Welfare-maximizing tax structure in a model with human capital

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Abstract

This paper studies the welfare-maximizing tax structure in a two-sector model of endogenous growth with human capital. Here, tax structure refers to the mix of taxes which satisfy an exogenously given government budget constraint. © 2000 Elsevier Science S.A. All rights reserved.

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JEL classification: H21; O41

1. Introduction

Quantitative assessments of tax reforms in endogenous growth models with human capital accumulation are relatively recent (e.g., Lucas, 1990; Pecorino, 1994; Stokey and Rebelo, 1995). While these studies concentrated basically on the relationship between tax rates and long-run growth, the focus in this paper is on the determination of the welfare-maximizing tax structure. Here, tax structure refers to the mix of taxes on physical capital income, labor income and consumption which satisfy an exogenously given government budget constraint. The government budget is assumed to balance every period and government debt is zero. This point is what singles out this work from other optimal taxation studies (e.g., Jones et al., 1997; Judd, 1999).

Section 2 describes the model. Section 3 discusses the calibration of the model to U.S. data. Section 4 presents the simulation results, and Section 5, the conclusions.

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2. The model

We consider a two-sector economy inhabited by an infinitely-lived representative household, whose preferences are described by the intertemporal utility function

\[ U = \int_0^\infty e^{-\rho t} \left( C_t L_t^\eta \right)^{1-\sigma} \frac{1}{1-\sigma} \, dt \]  

(1)

where \( C_t \) and \( L_t \) denote consumption and leisure at time \( t \), \( \rho \) is the rate of time preference, \( \sigma \) is the inverse of the intertemporal elasticity of substitution and \( \eta \) reflects preferences for leisure. The household owns the stocks of physical capital \( K \) and human capital \( H \) and rents them out each period to the firms. The budget constraint faced by the household is given by

\[ (1 - \tau^K_K)R^K_K K + p^K(1 - \tau^K_H)R^K_H (1 - L) H + S = (1 + \tau_c) C + p^H(1 - s^H) I_H + I_K \]  

(2)

\( I_K \) is the new physical capital, \( I_H \) the new human capital, \( R^K_i \) the rate of return of factor \( i (i = K, H) \) in sector \( j (j = K, H) \), \( p^K \), the relative price of human capital, \( s^H \), a proportional subsidy to investment in education, \( \tau^K_i \), the tax rate on factor \( i (i = K, H) \) in sector \( j (j = K, H) \), \( \tau_c \), the tax rate on consumption and \( S \) denotes government transfers. As in Pecorino (1994), \( \tau^K_H \) reflects the extent to which the human capital input into production of human capital is considered to be foregone earnings.

The laws of motion of the stocks of physical and human capital are given by

\[ \dot{K} = I_K - \delta_K K \]  

(3)

\[ \dot{H} = I_H - \delta_H H \]  

(4)

where \( \delta_K \) and \( \delta_H \) are the rates of depreciation of physical and human capital.

Physical output \( Y_K \) and human capital \( Y_H \) are produced with Cobb-Douglas technologies:

\[ Y_K = A(vK)^\alpha (uH)^{1-\alpha} \]  

(5)

\[ Y_H = B((1-v)K)^\beta (zH)^{1-\beta} \]  

(6)

where \( v(u) \) is the share of \( K(H) \) devoted to the production of goods, and \( z \) is the share of \( H \) devoted to education. We follow Pecorino (1994) in assuming that the (explicit) expenditure on education, \( E \), is

\[ E = E_K + E_H = R^H_K x K + (1 - \varepsilon)p^H R^H_H H \]  

(7)

\( \varepsilon \) is the percentage of the human input into production of human capital which represents foregone earnings. \( E_K \) and \( E_H \) are the physical and human capital (explicit) costs in the expenditure on education. Total output, \( Y \), is given by

\[ Y = Y_K + E \]  

(8)

Earnings foregone to accumulate human capital are not counted in GDP and this is reflected in (8).

The government is assumed to run a balanced budget and government debt is zero:

\[ \tau^K_K R^K_K K + \tau^K_H R^K_H K + p^K \tau^K_H R^K_H u H + p^H \tau^K_H R^K_H H + \tau_c C = S + G + p^H s^H I_H \]  

(9)
Table 1
Parametrization of the model

<p>| Technology and preference parameters |</p>
<table>
<thead>
<tr>
<th>A</th>
<th>σ</th>
<th>η</th>
<th>ρ</th>
<th>δ_H</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5</td>
<td>0.5</td>
<td>0.034</td>
<td>0.02</td>
</tr>
</tbody>
</table>

<p>| Data to match |</p>
<table>
<thead>
<tr>
<th>γ</th>
<th>C/Y</th>
<th>K/Y</th>
<th>E/Y</th>
<th>E_k/K</th>
<th>E_k/K</th>
<th>G_k/K</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.015</td>
<td>0.6283</td>
<td>1.6894</td>
<td>0.06689</td>
<td>0.195</td>
<td>0.7534</td>
<td></td>
</tr>
</tbody>
</table>

<p>| Fiscal policy parameters |</p>
<table>
<thead>
<tr>
<th>τ_K</th>
<th>τ_H</th>
<th>τ_H^I</th>
<th>τ_C</th>
<th>g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.42719</td>
<td>0.2536</td>
<td>(1 - ε)τ_H</td>
<td>0.05648</td>
<td>0.1677</td>
</tr>
</tbody>
</table>

_G_ is government spending on goods and services. Government spending as a percentage of output, _g_, is assumed to be constant in the long-run.

3. Calibration of the model

Predetermined parameters and data to be matched by the model are summarized in Table 1. Parametrization of preferences and technology follows Lucas (1990) and Pecorino (1994), except for _σ_ which is set equal to 1.5. A high value of _σ_ would produce counterfactual cross-country interest differentials and, in Lucas’s view, even _σ_ = 2 seems high (Lucas, 1990: p. 306).

Tax rate estimates are taken from Mendoza et al. (1997) (Table 2). Tax rates on income earned vary only by factor, _τ^K = τ^K_ and _τ^H = (1 - ε)τ^K_. Hereafter, _τ^K_ and _τ^H_ will denote the tax rates on incomes of physical capital and labor (_τ^K_ = τ^K_), respectively.

Long-run GDP ratios are based on data of the 1998 Economic Report of the President (Table B–2) over the period 1965–1991. Neglecting imports and exports, GDP was divided in the fractions 0.6448 to private consumption, 0.1371 to gross investment on physical capital and 0.2181 to government spending.

Data of expenditure on education are based on the Digest of Education Statistics 1996 (Table 30) and 1997 (Table 409) (U.S. Department of Education). The share of expenditure on education averaged 6.689% of GDP over the 1965–1991 period, and public expenditure on education, _G_E_, averaged 75.34% of total expenditure on education over the 1988–1993 period. Since private

Table 2
Results of the calibration

<table>
<thead>
<tr>
<th>B</th>
<th>α</th>
<th>β</th>
<th>δ_K</th>
<th>ε</th>
<th>s</th>
<th>s^H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure on education as a subsidy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1075</td>
<td>0.3737</td>
<td>0.02976</td>
<td>0.066</td>
<td>0.8733</td>
<td>0.1338</td>
<td>0.1149</td>
</tr>
<tr>
<td>Expenditure on education as an inframarginal in-kind transfer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1291</td>
<td>0.3737</td>
<td>0.0377</td>
<td>0.066</td>
<td>0.8379</td>
<td>0.1841</td>
<td>0</td>
</tr>
</tbody>
</table>
expenditure on education constitutes investment on human capital in this model, it must be subtracted from private consumption in the national income accounts to obtain a 62.83% consumption’s share of GDP. In this paper, public expenditure on education is treated either as an inframarginal in-kind transfer (as in Pecorino, 1994) or as a subsidy (as in Trostel, 1993). In any case, it must be subtracted from government spending to obtain the figure in Table 1. Using King and Levine’s (1994) estimates, the stock of physical capital to GDP ratio is found to average 1.6894 over the period 1965–88. The long-run growth rate, \( \gamma \), is set equal to 1.5% (as in Lucas, 1990 and Pecorino, 1994), and the share of physical capital costs in the expenditure on education, \( E_k/E \), is set equal to the average in the range 17–22% found in Bowen (1987).

Parameter values found in the calibration are reported in Table 2.

4. Simulation results

In this section, the welfare-maximizing tax structure is determined. Here, tax structure refers to the mix of taxes which satisfy the government budget constraint. The values of \( g \) and \( s_H \) are exogenously given by their pre-tax-reform values displayed in Tables 1 and 2, respectively. The post-tax-reform share of lump-sum transfers on GDP at the new balanced growth path is also set equal to its pre-tax-reform value reported in Table 2.

Following Lucas (1990), the net welfare effect of a reform is measured as the constant percentage increase, \( \kappa \) in \( C_t \) that leaves the household indifferent between the lifetime utility obtained by remaining in the pre-tax-reform equilibrium, and the lifetime utility obtained by undertaking the tax reform. Optimal tax structures are reported in Table 3.

If public expenditure on education is treated as a subsidy, a movement to the welfare-maximizing structure of income taxation involves lowering \( \tau_k \) by 24.08 and increasing \( \tau_H \) by 12.52 percentage points. As a result, a 0.2% growth fall and a 3.93% welfare gain are achieved. If \( \tau_C \) is optimally set too, the optimal \( \tau_H \) is 30.83% and \( \tau_k \) falls to 16.35%. Therefore, welfare rises by 4.06% and growth falls by 0.07 percentage points.

If public expenditure on education is treated as an inframarginal in-kind transfer, the optimal \( \tau_H \) becomes almost zero, and the lost revenue is replaced with higher consumption taxation. Now the welfare-maximizing structure of income taxes relies more heavily on \( \tau_k \).

<table>
<thead>
<tr>
<th>Table 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welfare-maximizing tax structure (in percent)</td>
</tr>
<tr>
<td>( \tau_k )</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td><strong>Expenditure on education as a subsidy</strong></td>
</tr>
<tr>
<td>Optimal ( \tau_k ) and ( \tau_H )</td>
</tr>
<tr>
<td>Optimal ( \tau_k ), ( \tau_H ) and ( \tau_C )</td>
</tr>
<tr>
<td><strong>Expenditure on education as an inframarginal in-kind transfer</strong></td>
</tr>
<tr>
<td>Optimal ( \tau_k ) and ( \tau_H )</td>
</tr>
<tr>
<td>Optimal ( \tau_k ), ( \tau_H ) and ( \tau_C )</td>
</tr>
</tbody>
</table>
5. Conclusions

Welfare-maximizing tax structure is considered when only income taxes are optimally set and when, in addition to these, consumption tax is optimally set, too. This issue is important because the composition of the income tax as well as the use of income versus consumption taxes lie in the center of discussion over tax policy.

Simulation results strongly suggest that higher reliance upon consumption taxation would increase welfare. The optimal \( \tau_K \) is significantly nonzero (over 16%) and considerably lower than its estimate. These results are robust to considering public expenditure on education as an inframarginal in-kind transfer or as a subsidy. However, optimal \( \tau_H \) depends markedly on the treatment of public expenditure on education. When only income taxes are optimally set, optimal \( \tau_H \) is higher than \( \tau_K \), and ranges between 33 and 38%, which indicates that shifting the burden of taxation from physical capital to labor would increase welfare.

Acknowledgements

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References