This paper surveys the tax policy implications in various endogenous growth models. The focus is on the long-run growth effects of income, consumption, and investment taxation in models whose engine of growth is the accumulation of human capital, technological innovation, and/or public infrastructure. The results depend on model specifications. This paper also reviews quantitative results from cross-country regressions and simulations, and indicates some statistical and methodological problems to which they are subject. Tax policy implications in endogenous growth models both with tax policy endogenously determined by a political process and with international capital mobility are also discussed.

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H20, O41

1/ The author is a doctoral student at Columbia University. This paper was written during his 1993 summer internship at the Fund, under the guidance of Howell H. Zee. The author would like to thank Mr. Zee for his invaluable assistance. The usual disclaimer applies.
Summary iv

I. Introduction 1

II. Basic Ingredients of Endogenous Growth Models 2

1. Growth driven by human capital 4
   a. The Ak model 4
   b. Models of human capital without knowledge spillover 4
   c. Models of human capital with knowledge spillover 5

2. Growth driven by innovation 5

3. Growth driven by public infrastructure 6
   a. Public inputs as private goods 6
   b. Public inputs as public goods 6
   c. Public inputs as public goods subject to congestion 7

III. Tax Policy Implications 7

1. Steady-state growth effects 7
   a. Income taxation 7
   b. Consumption taxation 12
   c. Investment taxation 13

2. Transitional growth effects 14

IV. Quantitative Assessment 16

1. Some evidence from simple correlations 16

2. Cross-country growth regressions 17

3. Simulations 20

V. Some Extensions 23

1. Endogenous tax policy 23

2. Tax policy in an open economy setting 24

VI. Conclusions 25

Tables

1. Growth Implications of Income Taxation in Various Endogenous Growth Models 8

2. Cross-Country Studies of Economic Growth and Taxation 19

3. Simulation Results of Steady-State Growth Effects of Taxation 21

4. Comparison of Growth Effects Due to Different Parameter Values 22
Figures

1. Economic Growth and Income Tax Rates in the U.S. 16a
2. Real Economic Growth and Tax Rates In OECD Countries 18a

References 28
Summary

The past few years have witnessed a rapid expansion of literature using endogenous growth models to explore the growth implications of tax policies. This paper reviews the main results of this literature. The growth implications of taxation depend on model specifications relating to the accumulation of human capital, technological innovation, and the way tax revenue is spent.

The incentive for agents to behave in a growth enhancing way is measured by the real rate of return to capital (both physical and human capital) in most endogenous growth models. A tax on income or investment will always have a negative direct effect on the long-run growth rate because it reduces this incentive. However, a tax on income or investment may have indirect growth effects through the steady-state factor ratio adjustment or productive tax revenue spending or both. The net long-run growth effects of income or investment taxation are negative if the positive growth effects from productive tax revenue spending and the steady-state factor ratio adjustment are small. The long-run growth effects of a consumption tax are generally believed to be insignificant, because a consumption tax will not affect the allocative decision between consuming today or tomorrow, that is, the incentive to accumulate capital, given the standard preference assumptions.

Empirical studies on the growth-taxation relationship do not show a consensus. Cross-country regressions seem to indicate a negative partial correlation between the economic growth rate and tax variables; however, this correlation is not strong. Moreover, the linear regression form used in cross-country studies cannot capture the possible nonlinear relationship between the growth rate and tax variables. Quantitative results from simulations are found to be very sensitive to the values of the elasticity of intertemporal substitution, the elasticity of labor supply, the depreciation rate of human capital accumulation, and the factor ratios in different sectors. Accurate estimates of these key parameters, however, are not yet available.

This paper also discusses the implications of endogenous growth models with tax policy endogenously determined by a political process and those of endogenous growth models with international capital mobility. In the case of endogenous tax policy, the adoption of a growth-enhancing tax policy depends on factors such as the status of income (wealth) distribution. Unequal income distribution tends to result in high taxation, hence it is harmful for growth. In the case of international capital mobility, the long-run growth effects of a national tax policy will be washed out under the source principle of international taxation, because the real rates of return to capital across countries are equalized by international capital movements. Under the residence principle of international taxation, however, growth differentials across countries due to different national tax policies can be consistent with international capital mobility.
I. Introduction

One striking fact in the world economy is that countries grow at very different rates over time. It is natural to ask whether this growth diversity is due partially to the policies implemented. The traditional neoclassical growth theory built on Solow (1956), Cass (1965), and Koopmans (1965), however, has little to say about the long-run growth effects of economic policy since the long-run growth rate in that theory is exogenously determined by population growth and technology change.

Recent studies also cast doubt on using the transitional growth generated in the standard neoclassical model to explain observed growth diversity. 1/

Recent development in the growth theory, namely the endogenous growth approach launched by Romer (1986) and Lucas (1988), is capable of generating sustained growth based on the optimizing decisions of economic agents, without resorting to exogenous forces such as technical progress and population growth. By endogenizing the long-run rate of growth, this approach provides a theoretical basis for examining the role of policies in the determination of the rate of growth in a steady state as well as in a transition.

The past few years have witnessed a rapid expansion of literature that uses endogenous growth models to explore the growth implications of tax policies. Different theoretical and empirical results have been obtained concerning the relationship between income, consumption, and investment taxation and economic growth. This paper will survey the tax policy implications of various endogenous growth models, review quantitative results from cross-country regressions and simulations, and clarify the conditions behind different theoretical implications and empirical results on the growth taxation relationship.

This paper is organized as follows. Section II establishes a framework which contains the basic ingredients of various endogenous growth models, including models of endogenous growth driven by the accumulation of human capital, technological innovation, and/or public infrastructure. Section III focuses on the tax policy implications of the models laid out in the previous section, particularly the steady-state growth effects of income, consumption, and investment taxation. Transitional growth effects of taxation are also discussed. Section IV reviews the quantitative results from cross-country regressions and simulations on the growth effects of taxation. Section V discusses two extensions of the endogenous growth models laid out in Section I and their implications on the growth taxation relationship.

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1/ According to King and Rebelo (1993), the transitional growth in the standard neoclassical model is not able to explain observed growth diversity without resorting to an implausibly high real rate of return to capital in a country's early development stage.
relationship. One is the political economy models which endogenize tax policy, the other is the open economy models which allow different principles of international taxation and international capital movement. Section VI gives the paper's conclusions.

II. Basic Ingredients of Endogenous Growth Models

Why can growth be sustained endogenously? To answer this question, we need to first understand why growth cannot be sustained (without exogenous forces) in traditional neoclassical growth models. The intuition is straightforward. Suppose goods are produced using labor and other inputs which we call the "k-factor." Labor supply is constant, but the k-factor can be accumulated over time. The neoclassical production function implies that the real rate of return to the k-factor diminishes as it accumulates. As a result, there is no incentive in the long run to accumulate the k-factor, therefore no long-run growth. Growth can only occur during the transition from the current factor ratio to the steady-state factor ratio.

The endogenous growth approach overcomes this unpleasant feature of neoclassical growth theory by "making" the real rate of return to the k-factor nondecreasing. An economy-wide nondecreasing rate of return to the k-factor maintains incentive for k-factor accumulation, therefore long-run growth is sustained.

To obtain a nondecreasing rate of return to the k-factor, some mechanism must be found to offset the diminishing trend due to k-factor accumulation. Different endogenous growth models specify different offsetting factors. Let us call any of the offsetting factors the x-factor. Goods are produced with labor, the k-factor, and the x-factor according to the following Cobb-Douglas production function in each period \( t \):  

\[
y_t = A k_t^{1-\alpha} x_t^\alpha
\]

(1)

where \( y_t \) is output per worker, \( k_t \) is the input of the k-factor, \( x_t \) represents the impact of the x-factor, all at period \( t \). \( A \) is a productivity parameter, which is assumed constant over time, and \( \alpha \) is the share parameter, \( 0 < \alpha < 1 \). Goods can be either consumed or used to increase the stock of the k-factor.

\[1/\text{The form of production function is not essential as long as it meets the neoclassical assumptions of constant return to scale, strict concavity, and the Inada conditions. Moreover, Stokey and Rebelo (1993) find that the substitution elasticity between k and x is not important in predicting growth effects of taxation, which implies that assuming the Cobb-Douglas production function is harmless in the current context.}\]
Following the conventional preference assumptions in the literature, we have the infinitely lived representative agent maximizing the discounted sum of utility from the consumption of goods

$$\text{Max} \int_0^\infty \frac{c_t^{1-\sigma} - 1}{1-\sigma} e^{-\rho t} dt$$

where $c_t$ is consumption per capita at time $t$, and $\rho$ is the positive and constant rate of time preference. The momentary utility function takes the form of CRRA (constant relative risk aversion), which implies a constant intertemporal elasticity of substitution $1/\sigma$.

The solution to this maximization problem implies that per capita consumption changes according to

$$c_t = \frac{r_t - \rho}{\sigma}$$

where $r_t$ is the real rate of interest at time $t$. 1/

Along a balanced growth path, growth rate of per capita income equals growth rate of per capita consumption. Equation (3) shows that under the current assumptions, growth can be sustained only if the real rate of interest is large enough to compensate for deferring consumption.

In competitive equilibrium, the real rate of interest must equal the real rate of return to the k-factor. This is given by

$$r_t = (1-\alpha)A\left(\frac{x_t}{k_t}\right)^{\alpha}.$$  

(4)

It is clear from equation (4) that whether the incentive to accumulate the k-factor (equal to the real rate of interest) can be maintained or not depends on the offsetting impact from the accumulation of the x-factor. If the x-factor is accumulated no slower than the k-factor, the real rate of interest will be nondecreasing, consequently the long-run growth will be sustained.

The endogenous growth mechanisms, accordingly, are characterized by the accumulation features of the x-factor. Different endogenous growth models have different specifications of the x-factor. The following is a brief summary of models of endogenous growth driven by different forces.

1/ Throughout this paper, a hat over a variable denotes its growth rate.
1. Growth driven by human capital

a. The Ak model

The Ak model is the simplest model that can generate long-run growth endogenously. The Ak model (Rebelo (1991)) was named after the form of the production function: \( y = Ak \).\(^{1/}\) This linear production function is thought plausible when the \( k \)-factor is interpreted as the broad capital including both human capital and physical capital. The implicit \( x \)-factor in the Ak model is human capital and it enters the production function in such a way that the real rate of return to broad capital is constant, that is, \( r_t = A \). As a result, the economy is always along a constant steady-state growth path. There is no transition to the steady state.

b. Models of human capital without knowledge spillover

In contrast to the Ak model which implicitly assumes that human capital and physical capital have the same accumulation process, there are models which specify these two accumulation processes separately. In Rebelo (1991), for example, the \( x \)-factor and the \( k \)-factor are the human capital and physical capital invested in the production of goods, respectively, and human capital accumulation follows

\[
x = B k_h^{1-\beta} x_h^\beta
\]

where \( k_h \) and \( x_h \) are the physical and human capital used in producing new human capital, respectively, \( B \) is the productivity parameter of human capital production, which is assumed to be constant over time, and \( \beta \) is the share parameter, \( 0 < \beta < 1 \).\(^{2/}\)

The feasibility of sustained growth is guaranteed by the linear homogeneity of the human capital production function. The steady-state growth rate is given by \( \gamma = (\Omega - \rho) / \sigma \), where \( \Omega \) is a function of \( A, B, \alpha, \) and \( \beta \).\(^{3/}\)

Moreover, this model has transitional dynamics. Define \( \kappa^* \) as the steady-state ratio of physical capital to human capital, and \( \kappa_0 \) as the initial factor ratio. If \( \kappa_0 \) is not equal to \( \kappa^* \), then there will be a period in which physical and human capital change at different rates.\(^{4/}\)

---

\(^{1/}\) For notational simplicity, the time subscripts on all variables will be omitted as long as no ambiguity arises.

\(^{2/}\) Throughout this paper, a dot over a variable denotes its time derivative.

\(^{3/}\) For derivation of this steady-state growth rate, see Rebelo (1991).

\(^{4/}\) Transition will be instantaneous if there is no adjustment cost between physical and human capital production. See Mulligan and Sala-i-Martín (1993) for details.
In Lucas (1988), however, new human capital is produced using human capital only, and human capital accumulation follows

\[ x_t = βx_{th} \]  

\( (5') \)

c. Models of human capital with knowledge spillover

Besides the internal effect of human capital captured in the above models, human capital accumulation may also have an external (spillover) effect. In Romer (1986), for example, the \( x \)-factor in equation (1) represents the spillover of knowledge from other producers, approximated by the amount of the average capital stock. In the steady state, \( x = k \). Thus \( r = (1-\alpha)A \) from equation (4) and the long-run growth rate is \( \gamma = [(1-\alpha)A - \rho]/\sigma \). There are no transitional dynamics. \( 1/ \)

Note that the private firms do not take the positive spillover effect into account. Consequently, capital is underaccumulated and the growth rate is lower than what can be achieved in a socially optimal situation.

2. Growth driven by innovation

Technological innovation is identified as another important growth factor. The innovation approach of endogenous growth theory emphasizes deliberate efforts to develop new products and technology. In models of endogenous growth driven by knowledge spillover, returns to knowledge accumulation are external to firms. Knowledge is accumulated because it is the by-product of the accumulation of other factors whose returns are internal to firms. In models of endogenous growth driven by innovation, however, such returns are internal (at least partially) to firms so that firms have incentive to innovate. The market structure of imperfect competition is used in the innovation approach to model the profit-seeking innovation process. Here we specify a model of product variety based on Romer (1990). Models of quality differentials have the same essence as models of product variety according to Grossman and Helpman (1991).

In this model, the \( k \)-factor in equation (1) is human capital and the \( x \)-factor is the input of capital goods which are defined by

\[ x_t = \int_0^n x_t^i d_i \]  

\( (6) \)

where \( x_t^i \) denotes capital good \( i \) produced according to the design \( i \) developed by a research sector in the economy, \( n_t \) is the number of product designs.

\( 1/ \) If physical and human capital accumulation processes are specified separately, however, there will be transitional dynamics as in models of human-capital driven growth without knowledge spillover.
available at time t. All capital goods are assumed to be substitutes and symmetric. The index for designs is treated as a continuous variable.

To isolate the effects of human capital accumulation from those of product variety development, we assume there is no human capital accumulation over time, that is, \(k_t = k\). The growth of the economy now is driven solely by the increase in the number of product designs. The production of product designs follows

\[ n = B k n \]  

(7)

where \(B\) is the productivity parameter of the production function for new designs and \(k_n\) is the human capital input in the production of new designs. Time subscripts are suppressed.

The key feature of this production function is that total number of product designs available, \(n\), has a positive external effect on the production of new designs. It is the linearity of \(n\) in \(n\) that guarantees a constant growth rate of new product designs, which is also the steady-state growth rate of the economy. This growth rate is given by \(\gamma = B k_n\), \(k_n\) being a constant in the steady state. As the product variety expands, profit per product design declines. The offsetting factor in this model is the decline in design producing cost, which is due to the spillover from the total stock of knowledge (the total number of designs). It is this knowledge spillover in design production that maintains the research incentive and sustains the growth.

3. Growth driven by public infrastructure

Public infrastructure is sometimes thought to play an important role in offsetting the decline in the returns to private investment. Barro (1990) and Barro and Sala-i-Martin (1992a), among others, have modeled this idea in the endogenous growth framework. Based on the nature of public services, the following three cases have been considered.

a. Public inputs as private goods

In the production function (1), the x-factor is now interpreted as the quantity of public services allocated to each producer. According to equation (4), the real rate of return to the k-factor is \(r_t = (1-\alpha)A(x_t/k_t)^\alpha\). Now if public input \(x_t\) increases at the same rate of k-factor accumulation, incentive to accumulate the k-factor will be maintained and growth sustained.

b. Public inputs as public goods

The production function is still equation (1), but the x-factor is now interpreted as the positive externality from the total amount of public services because public services in this case are nonrival and nonexcludable
public goods. If the impact of public services increases at the same rate as k-factor accumulation, incentive to accumulate the k-factor will be maintained and growth sustained.

c. **Public inputs as public goods subject to congestion**

Barro and Sala-i-Martin (1992a) argue that a substantial portion of the government’s productive services belong to this type. Define k as capital per producer, K as the total amount of capital in the economy, and G as the total amount of public services. The amount of public services that each producer enjoys is a proportion corresponding to his capital share in the total capital stock, as given by (k/K)G. This is the x-factor in the production function (1). The expansion of capital stock of any producer will lead to a decline in the amount of public services that other producers can enjoy, given the total amount of public infrastructure. According to equation (4), the real rate of return to capital in this case is

\[ r_t = (1-\alpha)A \left( \frac{G_t}{K_t} \right)^{\alpha} \]

Consequently, if the total amount of public infrastructure \( G_t \) increases at the same rate as that of accumulation of the total amount of capital in the economy, incentive for private agents to accumulate capital will be maintained and growth sustained.

### III. Tax Policy Implications

The endogenous growth framework laid out in Section II provides a theoretical basis for examining the comparative growth effects of alternative tax policies, in particular the relationship between income, consumption, and investment taxation and the long-run economic growth.

1. **Steady-state growth effects**

   a. **Income taxation**

   Consider a flat income tax at a rate \( \tau \). The after-tax per capita income is given by

   \[ y_t = (1-\tau)Ak_t^{1-\alpha}x_t^\alpha \]

   (1')

   and the after-tax rate of return to the k-factor is given by

   \[ r_t = (1-\tau)(1-\alpha)A \left( \frac{x_t}{k_t} \right)^\alpha. \]

   (4')

   The steady-state growth implications of this income tax in different endogenous growth models are summarized in Table 1.

   It is clear from Table 1 that growth implications of income taxation are sensitive to model specifications. The effects of an increase in the income tax rate on the long-run growth rate of the economy could be
Table 1. Growth Implications of Income Taxation in Various Endogenous Growth Models

<table>
<thead>
<tr>
<th>Stabil-State Growth Rate</th>
<th>Growth Effects of Income Tax</th>
<th>Growth Maximizing Income Tax Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ak models (Rebelo (1991))</td>
<td>$\gamma = (1/\sigma)[(1-\tau)A - \rho]$</td>
<td>Negative</td>
</tr>
<tr>
<td>H models without spillover (Rebelo (1991))</td>
<td>$\gamma = (1/\sigma)[(1-\tau)\Omega - \rho]$</td>
<td>Negative</td>
</tr>
<tr>
<td>H models without spillover (Lucas (1988))</td>
<td>$\gamma = (1/\sigma)[B - \rho]$</td>
<td>Zero</td>
</tr>
<tr>
<td>H models with spillover (Romer (1986))</td>
<td>$\gamma = (1/\sigma)[(1-\tau)(1-\alpha)A - \rho]$</td>
<td>Negative</td>
</tr>
<tr>
<td>Innovation models (Romer (1990))</td>
<td>$\gamma = [(1-\alpha)Bk - \rho]/(\sigma + 1 - \alpha)$</td>
<td>Zero</td>
</tr>
<tr>
<td>P models with inputs as private goods (Barro and Sala-i-Martin (1992a))</td>
<td>$\gamma = (1/\sigma)[(1-\tau)\rho/1-\alpha - \rho/1-\alpha - \rho]$</td>
<td>Positive or negative</td>
</tr>
<tr>
<td>P models with inputs as public goods (Barro and Sala-i-Martin (1992a))</td>
<td>$\gamma = (1/\sigma)[(1-\tau)\rho/1-\alpha - \rho/1-\alpha - \rho]$</td>
<td>Positive or negative</td>
</tr>
<tr>
<td>P models with congestion (Barro and Sala-i-Martin (1992a))</td>
<td>$\gamma = (1/\sigma)[(1-\tau)\rho/1-\alpha - \rho/1-\alpha - \rho]$</td>
<td>Positive or negative</td>
</tr>
</tbody>
</table>

Note: H models and P models refer, respectively, to human capital driven and public infrastructure driven endogenous growth models. The steady-state growth rate in each type of model is derived from a certain benchmark model of that type discussed in Section II.
negative, zero, or positive. The following discussions are aimed at clarifying the conditions behind these different growth implications.

The negative (steady-state) growth effects of income taxation are not difficult to understand, because an increase in income tax rate decreases the rate of return to the k-factor given the x-factor, as shown in equation \( (4') \), which in turn has a negative impact on the steady-state growth rate. What we need to examine further is the possible indirect growth effects from the change in the x-factor due to the increase in the income tax rate.

By combining physical and human capital into broad capital and implicitly assuming identical production technology of physical and human capital, the Ak model lacks the necessary structure to discuss the indirect growth effects mentioned above. This drawback is partially overcome by the models specifying physical and human capital accumulation separately. Growth implications of income taxation are found to be very sensitive to the specification of the human capital accumulation process and its tax treatment.

Suppose the tax treatment is such that income from the goods producing sector is taxed at the rate \( r \), while income from the human capital producing sector is not taxed. People respond to an increase in the income tax rate by investing more in the human capital producing sector, which leads to a lower steady-state physical to human capital ratio. According to equation \( (4') \), a lower steady-state physical to human capital ratio offsets the decline in the real rate of return to capital due to a direct disincentive from the income tax rate increase. If human capital accumulation is specified by equation \( (5) \) as in Rebelo (1991), that is, both physical and human capital are inputs in producing new human capital, the offset is partial and the net growth effects are negative, as shown in Table 1.

However, if only human capital is used as an input in the production of new human capital, as in Lucas (1988), the growth implications of income taxation will change dramatically. The real rate of return to capital is now given by

\[
 r = (1-r)(1-a)A\left(\frac{x_y}{x} \frac{x}{K}\right)^aB\left(\frac{x_h}{x}\right)
\]

\( (4') \)

where \( x_y \) and \( x_h \) are human capital allocated to goods production and human capital production, respectively. In the steady state, \( x_y/x \) and \( x_h/x \) are constant. As \( r \) rises, people respond by investing more in the human capital producing sector. This leads to a lower physical to human capital ratio in the long run which offsets completely the direct disincentive of an increase in the income tax rate on the real rate of return to capital; consequently, the net growth effects of this increase in the income tax rate are zero. The reason behind the different results of the Rebelo model and the Lucas model is that human capital accumulation, although not taxed directly due to the assumption on tax treatment, is taxed indirectly in the former through
physical capital used in the sector producing new human capital, but is not taxed indirectly in the latter because only human capital is used in producing new human capital. If the tax treatment is such that income from both sectors is taxed, however, the growth effects of income taxation are negative even in the Lucas model.

When knowledge spillover is introduced, whether the net growth effects of income taxation continue to be negative becomes ambiguous. First of all, since the private sector will not take the positive spillover effect into account, the equilibrium growth rate will be lower than the growth rate in a socially optimal solution. This implies that a subsidy or an investment tax credit can raise the steady-state growth rate above the equilibrium level. Both subsidy and investment tax credit, however, need to be financed with some taxation. If lump-sum taxation is infeasible and an income tax has to be imposed, the above discussed negative growth effects of income taxation will result. The net growth effects considering both effects from income taxation and effects from subsidy or investment tax credit are ambiguous.

The growth implications of tax revenue spending are very sensitive to where tax revenue is spent. If tax revenue is used to provide public services which enter people's utility function but not production function, it will not have steady-state growth effects. However, if tax revenue spending is productive, it may have effects on the long-run rate of growth. The nature of the public services on which tax revenue is spent also matters.

First consider the case that tax revenue is spent on the public inputs necessary for goods production and those inputs have the nature of private goods. The government budget is assumed to be balanced. The expression of the after-tax real rate of return to capital (4') now tells us that in addition to the negative direct effect of an increase in \(r\) on \(r\), there is a positive indirect effect through the increase in the spending of tax revenue \(x-ry\). From \(y-Ak^{1-\alpha}(ry)^{\alpha}\) we get \(y/k\), and, substituting it into (4'), we obtain

\[
\frac{\alpha}{r=(1-r)\frac{1}{1-\alpha}(1-\alpha)A^{\frac{1}{1-\alpha}}}
\]

To see the effect of an increase in the income tax rate on the real rate of return to capital, we take the derivative of \(r\) with respect to \(r\)

---

1/ In endogenous growth models built on the overlapping generations framework, however, an increase in government consumption leads to a reduction in the steady-state growth rate of the economy because the current generation knows that part of the tax burden will fall on future generations; hence they respond by making their consumption path flatter (see Alogoskoufis and van der Ploeg (1990)).

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It is now clear that an increase in $\tau$ will have a negative (positive) effect on $r$ and therefore on the steady-state growth rate if the income tax rate is higher (lower) than the competitively determined income share of government, which is the supplier of public inputs. In other words, the steady-state growth rate and the income tax rate have an inverted-U relation. Before the optimal size of public infrastructure is reached, the long-run growth rate will rise with the increase in the income tax rate, because more tax revenue is needed to finance more public infrastructure. After the optimal size of public infrastructure is reached, however, any further increase in public infrastructure will be adverse to the long-run growth rate and, therefore, an increase in the income tax rate will have negative effects on the long-run growth rate.

In contrast to the Ak model and the Rebelo-type human capital driven (without spillover) growth model where the growth maximizing income tax rate is zero, the growth maximizing income tax rate is now positive and equal to $\alpha$. The growth rate corresponding to $\tau - \alpha$ is, however, a second-best outcome, due to the distortion caused by income taxation. The Pareto optimal growth can only be achieved in principle by lump-sum taxation.

Barro and Sala-i-Martin (1992a) considered two other cases. One is that public inputs have the nature of public goods (nonrival and nonexcludable); the other is that public productive services are subject to congestion. The above inverted-U relation between the steady-state growth rate and income tax rate and the result that the growth maximizing income tax rate is positive and equal to $\alpha$ maintain under their model specifications. The special feature for the case of congestion is that income taxation leads to a socially optimal growth rate because here the distortion in the decentralized equilibrium lies in the excessive use of the public services and income taxation acts like a user fee for public services, which corrects this distortion. In the solution to the public goods case as shown in Table 1, there is an additional scale factor (the number of firms denoted by $n$) affecting the steady-state growth. The number $n$ is exogenous in their model, so that it is impossible to discuss further the possible effect of income taxation on this scale factor.

In all three cases that display the inverted-U relationship (discussed above) between the steady-state growth rate and the income tax rate, the ambiguity of the growth effects of income taxation arises from the presence of externalities (tax revenue is used to finance productive public goods). However, Zee (1994) has found that, even in a model without such externalities, but with endogenous time preference, the growth effects of an income tax would depend on the relative magnitudes of the income tax
elasticity of the savings rate and the tax rate itself. Hence, the ambiguous growth effects of an income tax need not rely solely on the presence of externalities.

It is a surprise to find that income taxation is irrelevant to the steady-state growth in the benchmark model of endogenous growth driven by innovation, since the innovation approach emphasizes deliberate efforts to innovate and income taxation may well be negatively affecting innovation incentive, and therefore long-run growth. It turns out that this negative impact on innovation from income taxation does exist, but is offset entirely. This result follows from the assumption that the price of a design, by the free entry condition, is equal to the present value of monopoly profits from exploiting the design. The monopoly profits in turn are positively affected by the price of the capital goods.

Hence, while income taxation does decrease the return to human capital in the final goods sector, it at the same time decreases the price of capital goods and, therefore the monopoly profits of purchasing a new design. Consequently, the price of design falls and returns to human capital in the research sector decline by the same proportion as that in the final goods sector. As a result, human capital allocated to the research sector does not change in equilibrium, hence the long-run rate of growth is not affected.

b. Consumption taxation

In endogenous growth models with an infinite horizon, exogenous labor supply and standard preference and technology, it is easy to show that consumption taxation has no growth effects. When a tax on consumption is imposed, the optimal response of people is to shift the level of the consumption path down but leave the growth rate of consumption unchanged.

When the labor supply depends on a labor-leisure choice, whether a consumption tax has growth effects depends on the specification of the momentary utility function and the way the tax revenue is used. Suppose the momentary utility function has the form

\[ u(c, \ell) = \frac{[cv(\ell)]^{1-\sigma}}{1-\sigma} \]  

(9)

where \( \ell \) is leisure, and \( v(\ell) \) is instantaneous utility from leisure. Given Ak-type technology, the steady-state growth rate can be derived and is given by

\[ \gamma = \frac{A - \rho + (1-\sigma)\hat{v}(\ell)}{\sigma} \]  

(10)

where \( \hat{v}(\ell) \) denotes the growth rate of instantaneous utility from leisure.
Equation (10) shows that the long-run growth rate of the economy depends on the growth rate of instantaneous utility from leisure (if $\sigma$ is not equal to 1), which in turn depends on the level of leisure. A consumption tax affects the level of leisure chosen by the representative agent in two opposite ways. On the one hand, a consumption tax leads people to substitute leisure consumption for goods consumption (substitution effect); on the other hand, more leisure means less labor supply, hence less income to buy leisure (income effect). Note also that if tax revenue is rebated to people, there will be an additional positive income effect. The equilibrium level of leisure is determined by weighing these two effects. Stokey and Rebelo (1993) point out that in the case where tax revenue is not rebated to households, these two effects are exactly canceled out, hence a consumption tax has no growth effects. They examine also the momentary utility function in the form of

$$u(c, l_x) = \frac{v(c, l_x)^{1-\sigma}}{1-\sigma}$$

(9')

where leisure is adjusted by human capital level $x$. The no growth effect result of consumption taxation is maintained in this case. A consumption tax distorts the leisure-labor mix, but not the relative price of consumption today versus tomorrow, hence the growth rate of consumption is unchanged.

A consumption tax will have negative growth effects, however, in endogenous growth models based on the overlapping generations framework. This is because the current generation knows that the tax burden will be partially shouldered by future generations, and therefore consumes at a higher rate and invests at a lower rate, leading to a lower steady-state growth rate.

c. Investment taxation

In the previous discussion, physical capital is assumed to be forgone consumption. To examine the growth effects of investment taxation, we follow Rebelo (1991) to separate investment goods production from consumption goods production.

Assume that the production of investment goods uses proportion 1-$\phi$ of the broad capital stock and follows the Ak technology: $k = i - A(1-\phi)k$, where $i$ denotes investment. The production of consumption goods uses proportion $\phi$ of the broad capital stock and follows the neoclassical production technology: $c = B(\phi k)^{\alpha T^{1-\alpha}}$, $0 < \alpha < 1$, where $T$ represents the fixed nonproducible factors and $B$ is a constant productivity coefficient. Denote $p$ as the price of investment goods in terms of consumption goods and $y$ as the income in terms of consumption goods, and we have $y = c + pi$.

Let $r_c$ and $r_i$ be the real returns to broad capital in terms of consumption goods and investment goods, respectively, and $r_c$ and $r_i$ be the
proportional tax rates on consumption and investment, respectively. By
arbitrage condition, $r_c = r_1 + \hat{p}$, where $\hat{p}$ denotes the rate of price change.
In equilibrium, competition among profit-maximizing firms in the investment
goods sector ensures that the real rate of return to the broad capital is
equal to its after-tax marginal product: $r_1 = (1 - r_1)A$. Since the marginal
productivities in the two sectors must be equal to each other, we have
$p = (\alpha - 1)\hat{k}$, where $\hat{k}$ denotes the growth rate of broad capital. Substituting
these expressions for $\hat{p}$ and $r_1$ into the arbitrary condition and then into
$c = (r_c - \rho)/\sigma$, using also $\hat{c} = \alpha\hat{k}$, we obtain

\[
k = \frac{(1 - r_1)A - \rho}{1 - \alpha(1 - \sigma)}
\]
\[
\gamma = \hat{c} = \alpha \frac{(1 - r_1)A - \rho}{1 - \alpha(1 - \sigma)}.
\]

That investment taxation has negative growth effects can be easily
verified by $d\gamma/dr_1 = -\alpha A/[1 - \alpha(1 - \sigma)] < 0$. An increase in the investment tax rate
decreases the rate of return to the investment activities of the private
sector and leads to a permanent decline in the rate of capital accumulation
and in the rate of growth. The growth maximizing investment tax rate is
zero and it corresponds to Pareto optimal growth.

Here we see another example that consumption taxation does not affect
the steady-state rate of growth, but only the level of consumption path. This is because consumption taxation in this model does not affect the
incentive to accumulate capital, since the rate of return to broad capital
is solely determined in the investment sector.

The growth implications of investment taxation are complicated when we
add more structure to the specifications of growth engines and tax revenue
spending. Growth effects of investment taxation may be negative, zero, or
positive, and the growth maximizing investment tax rate may be zero or
positive, depending on the situation. Since these extensions are basically
the same as those in our discussion of income taxation, we will not repeat
them here.

2. Transitional growth effects

An economy may well be along a transitional path toward the steady
state instead of along a steady-state growth path. Most endogenous growth
literature focuses on the steady-state growth path. To make our examination
of the growth implications of taxation more complete, we provide the
following discussion based mainly on Mulligan and Sala-i-Martin (1993).

Before examining the transitional growth effects of taxation implied
by endogenous growth models, it is helpful to look at the transitional
growth effects of taxation implied by the standard neoclassical model.
Without population growth and technical change, the steady state in the standard neoclassical model is characterized by zero growth. However, if the current capital stock level is not equal to the steady-state level, the economy will experience a period of transitional growth. The growth rate during the transition is given by

\[ \dot{y}_t = (1-\alpha)k_t. \]  

(12)

Suppose the economy is initially on a steady-state (zero) growth path. At time 0, an income tax is imposed. The after-tax, steady-state capital stock has to be lower so that the after-tax real rate of return to capital equals the rate of time preference. The transition is characterized as follows: consumption jumps to a higher level in the saddle path at time 0, that is, part of the current capital stock is consumed. Along the saddle path, both consumption and capital stock decline until the lower steady-state level of capital stock is reached. It is clear from equation (12) that the growth rate of the economy during the transition is negative because capital stock keeps decreasing during this period. Consequently, income taxation has negative transitional growth effects.

The issue of transitional growth effects is more complex in the endogenous growth framework. The one-sector Ak model has no transitional dynamics, since the economy is always on the steady-state growth path. Most endogenous growth models, however, fall into the framework of a two-sector model as laid out in Section II. Following Mulligan and Sala-i-Martin (1993), we discuss two possible cases of transitional dynamics in such a two-sector endogenous growth framework and their implications for income taxation. Assume the production of goods follows equation (1). Then the growth rate of the economy during the transition is a weighted average of the growth rates of different factors, as given by

\[ \dot{y}_t = (1-\alpha)(\dot{k}_t + \alpha \dot{x}_t). \]  

(12')

To be concrete, we assume that the k-factor is physical capital, and the x-factor human capital. The economy is initially on a balanced growth path. In the human capital driven without spillover models laid out in Section II, an income tax imposed at time 0 results in a decline in the steady-state ratio of physical to human capital, that is, \( \kappa_0 > \kappa^* \), where \( \kappa_0 \) and \( \kappa^* \) are the steady-state ratios of physical to human capital before and after tax, respectively.

Now there is an imbalance between the sector producing physical capital and the sector producing human capital with respect to the steady
state. To reach the steady state, physical and human capital must accumulate at different rates during the transition.

One possibility is that transition is instantaneous. This happens when there is no adjustment cost between physical and human capital production. Agents choose to invest (disinvest) at an infinite rate in the physical (human) capital-producing sector. The economy immediately jumps to the steady-state growth path.

When there exist adjustment costs between physical and human capital production, the economy will first jump to a saddle path, then converge to the steady-state growth path gradually. Mulligan and Sala-i-Martin (1993) prove that, in this case, there is global saddle path stability. Moreover, they find that if $\kappa_0 > \kappa^*$, as in the above case of income taxation, agents will respond by lowering the ratio of physical capital allocated to the final goods production and raising the ratio of consumption to physical capital immediately to their respective saddle path levels. Afterwards, physical capital accumulates slower and human capital accumulates faster until the ratio of physical to human capital reaches the after-tax steady-state ratio. The growth rate of the economy at each point of the transition is given by (12'). With the knowledge of the relevant parameters, we may be able to determine the transitional growth effects of income taxation.

The transitional growth effects of income taxation implied by the one-sector neoclassical model and the two-sector endogenous growth model cannot be directly compared. The study by King and Rebelo (1993), however, shows that the transitional growth implied by the standard neoclassical model is not able to explain observed growth without resorting to a counterfactually high real rate of return to capital in the early development stage of a country. More research is needed to characterize the transitional dynamics of endogenous growth models qualitatively and quantitatively.

IV. Quantitative Assessment

1. Some evidence from simple correlations

The U.S. economic history provides a natural experiment for examining the growth taxation relationship. Income tax revenue as a fraction of GNP increased dramatically in the United States in the early 1940s and the U.S. economy over the last century conforms well to the description of a balanced growth path. Figure 1 shows that although the growth rate of per capita real GNP in the United States dropped substantially following the jump in the ratio of income tax revenue to GNP, the long-run rate of growth seems to

1/ See Mulligan and Sala-i-Martin (1993) for more detailed discussion.
Figure 1

Economic Growth and Income Tax Rates in the U.S.

Income Taxes as Percentage of GNP

2

Source: Stokey and Rebelo (1993), Figure 6.

1 Revenue from federal, state, and local individual income taxes as a fraction of GNP.

2 Revenue from social security and retirement taxes and from federal corporate profits tax are also included.
have been unaffected. 1/ Stokey and Rebelo (1993) perform three statistical tests on the difference between the average growth rate before and after 1942. They find that this difference is statistically insignificant.

The simple correlation of average tax rates on income and profits with average per capita GDP growth in OECD countries for the period 1960-89, however, is significantly negative, as pointed out by Plosser (1992). Figure 2 gives an illustration. 2/

These findings are based on simple correlations; although instructive, they do not provide solid empirical conclusions since there are many other variables affecting the economic growth rate which should be controlled when the growth taxation relationship is under examination. In the U.S case, for example, there may exist positive growth effects from other sources which offset the negative effects from heavier income taxation, and those growth effects may have been larger after 1942 than before. For the result from OECD countries, Easterly and Rebelo (1993a) find that the negative correlation between growth and income taxes disappears once the level of income is controlled. This implies that the negative growth taxation correlation in Figure 2 may simply reflect the fact that average income tax rates tend to be higher in countries with higher income levels and that rich countries tend to grow slower. In the following two subsections, we review the results concerning the growth taxation relationship from cross-country regressions and simulations.

2. Cross-country growth regressions

There have been many studies using cross-country regressions to search for empirical linkages between long-run growth and economic policies. The basic form of these regressions can be expressed as

\[ \gamma = a_0 + a_1 y + \sum_{i=2}^{n} a_i x_i + b z \]

where:  
\( \gamma \) = rate of growth of real income per capita  
\( y \) = initial per capita real income  
\( x_i \) = variables explaining steady-state growth, \( i=2,3\ldots n \)  
\( z \) = policy variable  
\( a_i, b \) = coefficients, \( i=0,1\ldots n \).

---

1/ This is the Figure 6 of Stokey and Rebelo (1993). Line (1) shows the revenue from federal, state, and local individual income taxes as a fraction of GNP. In line (2), revenue from social security and retirement taxes and from federal corporate profits tax are also included.

2/ This is the Chart 6 of Plosser (1992).
One derivation of this regression form is given by Barro and Sala-i-Martin (1992b). The endogenous growth theory gives a theoretical basis for the choice of the variables $x_i$. Typically $x_i$ are proxies for human capital stock. Initial income level is used to control for transitory dynamics. A negative $a_1$ indicates conditional convergence, that is, poor countries tend to grow faster when controlling the factors determining the steady-state growth rate. The policy experiment is to see whether the estimate of $b$ has a statistically significant sign.

Among the 41 cross-section growth studies listed by Levine and Renelt (1991), 17 studies examine the growth effects of fiscal policy. More recent studies include Engen and Skinner (1992), Dowrick (1992), Canning, Fay, and Perotti (1992), and Easterly and Rebelo (1993a, 1993b). These studies, however, are far from reaching any consensus.

As far as tax policy is concerned, the difficulty of establishing a proxy for the tax policy in the cross-country regression remains a problem. Most researchers who use government consumption as a proxy for the distortionary taxes that must be raised to support the spending find negative partial correlation between growth rate and the proxy, although a few find that this correlation is insignificant, or even positive (Ram (1986)). Total government spending, a more complete proxy for distortionary taxes, is also found to be negatively correlated with growth rate in the base regression of Levine and Renelt (1991). The partial correlation between growth rate and government investment, however, is found insignificant in most studies, although a positive sign is obtained in some investigations.

There are also a number of studies which use indicators of taxes directly in their regressions. Their results seem to indicate a negative partial correlation between the economic growth rate and tax variables. Table 2 summarizes these studies.

Although there exist certain specifications that yield significant coefficient estimates between tax policy indicators and growth, these results are generally very sensitive to regression specifications, as found by Levine and Renelt (1992). By slightly altering the set of explanatory variables in any regression, the resulting estimates become insignificant.

Another problem is that those linear cross-country regressions are not capable of capturing the inverted-U relation between the steady-state growth rate and income tax rate in cases of productive public inputs discussed in Section II. The income tax rate and the growth rate are positively correlated when the income tax rate is higher than the competitively determined income share of government (the supplier of public inputs), and negatively correlated when the opposite is true. Thus, we expect zero cross-country correlation when the income tax rates are

---

Figure 2
Real Economic Growth and Tax Rates in OECD Countries

Average Per Capita Real GDP Growth 1960-1989

Average Tax Rates on Income and Profits

Table 2. Cross-Country Studies of Economic Growth and Taxation

<table>
<thead>
<tr>
<th>Partial Correlation with Growth Rate</th>
<th>Tax Variable</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marsden (1983)</td>
<td>Negative</td>
<td>20 countries</td>
</tr>
<tr>
<td>Mañas-Anton (1987)</td>
<td>Negative or insignificant</td>
<td>39 countries</td>
</tr>
<tr>
<td>Skinner (1987)</td>
<td>Negative</td>
<td>31 countries</td>
</tr>
<tr>
<td>Koester and Kormendi (1989)</td>
<td>Insignificant</td>
<td>63 countries</td>
</tr>
<tr>
<td>Martin and Fardmanesh (1990)</td>
<td>Negative</td>
<td>76 countries</td>
</tr>
<tr>
<td>Engen and Skinner (1992)</td>
<td>Negative</td>
<td>107 countries</td>
</tr>
<tr>
<td>Easterly and Rebelo (1993a)</td>
<td>Negative</td>
<td>53 countries</td>
</tr>
<tr>
<td>Easterly and Rebelo (1993b)</td>
<td>Insignificant</td>
<td>32 countries</td>
</tr>
</tbody>
</table>
optimally set. This means that the insignificant coefficient estimate obtained in some cross-country regressions cannot be interpreted as indicating no correlation between the growth rate and the income tax rate. 1/

3. Simulations

The steady-state growth effects of taxation can be estimated through simulation. The existing estimates, however, vary wildly from nearly zero in Lucas (1990) to 3.5 percentage points in Jones, Manuelli, and Rossi (1993). Table 3 shows the benchmark estimates of these simulations.

The divergence of simulation results, according to Stokey and Rebelo (1993), are due to different model specifications and parameter choices of different authors. For example, the trivial growth effect found by Lucas (1990) is due to his assumptions that new human capital is produced using human capital only, and human capital production is not taxed. The no growth effect result of the human capital (without spillover) model of Lucas (1988) has already been analyzed in Section III. In addition, labor taxation affects equally both the cost side and the benefit side of the marginal condition governing the learning decision, except through the labor-leisure choice which results in the small change in the rate of growth in Lucas (1990).

Some critical parameters affecting the size of the steady-state growth effects of income taxation have been identified by Stokey and Rebelo (1993). The shares of physical capital in total capital stock in the sector producing physical capital and the sector producing human capital are found to be extremely important in predicting the growth effects of income taxation. The elasticity of labor supply becomes important to growth effects when the share of physical capital in total capital stock is small. The low share of physical capital in the sector producing human capital (v=0.17) combined with the high elasticity of labor supply in Jones, Manuelli, and Rossi (1993) are what result in the large steady-state growth effects of income taxation in their study.

Table 4 illustrates the different growth effects calculated by Stokey and Rebelo (1993) based on their model using the parameter values in the above-mentioned simulations. The growth effects reflect the change in the steady-state growth rate when all taxes are eliminated.

The size of growth effects is also sensitive to the size of depreciation rates ($\delta^k$, $\delta^h$). If depreciation of capital is tax deductible, then the growth effects of taxation will be overstated assuming income is taxed gross of depreciation. If the King and Rebelo (1990) model is recalibrated

1/ Other methodological and statistical problems of cross-country growth regressions have been discussed in detail by Levine and Renelt (1991) and Levine and Zervos (1993).
Table 3. Simulation Results of Steady-State Growth Effects of Taxation

<table>
<thead>
<tr>
<th>Experiments</th>
<th>Change in the Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lucas (1990)</td>
<td>-0.0003</td>
</tr>
<tr>
<td>Eliminate capital tax and raise labor tax to 46 percent</td>
<td></td>
</tr>
<tr>
<td>King and Rebelo (1990)</td>
<td>-0.0152</td>
</tr>
<tr>
<td>Increase income tax by 10 percent</td>
<td></td>
</tr>
<tr>
<td>Increase capital tax by 10 percent</td>
<td>-0.0052</td>
</tr>
<tr>
<td>Kim (1992)</td>
<td>0.0085</td>
</tr>
<tr>
<td>Eliminate all taxes</td>
<td></td>
</tr>
<tr>
<td>Jones, Manuelli, and Rossi (1993)</td>
<td>0.0350</td>
</tr>
<tr>
<td>Eliminate all taxes</td>
<td></td>
</tr>
</tbody>
</table>
Table 4. Comparison of Growth Effects Due to Different Parameter Values

<table>
<thead>
<tr>
<th>Growth Effects</th>
<th>$w$</th>
<th>$v$</th>
<th>$\delta^k$</th>
<th>$\delta^h$</th>
<th>$1/\sigma$</th>
<th>Labor Supply Elasticity $r_{k,k}$ $r_{h,k}$</th>
<th>Tax Rates $r_{k,h}$ $r_{h,h}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lucas (1990)</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.50</td>
<td>Small</td>
<td>.26 .40 .00 .00</td>
</tr>
<tr>
<td>King and Rebelo (1990)</td>
<td>.0330</td>
<td>.33</td>
<td>.33</td>
<td>.11</td>
<td>.00</td>
<td>No</td>
<td>.20 .20 .20 .20</td>
</tr>
<tr>
<td>(0.0143)</td>
<td></td>
<td>(0.05)</td>
<td></td>
<td>(0.012)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kim (1992)</td>
<td>.01</td>
<td>.00</td>
<td>.05</td>
<td>.01</td>
<td>.52</td>
<td>No</td>
<td>.34 .17 .34 .17</td>
</tr>
<tr>
<td>Jones, Manuelli, Rossi (1993)</td>
<td>.0211</td>
<td>.36</td>
<td>.17</td>
<td>.10</td>
<td>.50</td>
<td>Large</td>
<td>.21 .31 .00 .00</td>
</tr>
<tr>
<td>(.0333)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(.91)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Stokey and Rebelo (1993), Tables 1-4.

Notes:

- $w$ - share of physical capital in total capital stock in the sector producing physical capital.
- $v$ - share of physical capital in total capital stock in the sector producing human capital.
- $\delta^k$ - depreciation rate of physical capital.
- $\delta^h$ - depreciation rate of human capital.
- $1/\sigma$ - elasticity of intertemporal substitution.
- $r_{i,j}$ - tax rate on the return to factor $i$ in sector $j$, $i=k,h$, $j=k,h$.

Growth effects - changes in growth rate when all taxes are eliminated.
Numbers in parenthesis - different values used in the same experiment with values of other parameters unchanged.
with $\delta^k$ and $\delta^h$ equal to 0.06 instead of 0.1, eliminating all taxes will raise the long-run growth rate by 2.5 percentage points rather than 3.3, according to Stokey and Rebelo (1993).

It is easy to understand that different choices of the elasticity of intertemporal substitution ($1/\sigma$) result in very different growth effects, since it acts like a multiplier in calculating the steady-state growth rate. If the Jones, Manuelli, and Rossi model (1993) is resimulated with $\sigma$ equal to 1.1 instead of 2, eliminating all taxes will raise the long-run growth rate by 3.3 percentage points rather than 2.1.

The results from simulations, like that from cross-country regressions, are inconclusive. As Stokey and Rebelo (1993) indicate, further efforts are needed to improve the estimates used in simulations, in particular the estimate of physical capital's share in the sector producing human capital and the estimates of the elasticity of intertemporal substitution and the elasticity of labor supply.

V. Some Extensions

1. Endogenous tax policy

So far, tax policy has been taken as exogenously determined. Redistribution of income due to tax policy change is implicitly assumed to have no effect on the steady-state growth rate. However, tax policy is typically made through a certain political process, and political process is characterized by conflicts and compromises. Recently there have been studies that endogenize tax policy as well as economic growth (see Perroti (1992b) and Persson and Tabellini (1992) for a review). These studies shed new light on the growth taxation relationship.

Distributional conflict and political process are modeled explicitly in this type of political economy model. In Alesina and Rodrik (1991), for example, individuals are assumed to own different amounts of capital in addition to one unit of labor endowment. They vote on the capital tax rate according to simple majority rule. The higher the labor-capital ratio of an individual, the higher the capital tax rate that the individual will vote for. The capital tax rate in the political equilibrium is the one chosen by the median voter. The more unequal the wealth distribution, the less the capital owned by the majority of the population and the higher the capital tax rate chosen in the political equilibrium. In Persson and Tabellini (1991), a capital tax $1/\sigma$ is used for redistribution purposes. The income an individual can own depends on his skill to utilize his capital. Different skill endowments correspond to different income levels. Individuals

1/ This capital tax can be interpreted more broadly as the regulatory policy such as patent legislation or property rights protection that reflects the restrictions on private appreciation of investment returns.
have the same initial capital stock, but their levels of capital stock vary because of their different skills in accumulating capital. As in Alesina and Rodrik (1991), the poorer the median voter is, the higher the capital tax rate he prefers.

Now the link between distribution and economic growth can be established by specifying an endogenous growth mechanism discussed in Section II. In Alesina and Rodrik (1991), tax revenue is used as public investment in such a way that the real rate of return to private investment is constant, therefore growth is sustained. The steady-state growth rate is negatively correlated with the tax rate on capital because capital taxation reduces the real rate of return to capital. Consequently, the more unequal the wealth distribution, the higher the capital tax rate and the lower the long-run growth rate of the economy. In Persson and Tabellini (1991), long-run growth is sustained by capital accumulation with knowledge spillover. The steady-state growth rate is again negatively correlated with the tax rate on capital; consequently, unequal distribution is harmful for growth. In Perotti (1992a, 1992b), growth is the result of private investment in education and only those individuals whose after-tax income is no less than the cost of education will invest in human capital and will have a higher pretax income next period. As a result, the level of the tax rate and, therefore, the level of redistribution determine which classes of agents can invest in human capital. This in turn determines the rate of growth and how income distribution evolves.

The above studies have also conducted some empirical investigations which generally support their theoretical findings.

2. Tax policy in an open economy setting

Diversity in growth rates across countries is a stylized fact. The endogenous growth models discussed in Section II imply that the difference in the real rates of return to capital is the reason for growth rate diversity, provided that preferences and policies are the same across countries. However, in an open economy with perfect capital mobility and under the source principle of international taxation, rates of return to capital across countries will be equalized, hence growth rate differences across countries will disappear. The long-run growth effects of a national tax policy derived from a closed economy setting will be washed out.

This drawback in many endogenous growth models has been recognized and efforts have been made to preserve growth rate differences in an open economy framework. Razin and Yuen (1992) point out that under the residence principle of international income taxation, growth differences across countries due to different national tax policies can be consistent with international capital mobility. The residence principle implies symmetrical tax treatment of domestic-source and foreign-source incomes for residents of each country, but asymmetrical treatment across countries. Residents of a country have to pay the same tax rate on capital income, whether the income comes from investment at home or abroad. According to Razin and Yuen
(1992), when people are more individualistic, residents of countries with higher tax on capital income will tend to substitute human capital investment for physical capital investment (either at home or abroad) if they care more about their own consumption, leading to a higher growth rate in per capita income; when people are more altruistic, they will tend to substitute fertility for physical capital investment, leading to a lower growth rate in per capita income.

The study of Frenkel, Razin, and Sadka (1991) shows that the residence principle is the dominant tax principle among countries in the world. Thus the asymmetry in cross-country capital taxes is a plausible explanation of growth rate diversity across countries. Razin and Yuen (1993) calibrate an open economy growth model to the Group of Seven data over the period 1965-87 under the residence principle. They find that low capital tax rates tend to be associated with faster growth in per capita income. Moreover, they find that the growth effects of changes in capital income tax rates can be much larger with than without capital mobility due to cross-border policy spillovers. The closed economy growth models may thus have underestimated the potentially large growth effects due to tax changes.

A few studies have tried to modify model specifications to make growth diversity consistent with capital mobility. By adding a subsistence consumption term in utility function, Rebelo (1992) establishes a case that the growth rate difference is consistent with perfect international capital markets. Jones and Manuelli (1990) also give an example where growth divergence can be preserved in an open economy. However, these examples are exceptional.

VI. Conclusions

The theoretical and empirical studies on the growth taxation relationship surveyed in this paper do not reach a consensus. Whether a tax policy has negative, zero, or positive effects on economic growth depends on specific situations, especially on the mechanism that growth is driven, the process that human capital accumulates, and the way that tax revenue is spent. Nevertheless, these studies have greatly enhanced our understanding of how alternative tax policies affect the long-run growth performance of a country and how large the growth effects can be under certain situations.

Long-run growth effects of income or investment taxation tend to be negative if the positive growth effects generated by using the tax revenue productively are small. The optimizing behavior of agents results in sustained growth only if the incentive crucial to growth is maintained. This incentive is summarized by the real rate of return to capital (both physical and human) in most endogenous growth models. A tax on income or investment will always have a negative direct effect on the long-run growth rate because it reduces the incentive for agents to behave in a growth enhancing way. However, a tax on income or investment may have indirect growth effects. First, if income from or investment in sectors producing
physical capital and human capital (or product design in the model of product variety) is taxed asymmetrically, the steady-state factor ratios will adjust to equalize the real rate of return to capital across sectors. Such an adjustment generally alleviates (at least to some extent) the direct negative effects of a tax on income or investment if the human capital sector is taxed more lightly. Second, if tax revenue is used to invest in public infrastructure, the steady-state growth rate and the income tax rate will have an inverted-U relation. Before the optimal size of public infrastructure is reached, the positive indirect growth effects from an increase in public infrastructure financed by a rise in the income tax rate will be larger than negative direct growth effects from income taxation. The net growth effects of income taxation will be negative if there has already been too much public infrastructure in the economy.

The direct effects of a consumption tax on the long-run rate of growth are generally believed to be insignificant. The reason is that a consumption tax will not affect the decision of consuming today or tomorrow, that is, the incentive to accumulate capital, given the standard preference assumptions.

Having realized that growth effects are different under different situations, it is not a surprise to find that results from cross-country regressions offer little help in enhancing our understanding of what the correlation between economic growth and tax policy really is. Countries differing in their ways of spending tax revenue, for example, will have, according to the theory, different growth effects of income or investment taxation. Moreover, the linear regression form used in all cross-country regressions is not suitable to the examination of the growth taxation relationship, which may well be nonlinear.

Quantitative results from simulations are subject to the problem that we lack good estimates of some key parameters that are necessary for model calibration. It has been found that the size of growth effects of a change in the income tax rate is very sensitive to the elasticity of intertemporal substitution, the elasticity of labor supply, the depreciation rate of human capital accumulation, and the factor ratios in different sectors. Until reliable estimates on these variables are available, it is difficult to have much confidence in the existing simulation results of growth effects of certain tax policy experiments.

The role that national tax policy can play in affecting growth performance of a country is weakened, in some sense, when the tax policy is endogenously determined by the political process, or when the country is placed in an open economy setting. When the national tax policy is determined through conflicts and compromises among individuals with different interests, the adoption of a growth enhancing tax policy depends on deeper factors, such as the state of income distribution. If unequal distribution tends to result in the adoption of a growth damaging tax policy, as some studies suggest, the policy to recommend should be the one which makes income more equally distributed. When globalization of the world economy is
considered, particularly when an international capital market is introduced, the incentive mechanism crucial for growth works in a dramatically different way. Under the source principle of international taxation, the long-run growth rates across countries will be equalized due to international capital movement, therefore national tax policy will have no effect on growth in the long run. However, under the residence principle of international taxation, residents of a country have to pay the same tax rate on capital income, whether the income comes from investment at home or abroad. Consequently, different capital tax rates across countries imply different real rates of return to capital, and therefore different growth rates of per capita income. Further research on the tax policy implications of the above two extensions of endogenous growth theory is called for.
References


