Taxation and Labor Supply Decisions:
The Implications of Human Capital Accumulation

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June 2002

1. Introduction

The conventional literature on the effects of labor taxation has typically ignored the role of education and human capital accumulation. The recent development in growth theory with the reinterpretation of human capital as an engine of growth, however, has set the path for a rich research on taxation and labor supply decisions. Though this research is still in its early stages, it has contributed a lot to our understanding of the distortionary effects of labor taxation. In particular this research has shown that labor taxes do not only affect the current labor supply decisions but also affect the future supply decisions and the growth rate of the economy. Unfortunately, the details of these effects appear to vary considerably and indeed it is a primary concern of this paper to explain and reconcile these differences. The typical conflicting results in this newly born literature arise in relation to whether labor taxes are more or less distortionary than capital taxes, and to whether labor tax reform or capital tax reform has the most effect on economic growth. The recent papers by Lucas (1990), Pecorino (1994), Devereux and Love (1994), Wang and Yip (1995), and Ihori (1997) lie within this domain. Although all these authors have used more or less the same conventional setup of two-sector endogenous growth models, their conclusions differ widely.

Lucas (1990) has found that a revenue-neutral replacement of capital tax by labor tax has virtually no effect on the US growth rate. In contrast, Pecorino (1994) has found that such a replacement reduces the growth rate of the US economy. Devereux and Love (1994) have concluded that capital tax is the least efficient way of raising revenue compared to either a wage tax or a consumption tax. Yet, for Taiwan, Wang and Yip (1995) have shown that a shift from capital to labor income taxation retards economic growth. Not the end of the confusion, Ihori (1997) has found that, when bequests are not operative, a tax on human capital does not reduce growth but a tax on physical capital does.

The frustrating frequency of such conflicting results raises many doubts on the basic setup in these models and greatly undermines the usefulness of the endogenous growth framework for addressing important policy issues such as tax reform. Hence, understanding and sorting out the sources of these conflicting results is exercise worth of pursuing. Stokey and Rebelo (1995) have addressed these sources among the endogenous growth studies that have looked specifically on the tax reform question in US. They found that the conflicting results on the effect of tax reform on the US growth rate are solely explainable by the differences in model parameters that have been used in these studies. In particular, they found that parameters such as factor shares, depreciation rates, the elasticity of intertemporal substitution, and the elasticity of labor supply have critical leverage on the obtainable results in these models.

Our objective in this paper, however, is more pedagogical. Different from Stokey and Rebelo (1995), our concern is to investigate more generally the implication of model parameters and assumptions in the generic endogenous growth setup for the conclusions to be drawn on the distortionary effects of labor vs. capital taxation. Also different from Stokey and Rebelo (1995) study, our focus is not limited to the steady state growth rates but, in addition, encompasses the growth effects during the transition to the steady state. Finally, different from all the aforementioned studies, our analysis, in addition to the growth effects, also accommodates the welfare impacts of taxes in these endogenous growth models. These latter two differences are particularly important and worth a brief comment at this stage. First, we find that the transitional impacts of different taxes on growth rates can be quite different in these models even when the steady state impacts are exactly identical. Second, in many instances, we find that the welfare effects can move in opposite direction to the growth effects when comparing the different tax packages. This suggests that two tax schemes that have identical steady-state effects may have quite different welfare implications. With this more general framework at hand, we are able to generate a range of possible outcomes on the distortionary effects of labor vs. capital taxation by only varying the representation of labor supply and the substitutability of labor and capital in the technology producing the consumption good. This range of outcomes accommodates virtually all the seemingly conflicting results in the literature reviewed at the beginning of this section.

The rest of the paper is organized as follows. Section 2 presents a standard two-sector model of endogenous growth and conjectures the implications of labor and capital taxation in this setup. Section 3 develops a stylized dynamic general equilibrium model that captures the main features of the theoretical framework. Section 4 presents our simulation results, and section 5 provides some concluding remarks.

2. The Theoretical Model

The theoretical setup is the standard two-sector model of endogenous growth described in the growth literature (e.g., see Barro and Sala-I-Martin 1995). Given consumption and factor prices, the representative household in the model chooses her optimal paths for consumption, leisure, financial capital, and human capital that solve:

$$\max \ U(.) = \sum_{t=0}^{\infty} \beta^t U(c_t, l_t) \tag{1}$$

Subject to the dynamic budget constraint:

$$c_t + a_{t+1} + p_{t+1}^h h_{t+1} = (1-\tau_h) w_t (h_t - l_t) + p_t^h h_t + a_t + (1-\tau_a) r_t a_t \tag{2}$$

In this representation *c* is household consumption, *l* is leisure or more generally human capital services employed at home, β is the discount factor, *a* is financial capital, *h* is human capital, p^h is the relative price of human capital[1], *w* is the return to human capital (the wage rate), *r* is the return to financial capital (the interest rate), and τ_h and τ_a are respectively ad-valorem tax rates on the returns to human and financial capital.

In addition, assume that all markets are competitive and complete and that firms producing the consumption good as well as those dealing in the education sector face constant return to scale (CRTS) technologies. Hence, in equilibrium all firms make zero profits and the returns to human and physical capital (*w* and *r*) equal their corresponding net marginal products. Further, markets clearance ensure that the total of human and physical capital (*h* and *a*) supplied by the household sector equal the corresponding demands by the production sectors (the usual *K* and *H*), and that the total amounts of goods produced satisfy the corresponding demands by household, investment, and the education sector. The usual rules of motion for physical and human capital accumulation that are implicitly embedded in (2) can then be expressed for the whole economy as:

$$K_{t+1} = (1-\delta_k) K_t + I_t^k \tag{3}$$

$$H_{t+1} = (1-\delta_h) H_t + I_t^h \tag{4}$$

Where δ is the depreciation rate and *I* is investment.

Setting up the Lagrangean for the system (1)-(2) and taking the derivatives, we obtain the following first order conditions:

(i) c_t: $\beta^t U_1(c_t, l_t) = \lambda_t$

[1] Notice that in equation (2) it is implicitly assumed that the technology producing the consumption good and the physical capital good are identical, whereas the technology producing the human capital good , i.e. education is allowed to be different.

(ii) l_t: $\beta^t U_2(c_t, l_t) = \lambda_t (1-\tau_h) w_t$

(iii) a_{t+1}: $-\lambda_t + \lambda_{t+1}[1+(1-\tau_a) r_{t+1}] = 0$

(iv) h_{t+1}: $-\lambda_t p_{t+1}^h + \lambda_{t+1}[p_{t+1}^h + (1-\tau_h) w_{t+1}] = 0$

Where λ is the Lagrangean multiplier associated with the budget constraint, and where the subscripts 1 and 2 denote the partial derivatives with respect to *c* and *l*, respectively. From (i) and (ii), we obtain the Euler's equation characterizing the intratemporal substitution between consumption and leisure:

$$\frac{U_2(c_t, l_t)}{U_1(c_t, l_t)} = (1-\tau_h) w_t \tag{5}$$

From (i) and (iii), we obtain the Euler's equation characterizing the intertemporal substitution between present and future consumption (i.e. the equation determining the rate of consumption growth):

$$\frac{U_1(c_t, l_t)}{U_1(c_{t+1}, l_{t+1})} = \beta \ [1+(1-\tau_a) r_{t+1}] \tag{6}$$

From (ii) and (iv), we obtain a similar equation characterizing the intertemporal substitution between present and future leisure (i.e. the equation determining the growth rate of labor supply):

$$\frac{U_2(c_t, l_t)}{U_2(c_{t+1}, l_{t+1})} = \beta \ [1+(1-\tau_h)\frac{w_{t+1}}{p_{t+1}^h}]\frac{w_t}{w_{t+1}} \tag{7}$$

Finally, from (iii) and (iv) along with (i) and (ii), we obtain the condition governing the equilibrium levels of physical and human capital:

$$(1-\tau_a) r_t = (1-\tau_h)\frac{w_t}{p_t^h} \tag{8}$$

Now, to emphasize the role of human capital in this model, consider the implications of an infinitesimal increase in τ_h on the labor supply decisions by inspecting the equilibrium system (5) through (8). Assuming that *U* is concave in each of its arguments *c* and *l*, four distortionary effects of such a tax increase may be verified:

(i) An intratemporal substitution effect:

From (5), the increase in the labor tax rate decreases consumption, increases the demand for leisure, and accordingly reduces the supply of human capital services to the production and education sectors. The size of this effect is controlled by the intratemporal elasticity of substitution between consumption and leisure.

(ii) An intertemporal substitution effect:

From (7), the increase in the labor tax rate increases the demand for leisure and reduces the supply of labor. The strength of this effect is essentially governed by the intertemporal elasticity of substitution.

(iii)A wealth effect:

This works through (5), (6), and (7). An increase in the labor tax rate reduces wealth, which in turn reduces both consumption and leisure, and accordingly increases the supply of human capital services to the market sectors. The size of this effect depends on whether the tax increase is permanent or temporary and on the income elasticity of labor supply.

(iv)An accumulation effect on human capital:

Given the presence of both human and financial capital accumulation in the model, the equilibrium has to satisfy equation (8), which says that the after tax rates of return on both types of capital should be equal. Increasing the tax rate on the returns to human capital disturbs this condition and sets in motion an adjustment process decreasing the rate of accumulation of human capital and increases that of physical capital, which in turn lowers the return to physical capital. This correction process continues until a new equilibrium is established with a lower level of human capital, a higher level of physical capital, and a lower rate of return on physical capital. But from (6), the lower rate of return on physical capital leads to a lower rate of consumption growth. Thus, the labor tax also has a similar effect on consumption growth as the capital tax.

In effect, the labor supply in this model is a complex function that includes all current and future wage rates, current and future interest rates, the implied current and future prices of human capital stock, and the intratemporal and intertemporal elasticity parameters.

Next to further articulate the effects in (a) through (d) and to provide more specific comparisons of the distortionary effects of labor vs. capital taxation in this model, consider the following specific form of the life time utility function:

$$U(c,l)=\sum_{t=0}^{\infty}\beta^{t}[\theta\log(c_t)+(1-\theta)\log(l_t)]$$

Where θ is the consumption expenditure share.[2]

Substituting out using this functional form, the Euler's equations in (5) and (6) may be rewritten as:

$$\frac{(1-\theta)}{\theta}\frac{c_t}{l_t}=(1-\tau_h)w_t \qquad (5')$$

$$g_t+1=\beta\ [1+(1-\tau_a)r_{t+1}]=\beta\ [1+(1-\tau_h)\frac{w_{t+1}}{p^h_{t+1}}] \qquad (6')$$

Where g_t is the consumption growth rate between period t and t+1, and where the second equality in (6') is from the equilibrium condition in (8).

Now with (5') and (6'), we may generate most of the recent literature results on labor vs. capital taxation by varying the representation of the labor supply decisions. First, the labor tax creates more number of distortions than the capital tax if there are both labor/leisure choice and human capital accumulation in the model. This is because a labor tax creates two distortions: an intratemporal one in (5') and an intertemporal one in (6'), whereas the capital tax creates only the intertemporal distortion in (6'). Second, the labor tax is equally distortionary as the capital tax if there is no labor/leisure choice but there is human capital accumulation in the model. This is because (5') is now irrelevant, and from (6') both taxes have similar effects on consumption growth. Finally, the labor tax is undistortionary whereas the capital tax is, if there is no labor/leisure choice and no human capital accumulation in the model. Thus in principle we may have different results on the effects of a labor tax and a revenue-equivalent capital tax just because of the differences of our representation of the labor supply decisions in the model. Nevertheless, within the same model structure the magnitudes as well as the directions of these effects can differ because of differences in the elasticities assumed. Such differences in effects are however hard to sort out analytically from the framework in (1)-(8). The following section develops a numerical framework to accomplish this task.

3. The Numerical Model

[2] This functional form implies that both the intratemporal and the intertemporal elasticities are unity.

3.1 The General Setup

The modeling framework adopted here is a stylized Computable General Equilibrium (CGE) model with endogenous physical and human capital accumulation. There are two goods in the model, *X* and *Y*, that are produced competitively subject to CRTS technologies.[3] The production technologies of these two goods are represented by Constant-Elasticity-of-Substitution (CES) functions with physical and human capital services as inputs. Output in each period is consumed, invested in physical capital, or invested in human capital (Education).

There are two investment sectors in the model: *INV* produces the physical capital, and *EDU* produces the human capital. Physical capital is produced from goods *X* and *Y* according to a CES technology with CRTS, and human capital is produced from human capital services (time) combined with *X* and *Y* according to a CES technology subject to CRTS. Both physical capital and human capital are accumulable in the usual way subject to depreciation. Accordingly, one unit of capital produced in the current period provides one unit of capital services this period and adds (1-δ) units to the next period stock of capital. Output of physical capital services is solely allocated to the production of *X* and *Y*. In contrast, the output of human capital services has three different uses: production of *X* and *Y*, the production of human capital (education), and the household home-production activity (or leisure).

Final demands are generated by an infinitely lived representative household that maximizes the sum of discounted utilities over time subject to a life time budget constraint. In each period the household derives utility from her consumption of *X* and *Y* as well as from leisure according to CES preferences subject to intratemporal substitutions between the goods bundle and leisure (*SIGMA*) and within the goods bundle (*XYSUB*). In turn, the present amount of utility is traded off against the future amounts of utility according to a CES-representation subject to both a discount factor (β) and an intertemporal substitution elasticity (*ISUB*). On the other hand, the lifetime budget constraint ensures that the present value of incomes equal the present value of

[3] The presence of two goods in the model is meant to potentially accommodate the assessment of differential factor taxes.

expenditures. The present value incomes are essentially the initial stocks of human and physical capital multiplied by their corresponding first period present value prices.

3.2 Benchmark Data and Model Parameterization

The hypothetical Social Accounting Matrix (SAM) used for simulating the model is provided in Table (1), in which the positive numbers represent output and income flows and the negative numbers represent inputs and expenditure flows. *INV* is the physical capital investment sector, *EDU* is the education sector, *W* may be interpreted as the household budget allocation sector, and *SAV* is the saving account sector. Notice that, consistent with the growth literature, education is human capital intensive in this hypothetical economy. The saving and the investment flows are calibrated such that the benchmark equilibrium in this economy is consistent with a balanced growth path. Along this balanced growth path, we have assumed a growth rate of 3%, equal depreciation rates of physical and human capital each of 7%, and a discount rate of 10%.[4] To narrow our focus to the distortionary impacts of labor *vs*. capital taxation, we have ignored the sectoral differences by treating *X* and *Y* as the same good, and the size differences by implying the equality of the initial stocks of physical and human capital.

With respect to the treatment of elasticities, we limit our emphasis to the labor supply elasticity and the substitution elasticity between labor and capital in the production of goods *X* and *Y*. The other elasticities in the model are fixed at some empirically plausible values. For the investment technologies: the elasticity of substitution between *X* and *Y* in sector *INV* and that among *X*, *Y,* and *H* in sector *EDU* are assumed to be unity (i.e. Cobb-Douglass). For the final demand sector: the intratemporal elasticity between *X* and *Y* within the goods bundle (*XYSUB*) is unity, and the intertemporal elasticity of substitution (*ISUB*) is assumed to be 0.5.

In contrast, for our elasticities of interest, we calibrate the intratemporal substitution elasticity between consumption and leisure (*SIGMA*) to match exogenously specified labor supply elasticities. The values of *SIGMA* used in the simulations are 0, 1, 5, and 10, with 1 being the value applied in simulating the central case. These values

[4] Except to the discount rate, these parameters are consistent with the empirical evidence for the US economy. We have intentionally employed this relatively high discount rate to emphasize the differences in the growth and welfare effects between the labor tax and the capital tax in the numerical simulations.

correspond to the labor supply elasticities 0.01, 0.13, 0.59, and 1.16, respectively. On the other hand, the elasticity of substitution between the inputs of physical and human capital services in the production of *X* and *Y* (*KLSUB*) has a low value of 0, a central value of 1, and a high value of 5.

3.3 Policy Scenarios and Model Solution

The policy scenarios simulated by the model are an endogenous tax on labor and an endogenous tax on capital that yield the same level of government revenues. The taxes apply only on the production of *X* and *Y* and the tax rates are flat and equal across *X* and *Y* in each scenario.

Numerically, the model is formulated and solved for a 50-periods horizon using GAMS/MPSGE Software described in Rutherford (1995,1997).

4. Numerical Results

For the central elasticities case (i.e. *SIGMA*=1, and *KLSUB*=1), the simulation results of equal-revenue capital and labor taxes are reported in Table (2). The statistics reported include the equivalent variation welfare index (expressed as a percentage of the initial period income) and the growth rates of consumption, physical capital, and human capital. The welfare index is displayed for the whole horizon, whereas the growth rates are reported as averages over the horizon (HORIZON), the first decade (T1), the second decade (T2), the third decade (T3), the fourth decade (T4), and over the fifth decade in the horizon (T5).

The first indication of the results is that the welfare cost of the labor tax is higher than the welfare cost of the capital tax even though the overall average growth rate of consumption is lower with the latter tax when compared to the former tax. This is consistent with our earlier analytical conjectures that in the presence of a labor/leisure choice the labor tax creates more distortions than the capital tax. Surprisingly, this is true even though the labor supply elasticity in this case is only 0.13. The second indication of the results in Table (2) relates to the transitional vs. the steady state growth impacts of labor and capital taxation in this model. In particular the results suggest the presence of sharp differences in the patterns of growth under the two tax regimes during the transition to the new steady state. For example most of the loss in consumption growth seems to occur early under the capital tax but only towards the end of the horizon under the labor tax scenario. Thus if we were to observe this economy only near the new steady state we might have concluded that the reduction in consumption growth is greater under the labor tax than under the capital tax regime. The third indication from Table (2) is the general result that both human and physical capital accumulation are on average negatively affected by the presence of either labor or capital tax in this initially-tax free economy. This is clearly reflected on having the average growth rates under either tax regime being less than the economy's baseline growth rate of 3%.

Having considered the welfare and growth effects in the central elasticities case, we now turn to consider the sensitivity of these effects to the representation of labor supply decisions and to the substitutability between human and physical capital in the model. Table (3) displays the sensitivity results for the labor supply representation. On the columns we have shown four variants of labor supply representation: no labor/leisure choice (NO_LL), low labor supply elasticity of 0.01 (SIGMA0), medium labor supply elasticity of 0.59 (SIGMA5), and a high labor supply elasticity of 1.16 (SIGMA10). The welfare results seem to exactly resemble our analytical conjectures on the leverage of the labor supply representation on the distortionary effects of labor vs. capital taxes. We see from Table (3) that the capital tax is associated with a greater welfare loss than the labor tax when either the model has no labor/leisure choice or the labor supply elasticity is very low. In contrast, we see that the welfare costs of the labor tax are clearly higher than those of the capital tax when the labor supply elasticity is relatively high. On the other hand, the directions of the growth effects across the four variants are quite similar to those we have commented on for Table (2). In particular, the negative effects on consumption growth are higher with the capital tax than with the labor tax.

Finally, we consider the implications of the substitution possibilities between human and physical capital in the production of goods X and Y. Table (4) reports the simulation results for this sensitivity exercise. As is evident from the table, the results suggest that capital and labor taxes which raise the same revenue are equivalent when human and physical capital are used in fixed proportions (KLSUB0). Yet, if physical capital services are sufficiently substitutable for human capital services (KLSUB5), the capital tax appears to be more distortionary than the labor tax both in welfare and growth terms. Nonetheless, an elasticity of substitution as high as 5 is certainly implausible.

5. Concluding Remarks

This paper has considered the welfare and growth impacts of labor and capital taxation in a model with endogenous accumulation of human and physical capital. A theoretical framework in the spirit of the standard two-sector growth models has been utilized for characterizing the distortionary consequences of labor and capital taxes in such an environment. The main insights from the theoretical model have suggested that labor taxes may create more distortions than capital taxes when there is a labor/leisure choice in the model and less distortions otherwise, yet the magnitudes of distortions will generally depend on the elasticities in the model. Based on this characterization, a numerical general equilibrium model has been synthesized to simulate the theoretical environment in order to discern the leverage of these elasticities on the extent of the distortionary effects of labor and capital taxation. The results from the numerical simulations are found to be in perfect concordance with the analytical insights. In particular, we have found for reasonable parameterizations that the labor tax is associated with a greater welfare loss than a capital tax that yields the same amount of tax revenues when there is a labor/leisure choice in the model. Yet, under the different labor supply elasticities used, the growth impacts on consumption associated with the capital tax are found to be relatively higher than those associated with the labor tax. Not the least, these are only tentative conclusions since we have not considered yet the leverage of model parameters and elasticities other than the labor supply decisions and the substitutability between human and physical capital in production. Finally, we close up by cautioning against drawing any sort of policy recommendations on the basis of the results in this paper on the tax reform question since our hypothetical economy has no pre-existing taxes.

Table (1) Benchmark Input-Output and Financial Flows for a Hypothetical Economy

	X	Y	W	INV	EDU	household

X	125.00	0.00	-60.00	-50.00	-15.00	0.00
Y	0.00	125.00	-60.00	-50.00	-15.00	0.00
W	0.00	0.00	340.00	0.00	0.00	-340.00
K	-85.00	-85.00	0.00	0.00	0.00	170.00
H	-40.00	-40.00	-20.00	0.00	-70.00	170.00
SAV	0.00	0.00	-200.00	100.00	100.00	0.00

* negative numbers are inputs and expenditure flows and positive numbers are output and incomes flows

Table (2) Capital vs. Labor Taxation: Summary of Welfare and Growth Impacts (%)

	HORIZON	T1	T2	T3	T4	T5
Capital Tax:						
WELFARE(EV%)	-7.05					
C_GROWTH	2.74	2.55	2.75	2.79	2.80	2.81
K_GROWTH	2.69	2.28	2.69	2.79	2.82	2.82
H_GROWTH	2.93	3.28	2.93	2.84	2.82	2.82
Labor Tax:						
WELFARE(EV%)	-7.06					
C_GROWTH	2.84	2.93	2.83	2.81	2.81	2.80
K_GROWTH	2.89	3.09	2.88	2.83	2.82	2.82
H_GROWTH	2.76	2.58	2.76	2.81	2.81	2.82

Table (3) Capital vs. Labor Taxation: Sensitivity to Labor Supply Representation (%)

	NO_LL	SIGMA0	SIGMA5	SIGMA10
Capital Tax:				
WELFARE(EV%)	-7.06	-7.03	-7.14	-7.31
C_GROWTH	2.78	2.78	2.58	2.28
K_GROWTH	2.71	2.71	2.61	2.46
H_GROWTH	2.95	2.92	3.00	3.11
Labor Tax:				
WELFARE(EV%)	-6.99	-7.00	-7.27	-7.57
C_GROWTH	2.86	2.83	2.77	2.50
K_GROWTH	2.91	2.91	2.79	2.63
H_GROWTH	2.80	2.75	2.83	2.95

Table (4) Capital vs. Labor Taxation: Sensitivity to Capital-Labor Substitutability (%)

	KLSUB0	KLSUB5
Capital Tax:		
WELFARE(EV%)	-6.93	-7.84
C_GROWTH	2.79	2.71
K_GROWTH	2.81	2.07
H_GROWTH	2.83	3.39
Labor Tax:		
WELFARE(EV%)	-6.93	-7.35
C_GROWTH	2.79	2.85
K_GROWTH	2.81	3.19
H_GROWTH	2.83	2.40

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Abstract

Recent studies on the implications of labor vs. capital taxation in endogenous growth environments have reported quite different and often conflicting results. Using a two-sector model of endogenous growth, this paper investigates the model features and elasticity assumptions that are consistent with these results. We find that, controlling for all other parameters, differences in the representation of the labor supply decisions alone are sufficient for the reconciliation of these conflicting results. Yet, for reasonable parameterizations we find that labor taxes are generally associated with higher welfare costs than capital taxes that yield the same revenue, even though capital taxes may have greater negative growth effects than labor taxes.