# Evaluation of interest tax policies in a model of finance and growth ☆

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## Abstract

We develop an overlapping generations model with an active financial sector to differentiate loan from deposit rates and to allow for endogenous credit rationing. We evaluate the macroeconomic consequences of two interest tax policies, an increase in interest tax exemption and a reduction in the interest income tax rate, with and without credit market imperfections. While these policies have different effects in unconstrained equilibrium, they are identical in credit-constrained equilibrium. While these policies may encourage growth with credit rationing when the speed of human capital accumulation is sensitive to education, no such conclusion can be reached in unconstrained equilibrium.
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## 1. Introduction

The development experience in Taiwan during the past three decades has been praised as an economic miracle. Many have argued that the Taiwan government played an important role in the process of its economic development. In particular, adequate tax incentives for promoting savings and investment have been widely believed contributing to this success. Among others, there is a rather unique policy, the interest tax exemption, which has seldom been used in other developed or developing countries (cf. Chang and Riew, 1990). While both the interest tax exemption policy and the interest income tax (subsidy) policy create intertemporal distortion via changes in savings behavior, the interest tax exemption is not percentage based and hence generates no intersectoral distortion via factor reallocation. Although there are abundant papers studying the growth effects of capital or interest income taxation, the macroeconomic consequences of the interest tax exemption policy have not been explored in the existing literature.[1] This paper intends to fill this gap within a dynamic general-equilibrium framework. The policy implications derived may be instructive for many developing countries where savings incentive and capital efficiency are major concerns.

As early as September 1960, the Taiwan government has already included formerly in the Special Investment Encouragement (SIE) Law free interest income tax treatment for time and savings deposits of more than two years in banks (cf. Tax Reform Commission, 1989). There were several amendments in broadening the interest tax exemption base during the next two decades.[2] In December 1980, interest income tax exemption was removed from the SIE Law to the Income Tax Law, and the interest income was exempted from taxes up to NT$360,000. Moreover, for all taxable interest income and stock dividends, one is eligible to choose between the income tax rate and a fixed rate at 20% whichever is lower. The most recent amendment in January 1992 allowed interest and dividend income of all kinds as a whole to be exempted from taxes up to NT$270,000, whereas any taxable portions were at the personal income tax rate.[3] It is important to note that in 1980,

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[1] The study of the long-run macroeconomic and welfare consequences of capital income taxation within the endogenous growth framework is pioneered by Lucas (1990). Using evidence from the advanced US economy, Stokey and Rebelo (1995) suggest that despite a noticeably negative level effect, the influence of capital income taxation on the rate of economic growth is negligible. However, capital income taxation is found to have significantly adverse long-run effects on investment activity and output growth in several developing countries, including Egypt (cf. Konan and Maskus, 2000), Mexico (Feltenstein and Shah, 1995), and Taiwan (Wang and Yip, 1995), to name but a few.

[2] Starting in December 1970, the interest income tax exemption was extended to more than one-year time deposit in banks and the Postal Savings for monthly deposits no more than 12,000 New Taiwan dollars (NT$) and to more than three-year government bonds that were issued for infrastructure construction. Moreover, the dividends of the stocks listed in Taipei Stock Exchange Market were exempted up to NT$60,000 per family. In December 1972, the SIE Law was expanded to include the Farmer Credit Association. The dividends of the stocks exempted were raised up to NT$240,000 per family in July 1977, and were later increased to NT$360,000 in July 1979.

[3] The foreign exchange rate between US$ and NT$ was 40:1 before 1973, 38:1 in 1977, 36:1 in 1979 and 1980, and 26.4:1 in 1992.

about 98% of depositors received interest income less than the exemption cap. Thus, the interest tax exemption base was extremely broad, including almost all the tax payers.

Given the emphasis of the practice of the interest tax exemption in Taiwan, one may wonder if such a policy is growth-promoting in dynamic general equilibrium. Moreover, does this exemption policy generate similar macroeconomic effects to the traditional interest income tax rate policy? Would the same conclusions be reached with and without credit market imperfections? To address these questions, this paper constructs an overlapping generations model of financial intermediation in an endogenous growth framework with an explicit account of capital income tax and interest tax exemption policies. There are four theaters of economic activities: households, firms, banks and the government. We emphasize the importance of incorporating an active financial sector that not only differentiates loan from deposit interest rates but allows for endogenous credit rationing.[4] Both of these features are crucial for a thorough examination of the underlying interest tax policies. In particular, while interest tax policies have direct effects on the deposit rate, it is the loan rate that is linked to physical capital accumulation and economic growth. Moreover, we will show that the responses of interest rates and output growth to various interest tax policies depends on the extent of credit market imperfection.

In the benchmark model, we consider only savings in kind via intergenerational human capital accumulation. Each household lives two periods, works when young and consumes when old. In the presence of parental altruism, a young household decides the division of time to work or to educate the next generation. The latter enables intergenerational accumulation of human capital. Due to forced savings in good, a household deposits the entire wages to a bank at the young age for consumption at the old age. Firms are infinitely lived, utilizing physical capital and effective labor, together with bank loan services, to produce a single final good. Perfectly competitive banks accept deposits from households and make loans to producers to achieve maximum periodic profits. The model is closed with a government sector, financing its nonproductive spending (of a fixed ratio to total output) by per capita income and interest income taxes to balance the budget periodically. In later sections, we consider endogenous credit rationing as a result of a moral hazard absconding behavior of the borrowers and allow for households to endogenize their savings in good.

We show that there is a unique unconstrained and a unique credit-constrained balanced growth equilibrium. The presence of credit constraints results in higher loan and deposit interest rates and lower loan service and physical capital accumulation ratios, human capital investment and economic growth. Both an increase in interest tax exemption and a reduction in the interest income tax rate in the unconstrained case tend to increase the deposit and loan rate, but have no effects on the

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[4] Chen et al. (2000) examine different effects of productivity and financial innovation on the deposit and the loan interest rates when there is an active financial sector transforming loanable funds into productive capitals.

interest rates in the constrained case. While the two policies have different macroeconomic consequences in unconstrained equilibrium, they are identical in constrained equilibrium. Moreover, while these interest tax policies may encourage growth in the presence of credit rationing when the speed of human capital accumulation is sensitive to education, no such conclusion can be reached under a perfect credit market. In the presence of endogenous savings in good, the interest income tax rate policy may promote savings with a strong intertemporal substitution effect, whereas the interest tax exemption policy may do so through an additional channel by encouraging human capital investment. In this case, the positive saving promotion effect of tax incentives may lead to higher loan service and physical capital accumulation ratios and a more rapid rate of economic growth.

The remainder of the paper is organized as follows. In Section 2, we describe the structure of the benchmark overlapping generations model, the individual optimizing behavior for households, firms and banks, and the government activity. Section 3 solves for the balanced growth equilibrium, while Section 4 performs comparative-static and calibration analyses with respect to the interest tax exemption and the interest income tax rate policies. In Section 5, we introduce the moral hazard problem and characterize the credit-constrained equilibrium. Section 6 then allows for endogenous savings in good, enabling the study of an additional channel for tax incentives to affect capital accumulation and output growth. Finally, possible extensions of interests are provided in Section 7.

## 2. The model

We construct an endogenous growth model of finance with overlapping generations (OG) of optimizing households to examine the long-run macroeconomic effects of interest tax policies. This OG framework offers a parsimonious structure enabling analytical solution and characterization of the equilibrium. In the model economy, there are four theaters: households, firms, banks and the government. There is a continuum of each type of economic agents (households, firms and banks) with unit mass. The consideration of an active financial sector is crucial for an adequate evaluation of interest tax policies. We begin by constructing a model with only savings in kind (intergenerational human capital accumulation) yet in a later section endogenizing the decision of savings in good.

Each household lives two periods, young and old.[5] Each household works when young and consumes when old. Each household is endowed with one unit of labor supply when young in which a fraction $v$ is devoted to educating its next generation and the remaining fraction $(1 - v)$ is to working. The wage rate (per unit of effective labor) is $w$ and, in the presence of forced savings, a household deposits the entire wages to a bank. The household redeems its deposits (with interests) in the second

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[5] Implicitly, one may imagine that each household lives three periods with a passive childhood period, a working middle age and a retirement period. Since there is no economic decision to be made during the childhood, it can be omitted without loss of generality.

period of its lifetime and consumes (i.e., there is no bequest in cash). However, parental altruism is allowed via education and a household cares for not only its own consumption when old but also the consumption of its next generation. Each household has an identical logarithmic preference that is monotone increasing in consumption. Let $C_{t+1}$ ($C_{t+2}$) be the consumption of the generation $t$ ($t+1$) when old. Then the utility of generation $t$ is given by

$$U_t = \ln C_{t+1} + \frac{1}{1+\rho} \ln C_{t+2},$$

where $\rho > 0$ is an intergenerational discount rate in order to capture less than 100% altruism.

The generation $t$ household has the following disposable income when young:

$$\Omega_t = [w_t(1 - v_t) - \lambda v_t]h_t \tag{1}$$

in which $h_t$ is the level of human capital for the household born in $t$ and $\lambda_t v_t h_t$ is the real resource costs required for educating its next generation. In contrast with the endogenous growth model of Lucas (1988), we allow for both time and real resource costs of education. The disposable income of a household is then the wage income subtracted by the pecuniary educational cost of education.

As a generation $t$ household saves all wage income when young and consumes when old, his before-tax income and consumption when old are respectively:

$$R_{t+1} = r_t \Omega_t, \tag{2}$$

$$C_{t+1} = (1 + r_t)\Omega_t - \phi h_t - \tau \max\{R_{t+1} - q\overline{\Omega}_t, 0\}, \tag{3}$$

where $r_t$ is the deposit interest rate between $t$ and $t+1$, $\phi$ is the head tax (per capita income tax), $\tau$ is the flat rate of interest income tax, and $q\overline{\Omega}$ is the interest tax exemption which is set to be proportional to the average disposable income of a household in the economy ($\overline{\Omega}$). This captures the fact that the interest tax exemption in Taiwan has been adjusted upwards with the standard of living from 1970 to 1992. For simplicity, we assume that all taxes incur during the second period of lifetime. Since our focus is on the interest tax policies, we consider the alternative tax in form of a household tax (or an "occupation tax" that depends on human capital rather than wage income). The proportional form of tax exemption is chosen to be consistent with a balanced growth path.

By examining (2), one can easily see that both the interest tax exemption policy and the interest income tax/subsidy policy create intertemporal distortion via changes in consumption-savings choice. However, the interest tax exemption is not percentage based and thus generates no intersectoral distortion via factor reallocation, contrasting with the interest income tax/subsidy policy. Therefore, there is a call for a full evaluation of the macroeconomic consequences of these interest tax policy instruments within a dynamic general-equilibrium framework.

Firms are owned by capitalists. Each representative firm in the economy uses capital ($k_t$) and effective labor ($(1 - v_t)h_t$), together with external finance or bank loans ($x_t$) to produce a single final good ($y_t$). Assuming complete capital depreciation, the

output is allocated to future capital ($k_{t+1}$) and consumption ($z_t$). The production function is given by

$$y_t = A \min\{k_t^\alpha, b x_t^\alpha\}[(1 - v_t)h_t]^{1-\alpha}, \tag{4}$$

where $A > 0$, $b > 1$ and $\alpha \in (0,1)$.

The significance of financial instruments for a firm's capital formation has been emphasized in the finance literature.[6] We consider in particular that physical capital and loan services are perfect complements, consistent with a fractional loan-in-advance constraint on investment. Moreover, we follow Diamond and Yellin (1990) assuming the goods producer (capitalist) is a residual claimer in the sense that it ingests the unsold consumption goods (which can be thought of as the conventionally modeled profit flow) in a fashion consistent with lifetime firm value maximization.[7] The net profit flow of a representative firm is

$$\pi_t = A \min\{k_t^\alpha, b x_t^\alpha\}[(1 - v_t)h_t]^{1-\alpha} - (1 + \delta_t)x_t - w_t(1 - v_t)h_t - k_{t+1}. \tag{5}$$

We now study the activity of the financial intermediation in which each bank accepts deposits from households and makes loans to producers in order to make periodic profits. The transformation of deposits into loans follows a simple Ricardian form

$$x_t = B a_t, \tag{6}$$

where $a_t$ is deposits, $x_t$ is loans and $B$ measures the financial intermediation's operative productivity (i.e., the inverse of unit input requirements). Denote $\delta_t$ the loan rate and $\mu$ the unit operational cost of making loans. We assume the banking industry is competitive and is free to enter. In any given period $t$, the profit of a bank is the revenue flow from loan receipts ($\delta_t x_t$), net of interest payments to its depositors ($r_t a_t$) and the bank operation costs ($\mu x_t$):

$$(\delta_t - \mu)x_t - r_t a_t.$$

Since households consume only during their second period of lifetime, they are forced to save the entire income in the first period. The deposits of a household are therefore

$$a_t = \Omega_t. \tag{7}$$

The government spends an amount of $G_t$ (nonproductive) in period $t$, which is assumed a fixed proportion $\theta$ of income (to be consistent with a balanced growth path): $G_t = \theta y_t$. The government uses tax revenue to finance its expenditure, including per head income and interest income taxes:

$$T_t = \phi h_{t-1} + \tau \max\{R_t - q\Omega_{t-1}, 0\} = G_t. \tag{8}$$

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[6] For example, Vinala and Berges (1988) illustrate that financial services have the potential to affect real investment decisions by making available to firms cheaper or flexible external financing sources and by allowing firms to make better investment decisions through monitoring.

[7] This is the simplest way to avoid the Arrow–Debreu redistribution of firm profits to consumers while maintaining the general-equilibrium nature.

To close the model, we must specify the intergenerational growth process. As in the conventional wisdom (Stokey, 1991; Glomm and Ravikumar, 1992), this growth rate may depend positively on the fraction of time devoted to education $v$. However, since physical capital accumulation plays an equally important role in our model, we argue that a higher physical capital per unit of human capital may also enhance growth. For analytical convenience, we assume it is the economy's average level of the physical–human capital ratio that counts. The aggregate rate of economic growth is then

$$g = g(v, \bar{k}/\bar{h}) \tag{9}$$

in which $g_v > 0$ and $g_{\bar{k}/\bar{h}} > 0$.

## 3. Optimization and balanced growth equilibrium

We start with the optimization of banks. Under perfect competition, the optimization of banks is consistent with the zero profit condition, which together with (7) implies

$$(\delta_t - \mu)x_t = r_t a_t = r_t \Omega_t. \tag{10}$$

In this benchmark model with forced savings in good, households' consumption and savings decision is trivial. Thus, the main task is to determine the fraction of time devoted to working $(1 - v_t)$ by maximizing the dynastic utility function subject to the budget constraint (3) given (1) and (2). The first-order necessary condition is

$$(w_t + \lambda)[1 + (1 - \tau)r_t] = \varepsilon \left\{ \left( w_{t+1} \frac{1 - v_{t+1}}{v_t} - \lambda \frac{v_{t+1}}{v_t} \right) [1 + (1 - \tau)r_{t+1}] - \frac{\phi}{v_t} \right\}, \tag{11}$$

where $\varepsilon(v) = \frac{E(v)}{1+\rho}$ and $E(v) = \frac{v}{1+g} \frac{d(1+g)}{dv} > 0$ is the education elasticity of human capital accumulation. In (11), the left-hand side is the marginal cost of reducing a unit of working time, including both time and real resource costs. The right-hand side is the generationally discounted marginal benefit, where the first term in the large bracket measures the net gain from educating the next generation multiplied by the after-tax rate of interest.

Finally, we solve the optimization of a representative firm. Facing a given rate of interest on loans ($\delta$), the representative producer in any given period $t$ chooses loan demand, labor demand and consumption goods supply to maximize its lifetime value $V$ (the sum of present discounted gross profit flows) subject to the capital formation Eq. (5). Thus, the discounted sum of profit flows can be specified as

$$V(k_t) = \max_{\{x_t, 1-v_t\}} \sum_{\tau=t}^{\infty} \Delta_\tau \pi_\tau, \quad \text{where } \Delta_\tau = \prod_{j=t}^{\tau} \left( \frac{1}{1+\delta_j} \right).$$

In the case where there is no credit rationing, i.e., $x_t \geqslant b^{-1/\alpha}k_t$, optimal loan satisfies

$$\frac{k_t}{h_t} = b^{1/\alpha}\frac{x_t}{h_t}. \tag{12}$$

Under (12), optimization $V(k_t)$ with respect to $1 - v_t$ leads to

$$Ab(1 - \alpha)(1 - v_t)^{-\alpha}\left(\frac{x_t}{h_t}\right)^{\alpha} = w_t. \tag{13}$$

From (13), we obtain $(1 - v_t)h_t = [\frac{A(1-\alpha)}{w_t}]^{-1/\alpha}$. Substituting this relationship into $\pi_t$, the discounted sum of profits can be written as the following Bellman equation:

$$V(k_t) = \left[A^{1/\alpha}\alpha\left(\frac{1-\alpha}{w_t}\right)^{(1-\alpha)/\alpha} - (1 + \delta_t)b^{-1/\alpha}\right]k_t - k_{t+1} + \frac{1}{1 + \delta_{t+1}}V(k_{t+1}).$$

We proceed with standard dynamic programming techniques by guessing the solution as such that it yields a linear value function: $V(k_t) = \Lambda_t k_t$. The Benvenistic–Scheinkman conditions imply

$$V(k_t) = (1 + \delta_t)k_t, \tag{14a}$$

$$A\alpha b^{1-1/\alpha}(1 - v_t)^{1-\alpha}\left(\frac{x_t}{h_t}\right)^{\alpha-1} = (1 + \delta_t)(1 + b^{-1/\alpha}). \tag{14b}$$

Thus, $\Lambda_t = 1 + \delta_t$ the value function is proportional to the amount of physical capital and the transversality condition for the firm's maximization is guaranteed by

**Condition T** (*Transversality*). $\delta > g$.

We are now ready to solve for the balanced growth equilibrium. First, we define the concept of a balanced growth path (BGP). Then we prove the existence and uniqueness of a BGP.

**Definition.** A BGP is a tuple $\{C_t/h_t, k_t/h_t, z_t/h_t, a_t/h_t, x_t/h_t, y_t/h_t, R_t/h_t, \Omega_t/h_t, V_t/h_t, T_t/h_t; v_t, g_t, w_t, r_t, \delta_t\}$ such that

  (i) households, firms and banks all optimize subject to relevant constraints: (1)–(3), (11); (4), (12)–(14b); (6), (10);
 (ii) government budget is balanced: (8);
(iii) goods and deposit markets are all clear: (5), (7);
 (iv) balanced growth: (9) is satisfied;
  (v) each of the variables is constant over time.

Obviously, by Walras's law, once goods and deposit markets are clear, the loan market must be also clear.

To characterize the BGP, we transform the system in steady state into two equations and two endogenous variables. First, from the deposit–loan transformation (6) and bank's zero profit condition (10), we get the loan interest rate as

$$\delta = \mu + \frac{r}{B}. \tag{15}$$

Utilizing firms' optimization conditions (14b) and (15), we get the loan–human capital ratio as

$$\frac{x}{h} = \left[ Ab^{1-\frac{1}{\alpha}} \Gamma(r) \right]^{1/(1-\alpha)} (1-v), \tag{16}$$

where $\Gamma(r) = \frac{\alpha}{(1+\mu+r/B)(1+b^{-1/\alpha})}$ with $\Gamma' < 0$. Combining (14b) and (13) to eliminate $x/h$ and then using households' optimization condition (11) and (15) to substitute out $w$ and $\delta$, we obtain

$$\frac{\lambda[1+\varepsilon(v)]v + \dfrac{\phi\varepsilon(v)}{1+(1-\tau)r}}{\varepsilon(v) - [1+\varepsilon(v)]v} = (1-\alpha)A^{1(1-\alpha)}[\Gamma(r)]^{\alpha(1-\alpha)}. \tag{17}$$

Eq. (17) is called the consumer efficiency (CE) locus, which depends only on two endogenous variables $v$ and $r$. The left-hand side of (17) represents the marginal benefit of investing an additional unit of time ($v$) in educating the next generation, whereas the right-hand side is the corresponding marginal cost measured by the marginal product of labor. It is obvious to see that the marginal benefit is a function of $v$ and the marginal cost is constant in $v$. In order to guarantee a unique interior solution of $v$ (satisfying the boundary and the second-order conditions), it is required that the marginal benefit be positive and decreasing in $v$. Without loss of generality, we assume that the effect of $v$ on economic growth is separable from that of $\bar{k}/\bar{h}: 1 + g(v, \bar{k}/\bar{h}) = \psi(v)\bar{k}/\bar{h}$ with $\psi'(v) > 0$, under which $E(v) = v\psi'(v)/\psi(v)$ and $\varepsilon(v) = [v\psi'(v)/\psi(v)]/(1+\rho)$. It suffices to require:

**Condition I** (*Interior human capital*). $\varepsilon(v) > \max\{\frac{v}{1-v}, v\varepsilon'(v)\}$.

The second inequality of this condition ensures that the marginal benefit of education investment is positive, while the first guarantees that the marginal benefit of education investment is diminishing and hence the second-order condition is satisfied.[8] These inequalities require that the effect of the time devoting to educating the next generation on the education elasticity of human capital accumulation be moderately strong whereas the education elasticity of human capital accumulation be sufficiently large.[9] Under this condition, there is an interior solution of $v$ for a given $r$ in (17). The left-hand side of (17) is now decreasing in both $v$ and $r$, and that the right-hand side is decreasing in $r$ but independent of $v$. Consider

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[8] Since the marginal cost is independent of $v$, the second-order condition holds if the marginal benefit is strictly decreasing in $v$. Straightforward manipulations of the derivative of the marginal benefit of $v$ yield the required second-order condition when $\varepsilon$, exceeds the second argument of the right-hand side of the inequality in Condition I.

[9] To provide further insight toward understanding Condition I, an example is in order. Consider $\psi(v) = \psi_0 v^{\varepsilon_0(1+\rho)}$, $\varepsilon_0 > 0$. Thus, we have $\varepsilon'(v) = 0$ and Condition I is satisfied if $\varepsilon_0 > v/(1-v)$, which basically eliminates the dynamically inefficient, high education investment equilibrium.
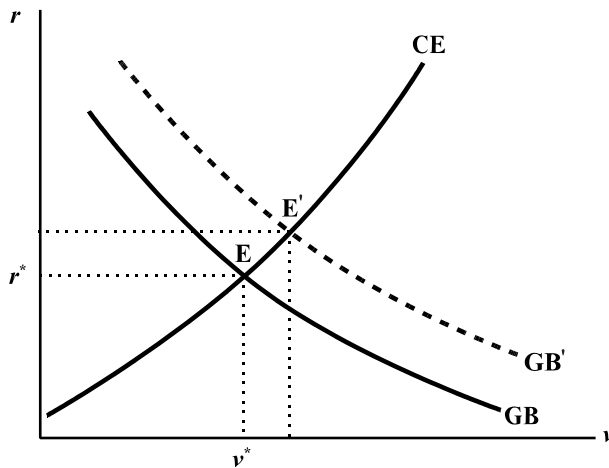
Fig. 1. Unconstrained equilibrium and effects of an increase in $q$.

**Condition H** (*Human capital investment*). $\phi\{(1-\tau)[(1+\mu)B+r] - \frac{\alpha}{1-\alpha}[1+(1-\tau)r]\} < \frac{\alpha}{1-\alpha}\frac{1+\varepsilon}{\varepsilon}\lambda v.$

Condition H requires the per head tax rate ($\phi$) be sufficiently small such that the effect of a higher rate of interest on deposits is to increase the net benefit of human capital accumulation.[10] It therefore guarantees that the CE locus is positively sloping in the $(v, r)$ space, as shown in Fig. 1.

We next transform the system to get the second relationship. It can be derived using the government balanced budget condition (8), together with (1), (2), (6), (7), (13), (14a–b) and (16) to obtain

$$\phi + \tau(r-q)[(1-\alpha)A^{1/(1-\alpha)}\Gamma(r)^{\alpha/(1-\alpha)}(1-v) - \lambda v]$$
$$= \theta A^{2/(1-\alpha)}\Gamma(r)(1-v)^{2-\alpha}\psi(v). \tag{18}$$

This relationship is called the government budget (GB) locus, which depends on two endogenous variables $v$ and $r$. The right-hand side of (18) is the ratio of government expenditure to human capital, whereas the left-hand side is the ratio of tax revenue to human capital. To guarantee sensible comparative results, we impose Correspondence principle *à la* Samuelson:

**Condition CP** (*Correspondence principle*). $v > \frac{D}{1+D}$, where $D = \left[\frac{(1-\alpha)A^{1/(1-\alpha)}}{\lambda} \times \frac{\alpha}{(1+\mu)(1+b^{-1/\alpha})}\right]^{\alpha/(1-\alpha)}.$

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[10] From (17), we can compute the derivative of the net marginal benefit of human capital investment as $\{\alpha/(1-\alpha)(1+\varepsilon)\lambda v/((1+\mu)B+r) - \phi\varepsilon[(1-\tau) - \alpha/(1-\alpha)[1+(1-\tau)r]/[(1+\mu)B+r]]\}/(\varepsilon - (1+\varepsilon)v)$, which is positive under Condition H.

Condition CP is also sufficient to guarantee positive interest income taxes on the left-hand side of (18), and thereby the government budget allocation is well defined in equilibrium. Under Condition CP, the government tax revenue on the left-hand side of (18) is increasing in $r$ and decreasing in $v$, where the government expenditure on the right-hand side is decreasing in $r$ and $v$. When the interest income tax accounts for a relatively small fraction of government revenue (i.e., $\tau/\theta$ is low), the effect of $v$ via the right-hand side dominates that via the left-hand side, implying a downward sloping GB locus in $(v, r)$ space as shown in Fig. 1.

We are now ready to define the existence and uniqueness of the balanced growth equilibrium. Under Conditions I and CP, the CE locus is upward sloping while the GB locus is downward sloping in $(v, r)$ space jointly determining the unique BGP values of $v$ and $r$ (see point $E$ in Fig. 1). Once the BGP values of $v$ and $r$ are pinned down, other endogenous variables on the BGP can be solved recursively. Specifically, when we substitute $v$ and $r$ into (15), (16) and (12), we obtain the BGP values of loan rate ($\delta$), the ratio of loans to human capital ($x/h$), and the ratio of physical to human capital ($k/h$), respectively. Substituting $v$ and $k/h$ (or, identically, $x/h$) into (9) and (13), we get BGP values of the balanced growth rate $g(v, k/h)$ and the wage rate ($w$). Subsequently, we obtain the BGP value of $\Omega/h$ from (1), $R/h$ from (2), $C/h$ from (3), $y/h$ from (4), $z/h$ from (5), $a/h$ from (7), $T/h$ from (8), and, finally, $V/h$ from (14a). Since all these recursive relationships are monotonic, the solution of the BGP is unique.

**Proposition 1** (Existence and uniqueness). *Under Conditions T, H, I and CP, there is a unique BGP.*

## 4. Comparative statics analysis

In this section, we characterize the balanced growth path by examining how tax policy changes affect the endogenous variables of our particular interest, including $v$, $r$, $\delta$, $k/h$ and $g$. We focus on two tax policies: an increase in interest tax exemption (a larger $q$) and a reduction in the interest income tax rate (a lower $\tau$). The results of the comparative statics are reported in Table 1. While Fig. 1 displays the effects of an increase in $q$, Fig. 2 illustrates the effects of a reduction in $\tau$.

When the interest tax exemption increases (a larger $q$), it is obvious to know from (17) that the CE is not affected, and from (18) that the GB locus shifts upward. Thus the new BGP equilibrium becomes $E'$ at which both the loan rate ($r$) and human capital investment ($v$) are higher (see Fig. 1). Intuitively, when the interest tax exemption is larger, the currently young generation can work less to get the same amount of interest income for the old age and therefore devote a larger fraction of time in educating the next generation. For a given ratio of government expenditure to output and a given interest income tax rate, a larger interest tax exemption tends to generate a government deficit and thereby reduces the supply of loans. As a consequence, the equilibrium loan rate ($\delta$) increases and, under banks' zero profit condition, the

Table 1
Comparative statics without and with credit rationing

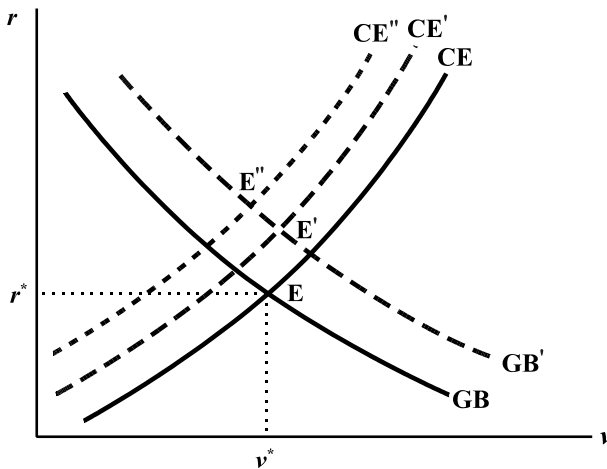| | Human capital investment, $v$ | Deposit rate, $r$ | Loan rate, $\delta$ | Physical to human capital ratio, $k/h$ | Growth rate, $g$ |
|---|---|---|---|---|---|
| *I. Unconstrained equilibrium* | | | | | |
| Increase in interest tax exemption, $q\uparrow$ | + | + | + | − | ? |
| Reduction in interest income tax rate, $\tau\downarrow$ | ? | + | + | − | ? |
| *II. Constrained equilibrium* | | | | | |
| Increase in interest tax exemption, $q\uparrow$ | + | 0 | 0 | − | +[a] |
| Reduction in interest income tax rate, $\tau\downarrow$ | + | 0 | 0 | − | +[a] |

[a] Assume $\varepsilon > 1/(1 - v)$.



Fig. 2. Effects of a decrease in $\tau$ in unconstrained equilibrium.

equilibrium deposit rate must rise accordingly. Under diminishing returns (of firm production), the physical to human capital ratio ($k/h$) increases, as does the ratio of loan services to human capital ($x/h$). Since $v$ increases but $k/h$ decreases, the effect on economic growth rate ($g$) is generally ambiguous.

A lower interest income tax rate ($\tau$) shifts both the CE and GB loci upward as illustrated in Fig. 2. Since a lower tends to create a government budget deficit, it requires, for a given level of human capital investment, a higher deposit rate to enlarge the interest income tax base and to balance the budget. That is, for the same $v$, $r$ becomes higher; hence, the GB locus shifts upward. A lower $\tau$ increases the opportunity cost of education and thus reduces the marginal benefit of human capital investment for a given level of $v$. To restore the equilibrium, the marginal cost must be lower, which can be achieved by a higher loan rate and thus a lower $k/h$ ratio and lower marginal product of labor. Under banks' zero profit, this requires the deposit

rate to increase and so the CE locus shifts upward. In the new equilibrium, both the deposit and the loan interest rate increase, which reduces the financial service and physical capital accumulation ratios (i.e., lower $x/a$ and $k/h$). This result is mainly due to our assumption of forced savings in good (which will be relaxed in Section 6). In particular, there is no intertemporal substitution effect via saving incentives. Rather, it is the wealth effect via government deficit that leads to this unconventional outcome. Depending on whether the relative magnitudes of the shifts in the two loci, the effect on $v$ is ambiguous. In Fig. 2, $E'$ and $E''$ depict, respectively, the cases where the GB and CE locus shift by more.[11] In the former case, $v$ increases and the effect on economic growth ($g$) is ambiguous due to the opposing effects via $v$ and $k/h$.

In summary, we can conclude:

**Proposition 2** (Characterization of the unconstrained equilibrium). *Under Conditions T, H, I and CP, the unique BGP processes the following properties.*

  (i) *Both an increase in interest tax exemption and a reduction in the interest income tax rate raise balanced equilibrium deposit and loan rates, leading to lower loan service and physical capital accumulation ratios in the presence of forced savings in good.*
 (ii) *Both interest tax policies generate ambiguous effect on economic growth, due mainly to potential conflicting effects via human and physical capital accumulation.*
(iii) *While the effect of an increase in interest tax exemption is to promote human capital investment, that of a reduction in the interest income tax rate is ambiguous.*

This proposition suggests that based on their effects on both human and physical capital accumulation, an increase in interest tax exemption may likely be a better policy instrument than a reduction in the interest income tax rate. Thus, it lends a theoretical support to the argument that the fiscal policy design of the Taiwan government promotes long-run economic development. Of course, in order to reconfirm this conclusion, a calibration analysis is now in order.

Specifically, we undertake this exercise based on the Taiwanese economy in 1978 when interest tax exemption was 0.24 million NT dollars. The short-term deposit and loan rates were $r = 6\%$ and $\delta = 10.75\%$, respectively (from *Taiwan Statistical Data Book, TSDB* henceforth, in 2001); the average growth rate from 1970 to 1985 was $g = 6.7700\%$ (*TSDB*, 2001); the ratio of nonproductive government spending to output was 10.16% (*Yearbook of Financial Statistics*, 1980). Measure every real value in million dollars at the 1978 price. Utilizing the loan–deposit ratio (457596/635581, *TSDB*, 2001), we can apply (6) to obtain $B = 0.72$, which can be substituted into (15) to compute $\mu = 0.02416$. Similarly, using the capital–loan ratio (2810803/457596, *TSDB*, 2001 and *The Trends in Multifactor Productivity*, 2000) and the

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[11] The former is likely to occur if both $1 - \alpha$ (the labor income share) and $\lambda$ (pecuniary education cost) are large so that the CE locus is relatively steep.

capital income share $\alpha = 1/3$, we get from (12) $b = 1.8314$. It is reasonable in oriental societies to assume that $\rho = 0$, that is, parents value their kids essentially the same as themselves. The three tax parameters are computed as follows. We set $\varphi = 10^{-8}$ so that the (nondistortionary) household tax revenue was 4.78 (in million NT dollars) and $\tau = 7\%$ which equals the household average income tax rate (*Yearbook of Tax Statistics*, 1979). The rate of interest tax exemption is $q = 0.24/\Omega$. Finally, we select $\varepsilon = 0.5$.[12] Using Eqs. (9), (16)–(18), we calibrate other parameter values as: $A = 0.00001406$, $\psi_0 = 4.6495$ and $\lambda h = 0.2396$, whereas the computed value of the fraction of time devoted to intergenerational human capital transfer turns out to be $v = 15.2420\%$, which seems reasonable.

We now alter the two tax policy instruments, $q$ and $\tau$. First, consider the interest tax exemption policy executed in July 1979 where $q$ increases from $0.24/\Omega$ to $0.36/\Omega$. The simulation results are given below: $r = 5.9996\%$, $v = 15.2423\%$, and $g = 6.7714\%$. That is, there is a moderate increase in human capital investment and economic growth, accompanied by a lower rate of interest. Alternatively, we consider a reduction in the interest income tax rate $\tau$ from 7% to 6%, the new steady-state equilibrium features: $r = 6.0796\%$, $v = 15.2555\%$, and $g = 6.6405\%$. Interestingly, using a set of parameter values mimicking the Taiwanese economy, a moderate reduction in the interest income tax rate raises human capital investment but lowers physical capital accumulation in a way such that the latter effect dominates, thus leading to lower economic growth in the long run.

## 5. Moral hazard and credit-constrained equilibrium

In this section, we examine what happens if there are credit market imperfections causing a moral hazard problem that results in credit rationing on investment loans. In this paper, we adopt a parsimonious form that captures Banerjee and Newman's (1993) arguments: "[a borrower may] attempt to avoid his obligations by fleeting from his village, albeit at the cost of lost collateral" (p. 280). Specifically, the lender cannot ensure that the money lent is indeed invested and thus fails to ensure the payment.[13] An individual firm, in anticipating a low rate of returns on productive investment, may have an incentive to "take the money and run" (i.e. to abscond), without repaying the loan.

We assume that failing to repay the loan, an individual firm would have a fraction of the productive capital stock seized and the entire value from production measured by $V(k)$ would be lost.[14] Thus, the value of taking the money and run is $x + (1 - \eta)k$. The incentive-compatibility constraint that eliminates this moral hazard behavior is therefore given by $V(k) \geqslant x + (1 - \eta)k$, which implies that the value of undertaking

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[12] We have performed sensitivity analysis on $\varepsilon$ ranging from 0.25 to 1.5 and found similar results.

[13] Traditionally, moral hazard behavior is usually modeled as for borrowers to take very risky projects after obtaining the loans and for lenders to be not able to ensure the return; see Hart and Moore (1994) and papers cited therein.

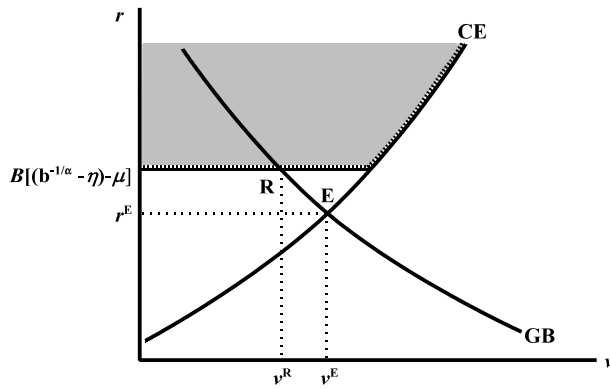[14] A similar assumption is made in Kehoe and Levine (1993).

Fig. 3. Credit-constrained equilibrium.

production exceeds the value of absconding. Using (12) and (14a), we can reduce the above inequality to $\delta \geqslant (1 - \eta)$, and using (15), we can reduce this inequality to

$$r \geqslant B[(b^{-1/\alpha} - \eta) - \mu]. \tag{19}$$

Thus, the "effective" consumer efficiency locus is now represented by the kinked dash line in Fig. 3 where in the shaded area, the incentive-compatibility constraint is met. Under equilibrium credit rationing, banks set an incentive-compatible loan interest rate at $\delta = 1 - \eta$ and therefore the competitive deposit interest rate at $r^R = B[(1 - \eta) - \mu]$ which is larger than the unconstrained equilibrium $r^E$, whereas the human capital investment in the constraint equilibrium ($v^R$) is therefore smaller than that in the unconstrained equilibrium ($v^E$).[15] Since the incentive-compatibility constraint must be met, moral hazard is not observed in equilibrium. It is easily seen that credit rationing is present when the unconstrained equilibrium deposit interest rate $r^E$ is lower than $B[(b^{-1/\alpha} - \eta) - \mu]$.

**Condition R** (*Credit rationing*). $r^E < B[(b^{-1/\alpha} - \eta) - \mu]$.

Comparing the credit-constrained equilibrium (see point $R$ in Fig. 4) with the unconstrained equilibrium ($E$), we can establish.

**Proposition 3** (Credit-constrained equilibrium). *Under Conditions T, H, I, CP and R, there is a BGP with credit rationing. The presence of credit constraints causes the loan and deposit interest rates to increase and the loan service and physical capital accumulation ratio, human capital investment and economic growth to decrease.*

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[15] The loan and deposit contracts specified above are optimal under a competitive setting. On the one hand, no individual bank would offer a higher deposit interest rate, as it would obviously result in a negative profit. On the other hand, if an individual bank would under-cut the deposit interest rate, it would end up with no customers. Thus, the credit-constrained deposit interest rate must be equal to the exogenous value $B[(b^{-1/\alpha} - \eta) - \mu]$ with no individual banks deviating in equilibrium.
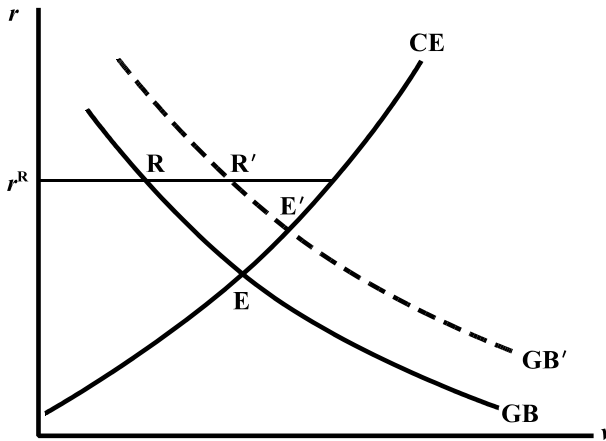
Fig. 4. Effects of an increase in $q$ in constrained equilibrium.

In our investment–loan production economy, a higher deposit interest rate and thus a higher loan interest rate serve as a mechanism to eliminate the moral hazard problem, since it assures the operation of firms with higher foreseen profitability. A higher interest rate thus leads to lower ratios of loan service and physical capital accumulation. Because investment in human capital also decreases, economic growth is lower unambiguously. Therefore, credit rationing is growth-retarding, corroborating with findings in the human capital investment, moral hazard model of Tsiddon (1992) and the physical capital investment, adverse selection model of Bencivenga and Smith (1993).

It remains to characterize the unique steady-state equilibrium with credit rationing. The results of the comparative-static analysis in the presence of credit rationing is summarized in Table 1. Focusing on a local analysis, we consider the case where the incentive-compatibility constraint is binding before and after the autonomous changes. As in the previous section, an increase in interest tax exemption (a larger $q$) only shifts the GB upward without affecting the CE locus (see the GB′ locus and the new constrained equilibrium $R'$ in Fig. 4). Thus, investment in human capital increases. Since the deposit interest and loan rates are pegged in constrained equilibrium (as neither the banking nor the absconding parameters are affected by interest tax policies), (14b) and (12) imply that both the physical to human capital ratio and the loan to human capital ratio decrease. The conflicting effects via human and physical capital accumulation generate an ambiguous growth effect. Yet, under credit rationing, we can compute explicitly that the interest tax exemption effect on growth is positive if the education elasticity of human capital accumulation is sufficiently large such that $\varepsilon > 1/(1 - v)$, which is stronger than the second inequality of Condition I.

A reduction in the interest income tax rate (a low $\tau$) shifts both the government budget balance locus and the consumer efficiency locus upward. Since the credit constraint is binding, the deposit interest rate remains pegged at $r^R$ and the GB locus

becomes the sole force determining the constrained equilibrium. As a result, the effects of a reduction in the interest income tax rate is exactly the same (qualitatively and quantitatively) as those of an increase in interest tax exemption, if the two policies shift government budget identically (as in standard differential incidence exercises).

**Proposition 4** (Characterization of the constrained equilibrium). *Under Conditions T, I and CP, the unique BGP possesses the following properties.*

  (i) *Both an increase in interest tax exemption and a reduction in the interest income tax rate have no effects on equilibrium deposit and loan rates, but suppress the ratios of loan service and physical capital accumulation.*
 (ii) *Both interest tax policies encourage human capital accumulation, leading to higher economic growth if the speed of human capital accumulation is sensitive to education.*

It is interesting to compare the comparative-statics results with respect to the two policy changes in the constrained equilibrium to those in the unconstrained equilibrium (based on Propositions 2 and 4). There are three major differences to comment in order. First, while both policies in the unconstrained case tend to increase the deposit and loan rate, they have no effects on the interest rates in the constrained case. Second, while the two policies have different macroeconomic consequences in unconstrained equilibrium, they are identical in constrained equilibrium. Finally, while these interest tax policies may encourage growth in the presence of credit rationing when the speed of human capital accumulation is sensitive to education, no such conclusion can be reached under a perfect credit market. Thus, it is likely that these tax incentives may work better in an economy with credit market imperfections.

## 6. Endogenous saving

To account for the effects of tax incentives on savings and physical capital accumulation, we extend the model to endogenize the saving decision in goods. Each generation therefore consumes both when young and old. The utility function of the generation $t$ is then modified to

$$\underset{\{C_t, v_t\}}{\text{Max}}\, U_t = \ln[(C_t^t)^\beta (C_{t+1}^t)^{1-\beta}] + \frac{1}{1+\rho}\ln[(C_{t+1}^{t+1})^\beta (C_{t+2}^{t+1})^{1-\beta}],$$

where $C_i^t$ denote the consumption of the generation $t$ in period $i$ and $\rho > 0$ captures less than 100% intergenerational altruism.

The four consumption measures, $C_t^t$, $C_{t+1}^t$, $C_{t+1}^{t+1}$ and $C_{t+2}^{t+1}$, satisfy respectively the following budget constraints:

$$C_t^t = [w_t(1 - v_t) - \lambda v_t]h_t - S_t, \tag{20a}$$

$$C_{t+1}^t = S_t(1 + r_t) - \phi h_t - \tau \min\{r_t S_t - q\overline{S}_t, 0\}, \tag{20b}$$

$$C_{t+1}^{t+1} = [w_{t+1}(1 - v_{t+1}) - \lambda v_{t+1}]h_{t+1} - S_{t+1}, \tag{20c}$$

$$C_{t+2}^{t+1} = S_{t+1}(1 + r_{t+1}) - \phi h_{t+1} - \tau \min\{r_{t+1} S_{t+1} - q\overline{S}_{t+1}, 0\} \tag{20d}$$

in which $\overline{S}_t$ is average $S_t$ in the economy.

Assuming $r_t S_t > q\overline{S}_t$ so that interest income tax is positive, a household chooses $C_t^t$, $C_{t+1}^t$ and $v_t$ by maximizing its utility subject to constraints (18a)–(18d). The necessary conditions are as follows:

$$\frac{C_{t+1}^t}{C_t^t} = \frac{1 - \beta}{\beta}[1 + r_t(1 - \tau)] \tag{21}$$

and (11). The former relationship is obtained because the behavior of firms and banks does not change when households endogenize savings in good. Thus, the equilibrium values of the deposit rate $(r)$, human capital investment $(v)$ and savings in steady state are determined by (17), (18) and (21). Notice that these three equations are recursive: (17) and (18) can be used to solve the equilibrium values of $r$ and $v$, and then the equilibrium value of $r$ can be substituted into (20a), (20b) and (21) to solve equilibrium savings in unit of the total wealth. Specifically, we divide (20b) by (20a) to get $C_{t+1}^t/C_t^t$ and then equate (21) to obtain in steady state,

$$s = \frac{(1 - \beta)[1 + r(1 - \tau)] + \dfrac{\beta\phi}{w(1 - v) - \lambda}}{(1 + r - \tau v) + \beta\tau q}, \tag{22}$$

where $s \equiv S/\Omega$ is the savings rate. It is clear to see from (22) that the savings rate is increasing in human capital investment $(v)$ and also increasing in the deposit interest rate $(r)$ so long as the per capita income tax rate $(\phi)$ is not too large (so that the positive substitution effect dominates the negative wealth effect).

Consider an increase in interest tax exemption (a larger $q$). There is a direct negative effect on the savings rate according to (22). This is because an increase in interest tax exemption creates a one-for-one effect on wealth but a less than proportionate effect on savings. An increase in interest tax exemption also has an indirect effect to increase savings rate through its positive effects on $v$ and $r$. This latter effect via $r$ captures the concept that tax incentives can promote savings (through intertemporal substitution). Interestingly, a reduction in the interest income tax rate (a smaller $\tau$) influences the macroeconomy very differently than the interest tax exemption policy. It has a direct positive effect on the savings rate, but an ambiguous indirect effect through $v$ and $r$. Unlike the interest tax exemption policy, the direct effect of the interest income tax rate policy in this case reflects the intertemporal substitution channel as indicated by (21). Since savings are channeled into the loan market, helping physical accumulation, it is possible that either policy may now raise the loan service and physical capital accumulation ratios. These are summarized by

**Proposition 5** (Characterization of the BGP with endogenous savings in good).
*Under Conditions T, I and CP, the balanced growth equilibrium possesses the
following properties.*

(i) *While the interest income tax rate policy may promote savings with a strong inter-
temporal substitution effect, the interest tax exemption policy may do so through
an additional channel by encouraging human capital investment.*

(ii) *By allowing for endogenous savings in good, the positive saving promotion effect
of tax incentives may lead to higher loan service and physical capital accumula-
tion ratios and higher growth.*

## 7. Concluding remarks

We evaluate the macroeconomic consequences of two interest tax policies, an in-
crease in interest tax exemption and a reduction in the interest income tax rate, with
and without credit market imperfections. We show that there is a unique uncon-
strained and a unique credit-constrained balanced growth equilibrium. Both interest
tax policies in the unconstrained case tend to increase the deposit and loan rate, but
have no effects on the interest rates in the constrained case. While the two policies
have different macroeconomic consequences in unconstrained equilibrium, they are
identical in constrained equilibrium. Moreover, while these interest tax policies
may encourage growth in the presence of credit rationing when the speed of human
capital accumulation is sensitive to education, no such conclusion can be reached
under a perfect credit market. In the presence of endogenous savings in good, the
interest income tax rate policy may promote savings with a strong intertemporal sub-
stitution effect, whereas the interest tax exemption policy may do so through an addi-
tional channel by encouraging human capital investment. In this case, the positive
saving promotion effect of tax incentives may lead to higher loan service and physical
capital accumulation ratios and a more rapid rate of economic growth. These policy
implications may be instructive for many developing countries where savings incen-
tive and capital efficiency are major concerns.

There are several ways to extend our analysis. For brevity, we only discuss two.
First, one may follow Lucas's (1990) Hicks Lecture to perform differential tax inci-
dence exercises by calibrating the balanced growth and transitional dynamics effects
of the two interest tax policies. Of course, one must realize that in our paper, there
are three optimizing agents (instead of one as in Lucas's model). Thus, the analysis
cannot be carried out smoothly without further simplification of the model structure.
Second, our framework may be used to reexamine the macroeconomic effects of the
financial repression policy in the presence of interest tax incentives. To reduce firms'
external financing costs, the financial repression policy tends to suppress the loan
rate, leading to a lower deposit rate in equilibrium. The latter implies a smaller inter-
est tax base and hence the interest tax incentives become less effective. This may re-
sult in a reduction in savings and funds supply, thus making firms' external financing
more difficult.

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