A Stylized Tax Reform in Presence of Precautionary Saving

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December 22, 2006

Abstract

This analyzes a stylized tax reform in a Bewley-type model in which agents face uninsurable idiosyncratic shocks and borrowing constraints. The reform replaces a progressive income tax system with an X-tax scheme. The X-tax preserves the risk-sharing characteristics existing in the progressive income tax system but, at the same time, removes distortions to saving behaviors. According to the model, capital would increases by 12 percent in the long-run; output would expand by 3 percent. The aggregate welfare gains are positive and equivalent to a 1.2 percent permanent increase in consumption. The majority of the population would experience welfare gains from moving from a progressive income tax system to an X-tax system.

*The views expressed in this paper are those of the author and should not be interpreted as those of the Congressional Budget Office. Prepared for presentation at the ASSA meetings 2007.

1 Introduction

Tax reform has been a subject of economic and political debate in the US during the last two decades. The main issues focus, on one hand, on the complexity of the tax code and, on the other hand, on more theoretical questions, such as taxing capital income and using separate tax schedules for capital and labor income. The current US federal tax system is based on a single non-linear tax schedule for income from capital and labor at the individual level and on a (mostly) linear schedule for capital income at the corporate level. In addition, a complex set of deductions, exemptions and accelerated depreciation rules allow for a reduction of the statutory marginal tax rates.

The system distorts individuals' economic behavior in several ways that have been widely investigated in the public economics literature. In particular, capital accumulation and labor supply decisions are distorted by progressive taxation and double taxation of capital income (i.e. at the corporate and individual levels). Moreover, because capital and labor income are taxed jointly (and non-linearly) at the individual level, decisions about saving affect the marginal tax rate on labor income and, conversely, decisions about labor supply affect the marginal tax rate on capital income.

The present paper investigates whether a particular type of reform proposed by Bradford (1984), the so called X-tax, would improve economic welfare in presence of realistic economic frictions, such as borrowing constraints and uninsurable risks. An X-tax type of system would maintain the progressivity of the current US tax system for labor income while imposing a linear tax rate on cash-flows from capital and allowing for full expensing of investment in new capital[1]. These features would result in a zero effective marginal tax rate on income from new capital.

Several previous papers have studied the possibility of removing some of the distortions characterizing the current US tax system. Most of the literature makes use of a representative-agent framework and traditionally focuses on eliminating capital income taxes (Lucas, 1990; King and Rebelo, 1990; Cooley and Hansen, 1992). All those works build on the seminal contribution of Chamley (1986), who showed that the optimal capital income tax rate is zero in a wide range of infinitely-lived representative agent models. Those studies all conclude that the economy would experience a substantial long-run welfare improvement and significant macroeconomic effects on capital accumulation and growth when capital income is replaced by a higher labor income tax or by consumption tax.

Models that include heterogenous agents find that the efficiency gains vary across different types of agents. For instance, Auerbach and Kotlikoff (1987) find that if income from capital and labor are unevenly distributed among the population, as in any standard overlapping generations model, changing the composition of taxes by taxing capital income at lower rates would redistribute wealth towards those households who own higher stocks of assets and whose income is mainly composed by capital income (old retired generations).

[1] The X-tax also allows for protection of residential wealth which reduces the effective taxation of cash-flows from capital.

Aiyagari (1995) shows that for a Bewley (1986) class of heterogeneous agents models in presence of uninsurable idiosyncratic risk and borrowing constraints, the optimal capital income tax rate is positive. The motivation for this result builds on the ex post heterogeneity that arises if agents cannot insure against their idiosyncratic uncertainty. Periods of good and bad uninsurable shocks would break the infinite horizon problem of the agents populating the economy into a sequence of short horizon optimization problems, very similar to the ones faced by agents in overlapping generations environments.

Furthermore, the uncertainty about the timing of the different shocks and the possibility of being borrowing-constrained drives the individual to accumulate a buffer-stock of precautionary savings such that the aggregate accumulation of capital is suboptimal compared to a representative-agent framework. The suboptimal stock of aggregate capital leads to a return on capital below the rate of time preference therefore a positive capital income tax rate would be necessary to bring the pre-tax capital return to equality with the rate of time preference.

Other works analyzing the elimination of capital income taxation in heterogenous agents models with precautionary savings are Domeij and Heathcote (2004) and Nishiyama and Smetters (2005). Domeij and Heathcote (2004) study the replacement of the capital income tax with higher labor income tax or with a consumption tax within a Bewley (1986) framework, similar to Aiyagari (1994, 1995), where agents face uninsurable earning ability shocks and borrowing constraints. They find that the elimination of the capital income tax in the US economy would cause a significant increase in the agents' asset accumulation but penalize significant fractions of low and medium income classes, depressing their consumption levels.

Nishiyama and Smetters (2005) study the replacement of a progressive income tax with a linear consumption tax exploiting a calibrated overlapping generations model with idiosyncratic earning ability shocks (similar to Aiyagari, 1994 and 1995) and life uncertainty. They find that this reform reduces efficiency, even though aggregate capital and output increase over the transition path and in the new steady state equilibrium. These dynamics result mainly from the reduction in the intragenerational insurance provided by the tax system and from an uneven intergenerational distribution of welfare gains and losses. In other words, most of the old-retired and poor generations would suffer from a tax on consumption while the middle-age working generations would also suffer from the loss of risk sharing provided through the current progressive taxation system.

This paper focuses on the X-tax, which eliminates distortions to savings decisions [2] while maintaining (or enhancing) the progressivity of the tax system with its risk-sharing properties. An environment *a la* Bewley (1986) represents an interesting laboratory for analyzing the impact of such a reform, since the features of insurance and risk-sharing of a progressive taxation system would

[2] Since cash flows from capital are taxed at a flat rate and it is possible to fully expense the investment in new capital, the effective marginal taxation of capital income would be zero.

play an important role, in presence of uninsurable idiosyncratic shocks. Furthermore, the X-tax introduces a separate schedule of taxes on capital and labor income, so that capital and labor income are not combined into a single tax base facing a single non-linear tax schedule. If agents save also for precautionary motives, the suboptimal asset accumulation affects the amount of marginal tax the individual pays on both capital and labor income, distorting two marginal decisions at the same time. By considering capital and labor income as two separate tax bases, the X-tax would eliminate this type of distortion.

My work relates closely to Domeij and Heathcote (2004). I adopt a general equilibrium, incomplete-markets model in which agents live infinitely and receive idiosyncratic shocks to their earning abilities. Constraints to borrowing capacities limit their ability to smooth consumption when received a low earning shock.

While Domeij and Heathcote (2004) consider the elimination of a capital income tax in a proportional taxation system, I instead model replacing the actual US progressive income taxation system with an X-tax. I calibrate the model to the US facts, with the constraint of reproducing a realistic distribution of wealth and labor earnings.

I then simulate the elimination of capital income taxation by replacing the existing progressive income taxation system with an X-tax scheme. The main findings are: (i) the introduction of an X-tax produces a significant capital accumulation and output increase; (ii) in contrast to the reform analyzed by Domeij and Heathcote (2004), the majority of the population would experience a welfare improvement from the introduction of an X-tax.

The rest of the paper is organized as follows. The second section presents the model economy and the calibration procedure. The third section describes the experiment and the results. Finally the fourth section adds some concluding remarks.

2 The model economy

The economy is populated by a continuum of households, a representative competitive firm and a government. The government operates under full-commitment rules and designs a policy schedule that shapes the taxation system.

2.1 Household

The economy's population is composed by a continuum of measure one ex-ante identical households living infinitely. Time flows through several calendar dates t and each time period is equivalent to one year. At each date t, the household receives a shock to its own labor earning ability e_t, taking values in the set $E = \{e_1, ..., e_i\}$, and cannot insure against it. The incompleteness in the insurance markets makes it possible for the idiosyncratic risk to make the households ex-post heterogeneous. The household's earning ability or productivity follows a first-order Markov process, with transition probabilities between two states

e_i, e_j in the space E given by $\pi_{i,j}(e_{t+1} = e_j \mid e_t = e_i)$. The probability measure or distribution of household on E at each time t is represented by μ_t, with $\mu_t(E) = pr(e_t \in E) \geq 0$. If the initial measure of households with respect to their earning ability is represented by a vector $\mu_{t=0}$, then the measure at some date t would be $\mu_t = \mu_{t=0}\Pi^t$, where Π represents the transition probability matrix, whose elements are the $\pi_{i,j}$.

At each date t, after observing the realization of e_t the household decides how much to consume c_t, how much labor to supply h_t, and next period's asset holding a_{t+1}, in the form of a single risk-free savings instrument. In the choice of the optimal assets to carry over the next period the household also faces borrowing constraints, in terms of the minimum assets he is allowed to hold. Hence, although agents live forever, sequences of bad shocks will lead to periods of binding borrowing constraints.

Let A be the asset space assumed to be non-negative, $A \in \mathbb{R}_+$. The household's state space is therefore determined by $(A \times E)$ and the household's states are represented by the vector $s_t = (a_t, e_t)$. Let $x_t(s)$ be the measure of households across both the individual assets and the earning abilities at time t, and $X_t(s)$ be the corresponding cumulative measure such that $\int_{A\times E} dX_t(s) = 1$.

Since the economy does not experience any aggregate uncertainty, the households have perfect foresight of the aggregate return on capital r_t and on the aggregate wage rate w_t, although they do not know their own future wage. The aggregate states of the economy relevant for the individual vector of decisions rules $d_t = (c_t, h_t, a_{t+1})$ are $S_t = (x_t(s), B_t)$, where B_t represents the government debt (wealth) that I will discuss in further details later. The economy is then characterized by a set of government policy schedules, affecting the individual's decision rules. Let Θ_t denote the policy schedule set by the governments. The optimization problem of the household can now be defined recursively as:

$$V(s_t, S_t; \Theta_t) = \max_{c_t, h_t, a_{t+1}} u(c_t, h_t) + \beta E_{e_{t+1}|e_t}[V(s_{t+1}, S_{t+1}; \Theta_{t+1})] \tag{1}$$

subject to

$$a_{t+1} = (1 + r_t)a_t + w_t e_t h_t - c_t - T(a_t, h_t; \Theta_t) + TR \tag{2}$$

$$A \in \mathbb{R}_+. \tag{3}$$

where β is the time preference parameter, $T(a_t, h_t; \Theta_t)$ represents the total individual tax function with a tax base jointly determined by the the asset holding a_t and by the labor supply h_t, and TR is a government lump-sum transfer. The utility function $u(c_t, h_t)$ expressing the individual preferences over the consumption level c_t and the leisure $\ell_t = (1 - h_t)$ is specified as a time-separable isoelastic Cobb-Douglas[3]:

$$u(c_t, h_t) = \frac{[c_t^{\alpha}(1 - h_t)^{(1-\alpha)}]^{(1-\gamma)}}{1 - \gamma} \tag{4}$$

[3] The utility specification makes preferences consistent with the analysis of Aiyagari (1994, 1995).

γ is the coefficient of relative risk aversion and α is the share of consumption in the household's preferences. Given the household optimization problem, the law of motion of the measure $x_t(s)$ is determined by:

$$x_{t+1}(s) = \int_{A\times E} I_{[a_{t+1}=a_{t+1}(s_t,S_t;\Theta_t)]}\pi_{t,t+1}(e_{t+1} \mid e_t)dX(s_t) \tag{5}$$

where $I_{[a_{t+1}=a_{t+1}(s_t,S_t;\Theta_t)]}$ is an indicator function taking value of 1 if the decision variable $a_{t+1} = a_{t+1}(s_t, S_t; \Theta_t)$.

2.2 Production

The production takes place in a representative firm operating with a Cobb-Douglas constant-return-to-scale technology. At each date t, the firm uses aggregate capital K_t and aggregate labor L_t as inputs to produce a single output Y_t through the production function $F(K_t, L_t)$. The firm pays a linear tax $\tau_{c,t}$ on its profits[4]. The tax system allows the firm to immediately expense a fraction z_t of the investment I_t in new capital as a deduction from the tax base and introduces a wedge between the value of the new and existing capital. Taking the latter into account, the firm chooses the optimal level of the inputs and investment to maximize a stream of profits:

$$\max_{L,K,I} \sum_{t=0}^{\infty} \prod_{n=0}^{t} (1+r_n)^{-1}[F(K_t, L_t) - w_t L_t](1-\tau_{c,t}) - I_t(1 - z_t\tau_{c,t}) \tag{6}$$

subject to

$$K_{t+1} = I_t + (1-\delta)K_t \tag{7}$$

where (7) represents the law of motion of capital and $F(K_t, L_t)$ determines the production technology as follows:

$$F(K_t, L_t) = A_t K_t^{\theta} L_t^{(1-\theta)} \tag{8}$$

The parameter θ represents the share of the capital input in the production process.

2.3 Government

The government designs the particular tax system, by choosing a policy schedule, and commits to it. At each date t, the government finances a constant public consumption G, a constant lump-sum transfer to the households TR, and by issuing one-period debt B_t[5] and by levying taxes. From the households'

[4] This tax can be interpreted as a corporate income tax or as a capital income tax, in general, and by owning shares of the representative firm the household receives an after-tax return on capital r_t.

[5] In the case in which the government run surplus over time and accumulate wealth, the B_t can be interpreted as government wealth and in this case represents a negative debt in the equations.

perspective, government debt (or wealth) and capital are perfect substitutes since both deliver a risk-free return in absence of aggregate risk and transaction costs. An equilibrium condition will equate the aggregate household asset holdings in the economy to the sum of the government debt and capital stock.

In this economic environment, by designing a certain tax system, the government also provides the only mechanism to share risk among households. The tax mix chosen as elements of the policy schedule vector Θ_t determines the amount of insurance against idiosyncratic shocks, along with the stock of assets accumulated for precautionary purposes.

The taxation system is shaped by a tax function, introduced by Gouveia and Strauss (1994), that taxes capital and labor income progressively and jointly:

$$T(a_t, h_t; \Theta_t) = \phi_0\{(\phi_c r_t a_t + \phi_l w_t e_t h_t) - [(\phi_c r_t a_t + \phi_l w_t e_t h_t)^{-\phi_1} + \phi_2]^{-1/\phi_1}\} \quad (9)$$

where ϕ_0, ϕ_1, ϕ_2 are the parameters that determine the progressivity of the system, with $\phi_1, \phi_2 > 0$, and ϕ_c, ϕ_l represents the parameters that transform the economic income into taxable income. The government defines the policy schedule vector that the households use in the economy to solve their optimization problems:

$$\Theta_t = (\phi_0, \phi_1, \phi_2, \phi_c, \phi_l, z, \tau_{c,t}, G, TR, B_{t+1})$$

The vector Θ_t includes a non-zero $\tau_{c,t}$ if the government taxes capital income at both individual and firm level[6]. The law of motion for the government debt is the following:

$$B_{t+1} = (1 + r_t)B_t + G + TR - \int_{A\times E} T(a_t, h_t(s_t, S_t); \Theta_t)dX(s_t) \quad (10)$$

2.4 Equilibrium definition

A recursive equilibrium for this economy is a value function $\{V(s_s, S_s; \Theta_s)\}_{s=t}^{\infty}$, and a vector of decision rules $\{c_s, h_s, a_{s+1}\}_{s=t}^{\infty}$ for the household optimization problem, a probability measure μ_0 and $\{\mu_s(E)\}_{s=t}^{\infty}$ for the initial and time path of the mass of the population in each earning ability state $e_s \in E$, the return on capital $\{r_s\}_{s=t}^{\infty}$ and the wage rate $\{w_s\}_{s=t}^{\infty}$, a measure of households across both the individual wealth and earning ability $\{x(s_s)\}_{s=t}^{\infty}$, a policy schedule vector $\{\Theta_s\}_{s=t}^{\infty}$ and a vector of aggregate variables $\{K_s, L_s\}_{s=t}^{\infty}$ such that:

1. $\forall t$ the decision rules $\{c_t, h_t, a_{t+1}\}$ solve the household's optimization problem described by (1)-(2), given r_t and w_t, the policy schedule in place Θ_t, and the sequence $\{\mu_s(E)\}_{s=0}^{t}$.

2. $\forall t$ the firm solves the optimization problem described by (6)-(8), given Θ_t and $x(s_t)$ and the arbitrage condition between installed and new capital,

[6] This specification captures one of the features of the US federal taxation system that levies taxes in a progressive way at the individual level and mostly in a proportional way at the firm level through the corporate income tax.

stemming from the firm's optimal investment rule, holds and requires the installed capital K_t having a unit value of:

$$q_t = 1 - z_t \tau_{c,t} \tag{11}$$

where q_t represents the Lagrange multiplier attached to constraint (7)[7]. From the solution of the firm's problem and given the condition (11), the return on capital and the wage rate satisfy:

$$r_t = \frac{\left\{[\theta K_t^{\theta-1} L_t^{1-\theta}](1-\tau_{c,t}) + q_{t+1}(1-\delta) - q_t\right\}}{q_t} \tag{12}$$

$$w_t = (1-\theta) K_t^{\theta} L_t^{-\theta} \tag{13}$$

3. $\forall t$ given the conditions (11)-(13) the factor markets clear:

$$K_t + B_t = \int_{A\times E} a_t dX(s_t) \tag{14}$$

$$L_t = \int_{A\times E} e_t h_t(s_t, S_t; \Theta_t) dX(s_t) \tag{15}$$

4. $\forall t$ given the policy schedule vector Θ_t, the prices r_t and w_t, the households decision rules $\{c_t, h_t, a_{t+1}\}$, the government budget constraint (10) is satisfied, such that the government debt is bounded.

5. $\forall t$ the goods market clears:

$$C_t + G + K_{t+1} - (1-\delta)K_t = F(K_t, L_t) \tag{16}$$

$$C_t = \int_{A\times E} c_t(s_t, S_t; \Theta_t) dX(s_t) \tag{17}$$

The equilibrium definitions highlight the fact that households do not make any portfolio choice between shares of the capital and government debt. Households are indifferent between capital and government debt because there is no aggregate uncertainty in the form of aggregate productivity shocks. The return on capital and from the government debt service is certain and in equilibrium the two returns must be equal.

The economy is in a steady state recursive equilibrium if the aggregate states of the economy are constant over time which implies that $S_{t+1} = S_t$.

[7] The arbitrage condition leads to the definition of the Tobin's q, that can be also seen as the value of one unit of capital in terms of consumption. It is necessary to apply q to convert one unit of physical capital into the equivalent consumption units.

2.5 Solution method

I first solve for a initial steady state equilibrium, where the economy is in $t = 0$, and then I simulate a tax reform and solve for the transition path to a final steady state.

To compute an equilibrium, I use an inner loop to solve for the households stochastic optimization problem and then aggregate the individual optimal decision rules to obtain the aggregate variables. I discretize the state space $A \times E$, using $g \times 3$ grid points to determine the assets and earning space, as a function of the scale and the standard deviation of the earning ability shock σ: $E = \{e_1, e_2, e_3\}$ and $A = \{a_1, ..., a_g\}$. The discretization of the space allows a solution of the household Euler equations and to find the value function that satisfies the Euler equations ever the entire assets space for the different types of households in the economy.

With an outer loop, the algorithm searches for convergence in the return on capital and the wage rate that, given the aggregate capital and labor, would satisfy all the conditions for the recursive equilibrium. The solution method is described in further details in Appendix A1.

2.6 Parametrization

Since the time period in the model is one year, all the parametrized values are in yearly terms. Some of the parameters are taken from the standard literature; some are calibrated to relevant facts of the US economy.

The following Table 1 reports the value assigned to the parameters characterizing the steady state equilibrium before time $t = 0$ (i.e. before any policy experiment).

Table 1

Parameter values in the initial steady state equilibrium

Capital share in the production function	θ	0.3
Depreciation rate	δ	0.05
Time preference parameter	β	0.956
Share of consumption in the utility function	α	0.58
Relative risk-aversion parameter	γ	2.0

2.6.1 Production

The parameters for the specification of the Cobb-Douglas technology and the depreciation of physical capital are standard. The capital's share θ in the production function is set to 0.3 and the depreciation rate δ is set to 0.05. At each date t, the capital K and the government debt B correspond to the sum of the private asset holdings. Given the specified technology, the capital-to-output ratio is targeted to 3.3, a value consistent with Cooley and Prescott (1994). To reproduce this fact, the time preference parameter β is set to 0.956.

2.6.2 Households

The share of consumption α in the utility function is 0.58 and the coefficient of relative risk aversion γ is 2.0. Given the latter, the α is chosen as to make the average working hours of a household to be the 39% of the maximum available time consistent with working hours data from SCF 2001, as reported in Nishiyama and Smetters (2005). The implied intertemporal elasticity of substitution (IES) for consumption is 0.63, consistent with a range of values estimated by Laitner and Silverman (2005) for the same utility specification.

Households' earning abilities and their stochastic properties are a key feature of the model since they will generate agents' ex-post heterogeneity in wealth and income. As I already mentioned, tax reforms that change the composition of capital and labor income taxes would have different impact on the welfare of the households populating the economy depending on their individual shares of the capital and labor income. The probability measure of household across the earning abilities states $\mu(E)$ and the matrix that defines the transition probabilities between two states, Π, are crucial to the realistic representation of the US distribution of capital and labor income. It is also necessary to define the persistence ρ and variance σ^2 of the earning ability shock and derive the condition that ensures that μ_t converges to a unique ergodic distribution μ^*, independent on the initial measure μ_0. The process involves finding the eigenvector μ associated with the unit eigenvalue of the matrix Π, such that $\mu = \mu\Pi$.

I follow Domeij and Heathcote (2004) in choosing a three-point discrete set for the earning ability state space, $E = \{e_1, e_2, e_3\}$ and their steps to compute the Markov transition matrix. They find this to be the smallest number of states that allows to minimize the number of parameters to choose to define the earning process under the constraint of representing the US wealth distribution, which appears particularly skewed. They also impose three constraints on the Π matrix:

(i) The fraction of the population the low and high earning ability households are the same. This imply that two of the elements of the eigenvector, μ_1 and μ_3, take the same value.

(ii) The household cannot move between the two extreme states of earning ability e_1, e_3 but they always pass through the intermediate one, e_2.

(iii) The probability of moving from the medium earning ability state e_2 to the low or high states be the same

Imposing these restrictions means that:

$$\pi_{11}(e_{t+1} = e_1 \mid e_t = e_1) = \pi_{33}(e_{t+1} = e_3 \mid e_t = e_3)$$

and the Markov transition matrix looks like:

$$\Pi = \begin{bmatrix} \pi_{11} & 1-\pi_{11} & 0 \\ \frac{1-\pi_{22}}{2} & \pi_{22} & \frac{1-\pi_{22}}{2} \\ 0 & 1-\pi_{11} & \pi_{11} \end{bmatrix}$$

The matrix has to reproduce, as the last constraint, a reasonable persistence ρ and variance σ for the earnings process consistent with empirical longitudinal studies. Most of these studies estimate these two parameters assuming that the labor (log) earnings process can be approximated by an AR(1), that has a discrete representation in a Markov chain. The AR(1) of a log-productivity process can be summarized by the serial correlation or persistence parameter ρ and by the standard deviation σ. I set $\rho = 0.9$ and $\sigma = 0.26$ consistent with the range of values found in many empirical studies of data from PSID (Card, 1991; Storesletten, Telmer, and Yaron, 2001).

I compute the elements of the transition matrix and the values for the three earning ability states following the procedure described by Domeij and Heathcote (2004). I choose some values for μ_1 and e_2 and compute endogenously the value for the transition probabilities and for the other states, having as constraints the points (i)-(iii), the condition $\mu = \mu\Pi$, and the chosen ρ and σ. The endogenous computation is such that when the economy is simulated the wealth distribution and the earning distribution reach some reasonable values, measured by the Gini coefficient.

Given the $\rho = 0.9$ and $\sigma = 0.26$ and the vector μ, the relevant elements of the Π are obtained as follows:

$$\pi_{11} = \rho + \frac{(1-\rho^2)(1-\log e_2)}{\sigma^2}$$

$$\pi_{22} = \frac{\mu_2 - 2\mu_1(1-\pi_{11})}{\mu_2}$$

The Gini coefficient for the asset holdings distribution is 0.74[8]. The economy earnings distribution instead is less concentrated and the Gini coefficient earnings is 0.34[9]. The values of the three states are reported in Table 2, where I summarize all the parameters that characterize the earning process stochastic properties.

[8] Kennickell (2004) reports Gini coefficients ranging from 0.73 to 0.76 for the time period 1989-2004 using the Survey of Consumer Finances data.

[9] Quadrini (2000) finds a Gini coefficient for labor earnings of 0.45 using Panel Studies of Income Dynamics (PSID) data and of 0.57 using Survery of Consumer Finances (SCF) data. A Gini coefficient of 0.33 is acceptable since the model abstract from households heterogeneity in life-cycle and education earnings' profiles.

Table 2

Earning ability process: stochastic properties	
e_1	0.16
e_2	0.92
e_3	5.04
μ_1	0.045
μ_2	0.909
μ_3	0.045
π_{11}	0.91
π_{22}	0.99
Wealth and earnings distribution	
$Earnings\ Gini$	0.34
$Asset - Holdings\ Gini$	0.74

2.6.3 Government policy schedule

Government sets the value of the government expenditure, the value for the next period debt and shapes the taxation system by choosing the relevant parameters for the tax function. In this way it designs the policy schedule Θ_t. Table 3 summarizes the value of the parameters characterizing the schedule at time $t = 0$.

I assume that the level of government consumption G, government lump-sum transfer TR and government debt B are set as a percentage of the aggregate output Y, in the initial steady state. TR is chosen to match the ratio of the transfers payments to the aggregate output Y of 0.13 (from National Income and Product Account data, 2005), and B is set to match a ratio of the government debt to the aggregate output Y of 0.37 (Budget of the US Government data, 2005). In the initial steady state at $t = 0$, G is used to close the budget constraint of the government Its value is 7 percent of the aggregate output, which closely matches the actual data.

Taxation system The fiscal parameters for the capital and labor income taxation are set to match the effective marginal tax rate on capital and labor income for the US federal tax system. Effective marginal income tax rates are lower than the statutory tax rates since the household's taxable income is lower than the economic income, because of various deductions and exemptions available to individuals and firms.

I choose to calibrate the taxes to the 2001 system and ignore the effect of the Economic Growth and Tax Relief Reconciliation Act (EGTRRA) reform, introduced after the 2001 and assumed to be in place for a short period of time, until the 2010. The calibration of the progressive tax system involves the choice of the parameters that specify the tax function in (9).

I use Nishiyama and Smetters (2002) estimates for the three parameters characterizing the Gouveia and Strauss (1994) tax function, that asymptotically reproduces the progressive US federal income tax system before EGTRRA. The parameter values are the following: $\phi_0 = 0.41, \phi_1 = 0.85$ and $\phi_2 = 0.106$[10]. When the parameters are plugged into the (9) the tax schedule in the model replicates the statutory one.

Household's economic income is transformed into the taxable income by applying some adjustment factors to the capital and labor components of the individual tax base. These factor are ϕ_c for the capital income and ϕ_l. Using data from the Bureau of Economic Analysis (2005), I compute the fraction of corporate income ϕ_{corp} on the total national income in the US economy. Using this fraction and data on total deductions and exemption from the IRS, I compute ϕ_c and ϕ_l to match the effective marginal tax rate from capital and labor income, following an algorithm described in details in Appendix A2.

The value for the parameter are: $\phi_c = 0.41$ and $\phi_l = 0.84$. I also impose a tax on the firm's profits calibrated to the higher corporate income rate, $\tau_c = 0.35$ and account for accelerated depreciation, through $z = 0.2$, and the fraction of total national income that is taxed at corporate level through $\phi_{corp} = 0.27$. The corporate income tax rate is then adjusted by multiplying it for the parameter ϕ_{corp} to account for the fact that not all the capital employed by the firm would be taxed as corporate capital.

Table 3

Policy schedule parameters in $t = 0$

G/Y	0.07
B/Y	0.37
TR/Y	0.13
ϕ_0	0.41
ϕ_1	0.85
ϕ_2	0.106
z	0.20
τ_c	0.35
Parameters to obtain effective taxation	
ϕ_l	0.84
ϕ_c	0.41
ϕ_{corp}	0.27

The calibrated vector of parameters and variables characterizing the policy schedule is:

$$\overline{\Theta} = (\phi_0, \phi_1, \phi_2, z, \tau_c, \phi_l, \phi_c, G, TR, B) \tag{18}$$

[10] The latter value is adjusted to be consistent with the unit of measure of the income in the model economies.

3 Policy experiment

The economy is in an steady state equilibrium, characterized by the policy schedule $\overline{\Theta}$ described in the previous section, when in $t = 0$ the government announces a new policy schedule $\Theta_{t=0}$, characterized by a reform of the current taxation system.

The reform replaces the current US federal progressive income taxation system, described in Section 2, with an X-tax system[11]. The particular system introduced can be seen as a consumption tax which maintains a progressive piece for the taxation of labor income.

The reform can be described by the change in some parameters that characterized the previous policy schedule, $\overline{\Theta}$. I set some of the elements of $\Theta_{t=0}$ to new values, $\phi_{c,t=0} = 0$, $\phi_{corp,t=0} = 1$ and $z_{t=0} = 1$, leaving the other parameters unchanged. Since $\phi_{c,t=0} = 0$, capital now does not contribute to the tax base jointly with labor at the individual level, but income from old capital is taxed at the firm level[12]. New capital is fully expensed. The tax on labor increases to make the reform revenue neutral. The government commits to the new policy schedule parameter vector from $t = 0$ on.

3.1 Results: impact on macroeconomic variables

Table 4 reports the results of the replacement of the progressive income taxation system with the X-tax scheme. The capital stock increases significantly during the transition and in the long-run reaches a level that is 12% higher than the initial steady state level. Labor supply weakly increases during the transition and in the long-run equilibrium represents the 0.14% of the initial steady state.

There are several forces driving these results. The elimination of the joint non-linear taxation of labor and capital income removes a distortion to the marginal decision of labor supply. Also the reduction in tax-adjusted q and the resulting decline in household's wealth during the early years of the transition will induce people to work, despite the increase in the marginal tax rates on labor income that depress the after-tax wage rate.

The fact that the new system allows for full expensing of the investment to leads to a substantial stimulus to capital accumulation that requires a sacrifice in the private consumption levels during the first transition years, although labor supply increases. Aggregate consumption drops but only for a few years, due to the effect of these forces, but then stabilizes at a higher level than the initial steady state one (2.5% higher in the long-run). The full expensing of investment in new capital and the removal of the distortion on individual saving decision

[11] The reform impleted here involves the introduction of a sort of pseudo X-tax. The X-tax in fact contemplates a special treatment for the housing sector. I do not consider it here explicitely but the my results would even be stronger since such a special treatment impose a more favorable tax relief for capital income.

[12] The X-tax would protect non-residential wealth from taxation so I account for the fact that non-residential assets represents roughly the 43% of the total US fixed assets (BEA, 2005).

has a significant impact on the after-tax return on capital in the short run. Capital accumulation reduces returns in the long run.

Table 4

Aggregate variables: percentage deviation from the initial steady state ($t = 0$)

	$reform : X - tax$				
	$t+1$	$t+5$	$t+20$	$t+50$	$long - run$
$capital\ (K)$	4.03	5.92	9.08	10.78	12.03
$labor\ (L)$	0.80	0.56	0.19	0.15	0.14
$output\ (Y)$	1.34	1.76	2.64	3.18	3.40
$consumption\ (C)$	-0.56	-0.02	1.75	2.26	2.53
$after - tax\ return\ (r)$	0.36	0.23	0.17	0.10	0.08
$after - tax\ wage\ (w)$	-0.81	-0.22	1.02	1.23	1.31

3.2 Results: impact on welfare

The welfare gains in the economy are measured in terms of the increment in wealth or consumption equivalent that the household would need in the no-reform case that would give it the same utility level as when the reform is enacted. Let $\{c(\Theta_{t=0}), h(\Theta_{t=0})\}$ and $\{c(\overline{\Theta}), h(\overline{\Theta})\}$ the two set of household's optimal consumption and labor supply respectively in the case of the reform announced at $t = 0$ and in the case of the initial no-reform state. The welfare gain is the percentage increase in household's resources Δ that leaves the household indifferent between the two states of the world, the reform and no reform case[13]. It solves the equation:

$$\begin{aligned}&\sum_{t=0}^{\infty} \beta^t u(c_t(s_t, S_t, \Theta_{t=0}), \ell_t(s_t, S_t, \Theta_{t=0})) \\ &= \sum_{t=0}^{\infty} \beta^t u((1+\Delta)c_t(s_t, S_t, \overline{\Theta}), (1+\Delta)\ell_t(s_t, S_t, \overline{\Theta}))\end{aligned} \tag{19}$$

This measure aims at considering the entire transition path to a new equilibrium, not the simple comparison between two steady states. The welfare gain can also be thought as the percentage of wealth or consumption equivalent that the household is willing to pay in order to have the reform implemented. The aggregate average welfare gain is then obtained by aggregating over the possible wealth and earning states:

$$\begin{aligned}&\int_{A\times E} \sum_{t=0}^{\infty} \beta^t u(c_t(s_t, S_t, \Theta_{t=0}), \ell_t(s_t, S_t, \Theta_{t=0}))dX(s_t) \\ &= \int_{A\times E} \sum_{t=0}^{\infty} \beta^t u((1+\Delta)c_t(s_t, S_t, \overline{\Theta}), (1+\Delta)\ell_t(s_t, S_t, \overline{\Theta}))dX(s_t)\end{aligned} \tag{20}$$

[13] The welfare gains are defined in this way since the specified utility function belongs to a family of homothetic and homogeneous functions.

Table 5 reports the welfare effects of the introduction of an X-tax reform after $t = 0$. The individual households compare their expected utility in presence of the reform with the no-reform state of the economy using (19). Depending on the sign of Δ they will be made better or worse off by the reform.

The aggregate welfare gains are positive and correspond to a 1.2% permanent increase in wealth or consumption equivalent. A large fraction of the population, 80%, would be made better off by the reform of the existing system. The gains do not accrue uniformly among the population. A significant fraction of the population of each earning class would experience a welfare improvement but the classes that would benefit the most are the low and medium income ones. Those classes in fact are the ones that would pay less taxes compared to the high earning classes, given the progressivity of the system, and would accumulate more capital than under the previous system, paying no capital income taxes on new investment. The welfare gains for all classes then would stem from taxing savings (at zero effective rate) differently from labor, in an environment in which agents systematically retain suboptimal buffer-stocks of capital for insurance purposes.

These welfare results differ from those in Domeij and Heathcote (2004) and Nishiyama and Smetters (2005) because, under the X-tax, elimination of capital income taxation is coupled with maintenance of a non-linear tax schedule on labor income and removal of other distortions.

Domeij and Heathcote (2004) analyze the elimination of capital income taxation in a linear tax system, in which labor and capital income face different linear schedules in the initial steady state. Within their model, capital income tax acts as a mechanism of risk-sharing since agents who receive positive income shocks save more and thus save more capital income taxes. The elimination of capital income taxation removes a distortion of saving behavior but would also lose this type of insurance and face higher taxation of labor income, generating aggregate welfare losses.

In contrast to them, the introduction of the X-tax in my model maintains a non-linear taxation of labor income and removes two types of distortions. On one hand, it removes the usual distortion of savings decisions. On the other hand, capital and labor income are not taxed jointly under a non-linear tax schedule. Savings decisions do not distort labor decisions since capital and labor income face different tax schedules: capital income faces a zero effective marginal rate (in a steady state equilibrium) and labor income faces a progressive schedule. Finally, the preservation (increase) of progressivity in the tax system plays an important role in differentiating my welfare results from the ones in Domeij and Heathcote (2004).

The role of insurance mechanism recognized in this environment to a progressive taxation system emerges clear from Nishiyama and Smetters (2005) work. They implement the replacement of a progressive income taxation system with a pure consumption tax. They find that adopting the consumption tax produces an efficiency loss when uninsurable wage shocks were taken into account. The elimination of a progressive taxation system in their model would reduce the amount of risk sharing among the households and this represents the main reason why my results differ from Nishiyama and Smetters (2005).

Table 5

Welfare effects

	$reform: X - tax$	
$Aggr.\ welfare\ gain(\Delta\%)$	1.23	
fraction of earnings classes better off		
low	0.86	
$medium$	0.81	
$high$	0.72	
$entire\ population$	0.80	
Wealth-distribution effects		
	$reform: X - tax$	
	$Initial\ SS$	$Final\ SS$
$Gini\ coefficient$	0.74	0.71

4 Concluding remarks

The present paper analyzes a stylized tax reform in an economy *a la* Bewley (1994) in which agents face uninsurable idiosyncratic shocks and borrowing constraints. The reform contemplates the replacement a progressive income tax system with an X-tax scheme.

According to the model, the capital stock would increase by 12 percent and the aggregate output would increase by 3.4 percent compared to their initial steady state levels. The aggregate welfare gains are positive and equivalent to a 1.2 percent permanent increase in wealth or consumption equivalent, taking into account short as well as long-term dynamics. A large fraction of the population, 80 percent, would experience welfare gains.

The X-tax preserves the risk-sharing mechanism in the existing progressive tax system but, at the same time, removes distortions to saving behavior by eliminating the joint taxation of capital and labor income and the tax on new investment.

Appendix

A1. Solution method

To solve for an equilibrium I discretize the household state space $s \in A \times E$ using g grid points for the asset space, $A = \{a_1, ..., a_g\}$, and 3 grid points for the earning space $E = \{e_1, e_2, e_3\}$. Consistent with the individual state space the aggregate state space of the economy will be $S = (x(s), \cdot)$. I first compute an initial steady state equilibrium in $t = 0$ and then, after the policy experiments I compute the transition path to a new steady state equilibrium.

Steady state equilibrium: the initial steady state is characterized by a time-invariant government policy schedule $\overline{\Theta}$. Given this schedule the algorithm uses an inner loop to compute the individual optimal behavior, as follows:

1. Set the initial values for the capital-to-labor ratio, $K/L^0_{t=0}$, and given the production function specification and equilibrium conditions compute the return on capital $r^0_{t=0}$ and the wage rate $w^0_{t=0}$
2. Given $r^0_{t=0}$ and $w^0_{t=0}$ (and an initial government policy variable G^0) find the optimal household decision rules $d_t(s, S_{t=0}; \overline{\Theta})$ for all points in the state space $s \in A \times E$ as follows. Guess an initial value for the next period asset holdings $a^0_{t+1}(s, S_{t=0}; \overline{\Theta})$ and compute the optimal consumption and working hours:
$$\begin{aligned} c^0_{t=0}(s, S_{t=0}; \overline{\Theta}) &\in (0, c^{\max}(a^0_{t+1})] \\ h^0_{t=0}(s, S_{t=0}; \overline{\Theta}) &\in [0, 1] \end{aligned}$$
3. Compute the numerical derivative of the value function with respect to the asset holding $V_a(s, S_{t=0}; \overline{\Theta})$, using log-linearization, and the value function $V(s, S_{t=0}; \overline{\Theta})$.
4. Plug optimal decision rules $c^0_{t=0}$, $h^0_{t=0}$ (found for each possible individual state) in the Euler equation (for consumption) along with the $V_a(s, S_{t=0}; \overline{\Theta})$. Check whether the Euler equation holds with a small error[14] and thus stop. If the error is not small enough instead update the guess a^0_{t+1} and repeat the process from step 2 through 4 again. The algorithm here uses a bisection search to update and finding the optimal next period asset holding, given the individual states.
5. Compute the measure of households on the asset and earning state space $x(s, S_{t=0}; \overline{\Theta})$ using the decision rules found with steps 2 through 4.

[14] The convergence criterion for the Euler equation to converge is set to a tolerance degree of 10^{-5}.

6. An outer loop at this point computes the aggregate variables, the new $r^1_{t=0}$ and $w^1_{t=0}$ and the new policy variables satisfying the government budget (in this case the government consumption G^1) consistent with the measure $x(s, S_{t=0}; \overline{\Theta})$.

7. Compare the $r^1_{t=0}$, $w^1_{t=0}$ with $r^0_{t=0}$, $w^0_{t=0}$ and G^1 with G^0 if the difference is sufficiently small[15] then stop. Or otherwise update the guesses and start from step 1 again.

Transition path equilibrium: the economy is in the initial steady state equilibrium when at the beginning of time $t = 0$ the government announces new policy schedule $\Theta_{t=0}$characterized by new tax rates and tax parameters. The aggregate state of the economy at the beginning of $t = 0$ is the initial steady state one. The algorithm compute the transition to a new steady state, assumed to be reached at some date T.

1. Guess a path for the return on capital $\{r^0_s\}^T_{s=t+1}$ and the wage rate $\{w^0_s\}^T_{s=t+1}$ and the government policy. Keeping G fixed at the initial steady state level, consistently guess a path for the new labor taxation parameters (i.e. a ϕ_{adj} to apply to the individual tax base, depending on the type of reform implemented, to make the experiment revenue neutral).

2. Given the previous set of guesses, since there is no aggregate uncertainty the path for the aggregate state S_t is deterministic and so is $\{r_s, w_s, \Theta_s\}^T_{s=t+1}$ from an household point of view. So find final steady state decision rules $d(s, S_T; \Theta_T)$, the numerical derivative $V_a(s, S_T; \Theta_T)$, and the value function $V(s, S_T; \Theta_T)$, the measure of households $x(s, S_T; \Theta_T)$ for all the states $s \in A \times E$, using the steady state algorithm described above, and then update the guesses made under step 1.

3. Given the guesses $\{r^0_s, w^0_s\}^T_{s=t+1}$ and the new policy parameter to balance the government budget compute the decision rules $d(s, S_t; \Theta_t)$, the numerical derivative $V_a(s, S_t; \Theta_t)$, and the value function $V(s, S_t; \Theta_t)$, working backward from the final steady state, $t = \{T - 1, ..., 0\}$ and using $V_a(s, S_{t-1}; \Theta_{t+1})$, and the value function $V(s, S_t; \Theta_{t+1})$ recursively in the Euler equation.

4. For $t = \{1, ..., T - 1\}$ now compute forward the new path $\{r^1_s, w^1_s\}^T_{s=t+1}$, the new policy parameters to balance the government budget and the measure of households $x(s, S_{t+1}; \Theta_{t+1})$ using the decision rules $d(s, S_t; \Theta_t)$ computed in the previous step 3.

5. Compare the new $\{r^1_s, w^1_s\}^T_{s=t+1}$, the new policy parameters to balance the government budget with the initial guess made in the step 1. If the

[15] The tolerance in this case is set as follows:

$$\max\left\{\left|K/L^1 - K/L^0\right|, \left|G^1 - G^0\right|\right\} < 10^{-5}$$

difference is small enough (using criteria specified in the steady state algorithm) then stop. Otherwise start from step 2, using these new guesses again.

A2. Effective marginal tax rates

The (external) algorithm to compute the weights $\{\phi_c, \phi_l, \phi_{corp}\}$ applied to the economic income to transform it into taxable income in a tax function with statutory tax rates is the following.

1. From the Internal Revenue Service (IRS) tables, 2005, get the total labor income (income from wages and salaries) w_inc, the total income from capital c_inc.and the aggregate level of all the individual deductions and exemptions $deduc$.

2. Get the fraction of corporate income on national income in the US economy ϕ_{corp} from the Bureau of Economic Analysis (BEA), 2005 and the statutory tax rate tax_corp

3. Solve the following four-equation, four-unknow system:

$$\begin{gathered}
\phi_l \cdot \sum\nolimits_i x_i \cdot tax_inc_i = eff_tax_L \\
tax_corp \cdot \phi_{corp} + \phi_c \cdot \sum\nolimits_i x_i \cdot tax_inc = eff_tax_C \\
c_inc = (1 - \phi_{deduc}) \cdot deduc + \phi_c \cdot c_inc \\
\phi_l \cdot w_inc = w_inc - \phi_{deduc} \cdot deduc
\end{gathered}$$

   where x_i represents the measure of individuals paying taxes at the rate tax_inc_i in the tax statutory bracket i, eff_tax_L and eff_tax_C are the average effective marginal tax rates and are set respectively to 0.30 and 0.16. The latter are the value of the effective marginal tax rates estimated for the 2011, when the EGTRRA reform will expire (see Congressional Budget Office, Analysis of the President Budget 2006). ϕ_{deduc} is a weight accounting for the fraction of the total individual deductions and exemptions that is deductible from its labor income (so $1 - \phi_{deduc}$ represents the fraction that is deductible from capital income).

4. Solve for the four unknowns $\Omega = \left\{\sum\nolimits_i x_i \cdot tax\_inc_i, \phi_{deduc}, \phi_c, \phi_l\right\}$

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