatment of capital income.

Progressive Taxation of Labor Income I now consider a tax system where labor income is taxed at progressive rates while capital income is taxed at a fixed

Figure 3: Age-Independent vs Progressive Taxation on Total Income



proportional rate—the tax system at the heart of the analysis of Conesa et al. (2009). It is interesting to note that the optimal labor income tax profile under the restriction that capital income be taxed at a flat rate is more hump-shaped than the one shown in Figure 1.[16]

The budget constraint under this tax system is given by

$$c_j + a_{j+1} = [1 - \bar{\tau}(y_j^l)]y_j^l + [1 + (1 - \tau^k)\hat{r}]a_j, \quad j = 0, \ldots, J,$$

where $y_j^l = \hat{w}z_j l_j$. The optimality conditions under this tax code, which show that the asset accumulation decision is no longer directly affected by progressive taxation, are as follows:

$$-U_{c_j} + \beta U_{c_{j+1}}[1 + (1 - \tau^k)\hat{r}] = 0,$$
$$U_{l_j} + U_{c_j}[1 - \tau(y_j^l)]\hat{w}z_j \leq 0, \quad \text{with equality if } l_j > 0.$$

As a starting point, the tax rate on capital is set at $\tau^k = 9.92\%$, its value under the optimal age-independent tax system. I then vary the tax rate on capital income

[16] Details are available upon request.

Table 2: Progressive Taxation vs Optimal Proportional Taxation

	Age-Independent Taxes	Progressive Taxation of Labor Income $\tau^k = 9.92\%$	$\tau^k = 0.0\%$	$\tau^k = 40.0\%$
q	1.000	0.973	0.974	0.948
c	0.607	0.585	0.580	0.587
i	0.203	0.198	0.204	0.171
k	2.711	2.643	2.721	2.277
l	0.571	0.554	0.546	0.579
$ccomp$ (%)	0.000	-1.060	-2.640	1.525

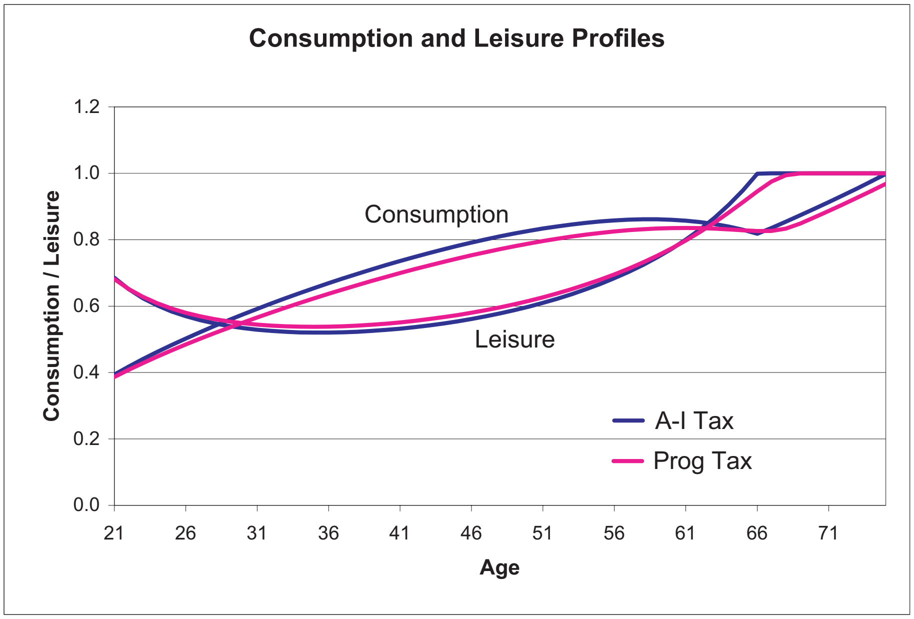
to measure its impact on the economy, adjusting the parameter π_0 of the labor tax functions to keep government debt equal to zero under a constant level of per-capita government spending. Results appear in Table 2.

The impact on the capital stock of taxing labor income at progressive rates is much less pronounced than with total income as a tax base. With $\tau^k = 9.92\%$, capital is only 2.5 percent lower than under the optimal age-independent tax code. This translates into higher output and consumption than under progressive taxation on total income, even though labor is slightly lower. Nevertheless, the shape of the consumption and leisure profiles, shown in Figure 4 for $\tau^k = 9.92\%$, is such that individuals prefer the age-independent tax system.

Interestingly, the fact that individuals are not better off under a flat capital income tax is not because the level of that tax is too high, as the fourth column of Table 2 indicates. The results in that column were obtained under progressive labor income taxes and a proportional tax on capital income equal to zero. While the capital stock is now higher than under age-independent taxes, the labor supply is much lower. Since the interest rate is higher than under age-independent taxes, the consumption profile, shown in Figure 5, is not as flat as it is under age-independent taxes. The fact that leisure is higher during the first and last few years of life does not make up for the lower consumption profile, and age-independent taxes are still preferred to progressive taxation.

The value of τ^k which achieves the highest level of utility—adjusting π_0 to keep tax revenues constant—is around 40.0%. Results from this experiment appear in the

Figure 4: Age-Independent vs Progressive Taxation on Labor Income: $\tau^k = 9.92\%$



last column of Table 2. Even though capital is 16 percent below its benchmark level, consumption is only 3 percent lower. As Figure 6 shows (under $\tau^k = 40.0\%$), the higher tax rate on capital income lowers the after-tax interest rate and induces individuals to choose flatter consumption/leisure profiles. These flat profiles more than compensate for the lower aggregate consumption and leisure levels, as the progressive tax system is now preferred to the optimal age-independent tax system. Figure 7 shows the main reason why a certain degree of labor tax progressivity is desirable in this environment, namely that the implied tax profile of this tax system imitates, albeit imperfectly, the optimal age-dependent tax rates found in section 2.3. It is also interesting to note that retirement, which is endogenous here, occurs much later under the progressive tax system than under the age-dependent or the age-independent tax systems, as the tax around retirement are lower under the progressive tax system.

As a final remark, note that the capital stock under this tax system (with $\tau^k = 0.40$) is *lower* than it is under the tax system with progressive taxation of total income (see Table 1). If we take the latter tax system as an approximation of the U.S. tax system, this last remark suggests that generations in a transition from the U.S. tax system to a tax system with progressive taxation on labor income (with a relatively high tax rate on capital income) may also gain from such a tax reform.

4 Conclusion

This paper studies optimal and progressive taxation in a standard life-cycle economy. In this economy, it is generally optimal for a government to use both capital and labor income taxes, even in the long run. Under a widely used utility function, the optimal tax rate on capital and labor income vary with age and are a function of the labor supply: when the labor supply increases (decreases), the tax rate on capital income is negative (positive) and the tax rate on labor income is increasing (decreasing). Through these principles, the government essentially attempts to tax consumption and leisure relatively heavily when they are relatively high/inelastic. Conversely, the marginal tax rates that individuals face in the U.S. also depend on age, simply because of the progressivity of the tax code and the fact that earnings vary with age.

Allocations under different progressive tax systems are compared to a benchmark allocation taken to be the solution to a Ramsey problem which imposes tax rates to be age-independent. Results indicate that even if the progressivity of the tax code introduces additional distortions, a tax system in which labor is taxed at progressive rates with a relatively high tax on capital income is preferred to optimal flat taxes. The underlying reason for this result is that progressive taxation can imitate optimal age-dependent tax rates, albeit imperfectly so. As such, the desirability of progressive taxation emanates from efficiency reasons alone, without relying on any insurance nor re-distribution arguments.

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Figure 5: Age-Independent vs Progressive Taxation on Labor Income: $\tau^k = 0\%$

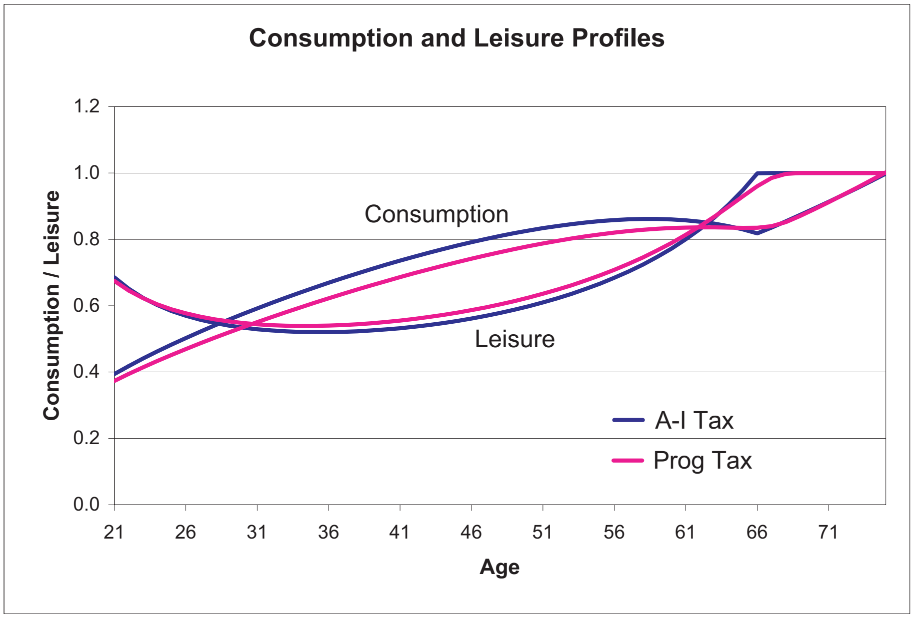


Figure 6: Age-Independent vs Progressive Taxation on Labor Income: $\tau^k = 40\%$

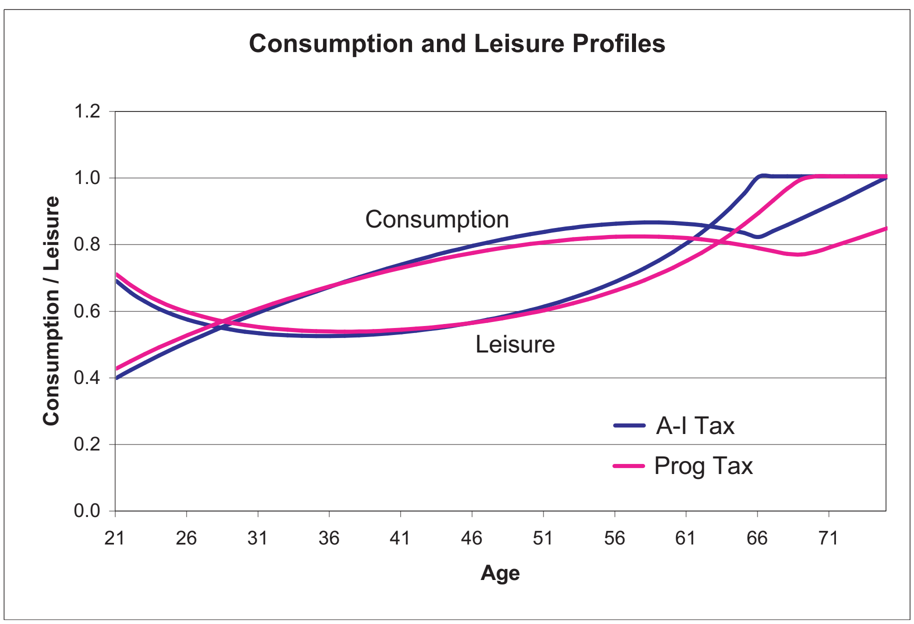
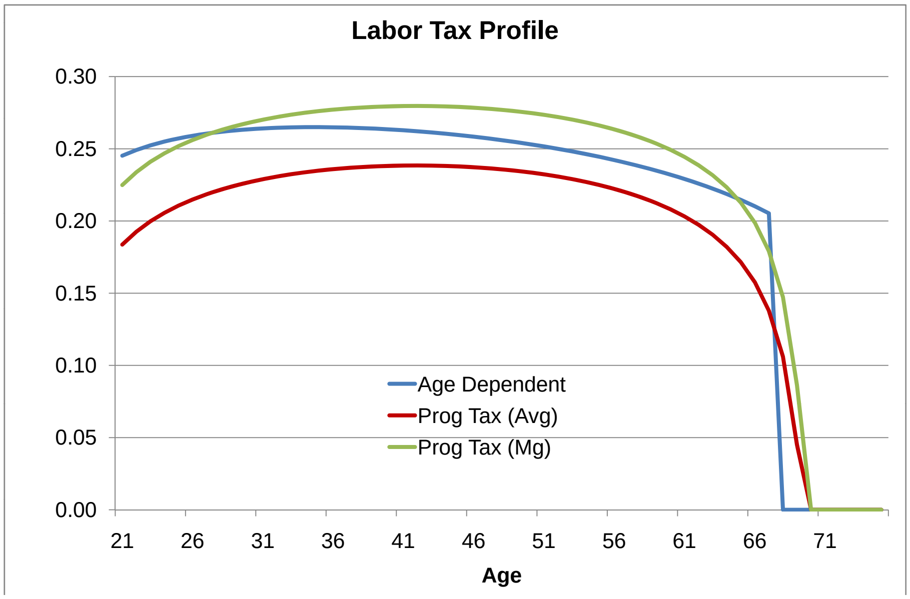


Figure 7: Age-Dependent and Progressive ($\tau^k = 40\%$) Labor Income Tax Rates



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