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Review of Economic Dynamics 6 (2003) 381–403
Review of Economic Dynamics
www.elsevier.com/locate/red

Tax evasion in a model of endogenous growth

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Received 17 February 2000; revised 8 September 2002

Abstract

This paper integrates tax evasion into a standard AK growth model with public capital. In the model, the government optimizes the tax rate, while individuals optimize tax evasion. It studies tax rate, tax evasion and economic growth, and compares them with otherwise identical economies except those without tax evasion. It inquires into the effects of three government policies on tax rate, tax evasion, and economic growth. It finds that an increase in both unit cost of tax evasion and punishment–fines reduces tax evasion, whereas an increase in tax auditing reduces tax evasion only if the cost of tax enforcement is not too high. The three policies theoretically have ambiguous effects upon economic growth, due to their indirect effects upon tax evasion and optimal tax rate. The model is calibrated to quantitatively assess the effects of the three above-mentioned policies. It finds that the three policies are quantitatively effective in discouraging tax evasion, but with small growth effects, unless the degree of government externality is very high.

JEL classification: E2; O4

Keywords: Tax evasion; Economic growth; Deterrence

1. Motivation

This work integrates tax evasion into a general-equilibrium, economic growth framework. Two lines of conventional wisdom are related with this topic: the optimal income taxation and tax evasion initiated by Mirrlees (1971), and the endogenous growth pioneered by Romer (1986). While the main focus of the former line is the effectiveness of various policies upon tax evasion (e.g., Schroyen, 1997), the major emphasis of the latter line is the effect of policies upon long-run economic growth (e.g., Rebelo, 1990). Conven-

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1094-2025/03/$ – see front matter
doi:10.1016/S1094-2025(03)00002-4

tional works on income taxation and tax evasion conduct analysis in a partial-equilibrium setup, without taking into account an economy's resource constraints and feedback effects, whereas existing general-equilibrium endogenous growth models do not analyze the implications of tax evasion on economic growth.[1] It is worthwhile to determine the tax rate under tax evasion, and to explore the effectiveness of deterrence policies upon tax evasion and economic growth in a general-equilibrium framework.

Tax evasion is examined in East Asian economies, where some economies have a severe tax evasion problem and others do not.[2] Existing growth models (Lucas, 1993) and data (Summers and Heston, 1991) indicate that East Asian tigers have performed equally well and extraordinarily better than all other areas in the past two decades. These above stylized facts seem to indicate that policies leading to more severe tax evasion, do not necessarily hurt economic growth in East Asia. This paper attempts to analyze economic growth in models of tax evasion, and to probe into their possible reasons.[3]

As a first attempt, this paper follows the standard AK model in Barro (1990), and considers a twist in tax evasion. In the model, the government provides productive services that externally enhance private production. Provision of public services offers a rationale for taxation. The government decides the optimal tax rate and the optimal expenditure. Given the tax rate, the households–firms then choose optimally the tax compliance rate and consumption–savings. Taxation and tax evasion, in turn, influence public expenditure and capital accumulation, which affect output and economic growth. We analyze the tax rate, the degree of tax evasion, and the economic growth rate in equilibrium, and compare

[1] Roubini and Sala-i-Martin (1995) are the only exceptions. Although Roubini and Sala-i-Martin also deal with tax evasion in the endogenous growth model, there are, however, several differences between our work and theirs. In our work, the degree of tax evasion is an optimal choice and the size of government is allowed to vary as will be seen later, whereas in Roubini and Sala-i-Martin, tax evasion is an ad hoc function by specification and a constant size of government is assumed. As a result of optimal tax evasion, we are able to study the effects of evasion-deterring policies upon tax evasion, economic growth and other variables.

[2] It is believed that within East Asian tigers, tax evasion is more severe in South Korea and Taiwan and much less of a problem in Hong Kong and Singapore. In a value-added tax (VAT) evasion study, for example, Fu (1995) estimates and finds that the annual VAT evasion as a fraction of potential VAT base in Taiwan during the period from 1987 to 1993 was 20.9%, on average. It is well known that VAT affects the reports of income tax revenue due to its self-enforcing element, because each buyer will demand a copy of such a receipt. The evasion of VAT therefore leads to the evasion of income tax. Indeed, in an interview survey in Taiwan conducted by Chu (1990), the CPAs reported that, on average, 66.4% of the companies they represented regularly under-reported their incomes and profits by various methods. Similar situations can be found in South Korea (Choi, 1997). On the other hand, tax evasion is much less severe in Singapore and Hong Kong. See Das Gupta and Mookherjee (1998) for Singapore. There is no data for Hong Kong about tax evasion, but tax evasion should not be a serious problem in Hong Kong, given the fact that non-tax revenues from land account for a major source of government revenue; e.g., the share of land revenue in total government revenues is bigger than 50% in 1997 and 1998 (Source: *Hong Kong Annual Digest of Statistic*, 1998).

[3] Although this paper focuses on tax evasion, we should mention that tax evasion is related to the size of underground economies. Tax evasion and underground economies are prevailing not only in developing economies, but also in developed economies. Within the USA, for example, about 17 percent of income taxes are estimated unpaid (Slemrod and Yitzaki, 2000), and the underground economy is about 26 percent of total economy (Feige, 1979). See National Center for Policy Strategies (1998) for the estimated size of underground economies in Great Britain, Italy, Germany, Russia, and East Europe. See also papers edited in Feige (1990) for the relationships between tax evasion and underground economies.

them with otherwise identical economies without tax evasion. We analyze and quantify the effects of three policies by the following: (1) increasing the unit cost of tax evasion, (2) increasing the punishment–fines, and (3) increasing tax auditing efforts.

Our work contributes to existing literature in at least five significant aspects.

(i) This is the first model, to our knowledge, to study optimal tax setting and optimal tax evasion in the context of endogenous growth.
(ii) Tax evasion provides a new mechanism for the optimal tax rate to deviate from the degree of government externality (e.g., Turnovsky, 1997).
(iii) It adds a dynamic general-equilibrium formulation into the existing partial-equilibrium models of tax evasion (e.g., Polinsky and Rubinfeld, 1991).
(iv) It elaborates and quantifies in a dynamic general-equilibrium framework, where the relative effectiveness of enforcement policies is analyzed in static, or partial-equilibrium, crime literature since Becker (1968).
(v) Finally, it studies and quantifies the effect of deterrence policies upon economic growth that has never been investigated before.

By allowing for tax evasion in an otherwise standard AK-type growth model, two features are introduced. First, tax evasion is optimized, and anticipations of tax evasion affect the government's optimal tax rate. Second, tax administration and enforcement policies affect tax evasion, and thus optimal tax rates. In particular, as some of these policies require resources, the enforcement affects both public expenditure and disposable income, resulting in either adverse or ambiguous effects upon economic growth. In addition, enforcement policies generate two indirect effects on economic growth. One is through changes in optimal statutory tax rate, in order to optimize the productive government expenditure. The other is through tax evasion responses to enforcement polices. Both indirect effects may enhance or discourage economic growth, depending on their relative effects upon disposable income and public expenditure. As a result, the net effect on economic growth of the three aforementioned policies is usually ambiguous.

Besides the above results, other main findings may be briefly summarized as follows. First, the equilibrium tax rate is bigger and the economic growth rate is smaller in an economy with tax evasion, than otherwise identical economies without tax evasion. Second, while a higher unit cost of tax evasion and a higher punishment–fines both are effective in deterring tax evasion, a higher tax auditing probability may not be effective, due to a general-equilibrium feedback effect. Finally, the calibration results indicate that all the three enforcement policies are effective in bringing down tax evasion, however they only have negligible effects upon economic growth, unless government externality is very large. Under moderate degrees of government externality, our findings suggest that an economy that enforces tax evasion more seriously has a higher tax compliance rate, with similar rates of economic growth to that of otherwise identical economies with laxer tax enforcement.

Following Section 1, this paper is organized as follows. In Section 2, we construct a one-sector model, and analyze its optimization problems and steady-state equilibrium. In Section 3, we investigate the properties of the steady-state equilibrium, in particular the effects of three government policies on tax rate, tax evasion, and economic growth. In

Section 4, we calibrate the model to assess quantitatively the effects of the three policies. Finally, Section 5 discusses the limitations of this work and potential extensions.

2. An economy with tax evasion

Our model draws on the standard AK model in Barro (1990). Consider an economy that is populated by households and firms. Time is continuous. There exists a continuum of identical infinite-lived households, with no population growth. There also exists a continuum of representative firms, and households own the shares. It follows that the economy is a world of a representative household producer.

The representative household is assumed to possess the following discounted lifetime utility:

$$\int_0^\infty \mathrm{e}^{-\rho t} \frac{c^{1-\sigma}(t) - 1}{1-\sigma} \, \mathrm{d}t, \tag{1}$$

in which $\rho > 0$ is the instantaneous time-preference rate, and $\sigma > 0$ is the reciprocal of the intertemporal elasticity of substitution. Function $c(t)$ is the instantaneous private consumption expenditure.

As in Barro (1990), the representative firm is assumed to own the following production technology:

$$y(t) = Ak^{\eta}(t)g^{1-\eta}(t), \tag{2}$$

in which $0 < \eta < 1$, $y(t)$ is the instantaneous output per capita, $k(t)$ is the instantaneous capital input per capita, and $g(t)$ is the productive government services in t. Parameter $A > 0$ is a productivity parameter summarizing the level of technology. This technology is externally, positively affected by public services, with the degree of government expenditure externality of $1 - \eta$. Examples of public services comprise of infrastructural services provisions, protection of property rights, and others. We assume that the government purchases a portion of private output, and then provides services to private producers free of charge. The production function ensures that the maximization problem faced by each firm, is concave and well-defined. For simplicity, we assume that capital does not no depreciate. Firms are competitive in goods markets.

With taxation, a firm may be unwilling to report its output completely to the tax authority. Denote by τ the income tax rate set by the government, and $\beta \in [0, 1]$ the fraction of output reported by a firm. As a result, the reported quantities of income taxes are $\tau\beta y$. Tax evasion involves the transaction costs and the states of success and failure (e.g., Cowell, 1990). The transaction costs include hiring CPAs and lawyers to dodge taxes, and particularly bribing tax officials and law administrators, along with other concealing activities. In general, these transaction costs increase along with both the degree of tax evasion and the income level. To be consistent with a sustainable growth setup, the costs incurred in evading taxes are assumed to be $h_0(1 - \beta)^2$, with $h_0 > 0$ as a cost parameter. A smaller h_0 captures the situation, where an economy is more corrupt, so that it is easier to dodge taxes. In the event of tax evasion, the tax authority will audit and detect the cases.

Suppose that p is the probability that a firm is discovered—and convicted—of tax evasion. For a potential evader, there are (ex ante) two possible states: "success" (i.e., getting-away-with-it) and "failure" (i.e., discovery and conviction). If a firm is found guilty of concealing an amount of income $(1-\beta)y$, then it has to pay the amount of the evaded taxes, $\tau(1-\beta)y$, and the quantity of fines at a fixed penalty rate of $\pi - 1 > 0$.[4] The administrative cost of penalties is usually quite minor (Skinner and Slemrod, 1985) and, for simplicity, we assume that it is negligible. For interior tax evasion, it is necessary to require that the expected penalty rate be less than one, i.e., $p\pi < 1$.

As the tax auditing occurs randomly, under a representative firm–household setup, a fraction $1 - p$ of firms–households evades taxes successfully, whereas the remaining fraction fails. The net income $[(1-\tau\beta) - h_0(1-\beta)^2]y$ is obtained for a successful tax evasion, while it becomes the same amount of net income minus the penalty $\pi\tau(1-\beta)y$ for a failed case. As households own firms' shares, the representative household's disposable income is:[5]

$$\begin{aligned} y_d &= (1-p)\big[(1-\tau\beta) - h_0(1-\beta)^2\big]y \\ &\quad + p\big[(1-\tau\beta) - h_0(1-\beta)^2 - \pi\tau(1-\beta)\big]y \equiv (1-\tau_{\mathrm{E}})y, \end{aligned} \tag{3}$$

where $\tau_{\mathrm{E}} \equiv \tau[1-(1-\beta)(1-p\pi)] + h_0(1-\beta)^2$ denotes the effective tax rate (including the cost of tax evasion).

Disposable income, not consumed currently, becomes savings, which augments capital:

$$\dot{k} = (1-\tau_{\mathrm{E}})y - c. \tag{4}$$

Finally, the government needs tax revenues to provide productive services, and to enforce taxation in the event of tax evasion. Assume that the revenues are financed contemporarily by income taxes, with a flat tax rate τ. In consistence with sustainable growth, we assume that the cost of tax auditing is f_0py, where $f_0 > 0$ is a cost parameter. Therefore, the contemporary government budget constraint becomes:

$$\tau\big[\beta + p\pi(1-\beta)\big]y \equiv T = f_0py + g. \tag{5}$$

The sequence of optimal decisions proceeds as follows. The government–tax authority announces an optimal tax rate, taking into consideration the best response of representative agents. Given the announced statutory tax rate, the representative household–firm then chooses its decisions about the fraction of income reported to tax authority and the optimal

[4] We abstract from the setting that the government chooses the enforcement probability (p) and the penalty rate (π) by setting up parametric p and π, as otherwise the resulting three simultaneous equations for τ, p, and π of the form like Eq. (12) below are too complicated to analyze. Nevertheless, the setup facilitates a comparison with conventional wisdom in the effectiveness analysis of two popular deterrence policies, namely, raising the *certainty* of punishment and increasing the *severity* of punishment (e.g., Davis, 1988; Leung, 1995). Our setup for π follows existing literature, whereby it is assumed to be either a maximum or a predetermined value (e.g., Schroyen, 1997). For p, we could assume $p = p_0 + m(\beta)$, where $p_0 > 0$ and $m'(\beta) < 0$, in which households treat p as given whereas the government adjusts m in response to its expectations of β. This alternative specification does not bring any different results but algebraic complications. For optimizing p, we will comment the robustness of our results in the concluding section.

[5] Without abuse of notations, we drop the time subscript.

consumption–savings. The optimization problem is solved backwards, starting from the household's problem, and then the government's problem.

2.1. Household optimization

The representative household's problem is equivalent to the second-best welfare maximization problem, where the planner is constrained to ignore the externalities (see Barro (1990) for the proof). The constrained planner under concern chooses not only c and k, but also β, to maximize discounted lifetime utility (1) subject to (2)–(4), with given p, π, and g. To solve the dynamic optimization problem, we define the following present-value Hamiltonian equation:

$$J = \frac{c^{1-\sigma}-1}{1-\sigma}\mathrm{e}^{-\rho t} + \lambda\bigl\{\bigl(1-\tau\bigl[\beta+p\pi(1-\beta)\bigr]-h_0(1-\beta)^2\bigr)Ak^{\eta}g^{1-\eta}-c\bigr\}, \quad (6)$$

in which λ is the present-value shadow price of capital formation, and the expression inside the big brackets equals $\dot{k}$ in (4). Denoting $\dot{c} \equiv \mathrm{d}c/\mathrm{d}t$, the optimal conditions lead to the following relationships:

$$2h_0(1-\beta) = (1-p\pi)\tau, \quad (7)$$

$$\frac{\dot{c}}{c} = \frac{1}{\sigma}\left\{A\eta\left(\frac{g}{k}\right)^{1-\eta}(1-\tau_{\mathrm{E}})-\rho\right\}, \quad (8)$$

$$\lim_{t\to 0} k(t)\lambda(t) = 0. \quad (9)$$

Equation (7) determines the degree of tax compliance, whereby marginal cost of tax evasion equals marginal gains from tax reduction. Equation (8) determines the growth rate of consumption, which is also the growth rate of income, under our framework. This growth rate depends on the gap between net marginal productivity of capital per capita and time-preference rate. The tax evasion indirectly affects the growth rate via the effective tax rate. Equation (9) is the transversality condition, which restricts k from growing too fast. Examining (7) yields the relationship $\beta^* = 1-(1-p\pi)\tau/(2h_0)$, and thus:

Lemma 1 (Optimal tax evasion). *Under $h_0 > 0$, $p\pi < 1$, and $0 < \tau < 2h_0/(1-p\pi)$, there is positive, but not full tax compliance. The optimal tax compliance decreases in the statutory tax rate, and increases in the unit cost of evading taxes, the probability of detection, and the severity of punishment.*

Intuitively, other things being equal, a higher statutory tax rate (τ) increases marginal gains of tax evasion, and at optimum, the representative firm thereby evades more taxes. For a given statutory tax rate, however, the higher unit cost of tax evasion (h_0), the higher probability of detection (p), and the heavier punishment (π)—all lower marginal gains of tax evasion. Tax compliance increases accordingly.

2.2. Government optimization

The government decides the optimal tax rate that maximizes the representative individual's discounted lifetime utilities, subject to its budget constraint, taking into consideration that individuals will optimally respond to tax policies by changing tax compliance and consumption–savings, as illustrated by (7)–(8). As the discounted lifetime utilities are increasing in c, it can be shown that maximization of discounted lifetime utilities is equivalent to maximization of the consumption growth rate, if (i) the utility is bounded and (ii) the elasticity of substitution between g and k in production is unity (see Barro, 1990, pp. S111–S112, for a sketch of proof). The required conditions are met under our setup, as seen from the Cobb–Douglas technology in (2) and Condition PB later imposed for a bounded discounted lifetime utility. Rearranging the government budget constraint (5), together with the production function (2), generates

$$\frac{g}{k} = A^{1/\eta}\big[\tau_{\mathrm{E}} - h_0(1-\beta)^2 - f_0 p\big]^{1/\eta}. \tag{10}$$

Substituting (10) into (8) leads to

$$\underset{\{\tau\}}{Max}\,\frac{\dot{c}}{c} = \frac{1}{\sigma}\big(A^{1/\eta}\eta\big[\tau_{\mathrm{E}} - h_0(1-\beta)^2 - f_0 p\big]^{(1-\eta)/\eta}(1-\tau_{\mathrm{E}}) - \rho\big). \tag{11}$$

Maximizing (11) with respect to τ, and taking into account the best response of tax compliance (7), yields the following third-order polynomial Ramsey–Rule relation:

$$\begin{aligned}&\frac{1-\eta}{\eta}\left(1-\frac{1-p\pi}{h_0}\tau^*\right)\left(1-\tau^*+\frac{1-p\pi}{4h_0}\tau^{*2}\right)\\&\quad=\left(\tau^*-\frac{1-p\pi}{2h_0}\tau^{*2}-f_0 p\right)\left(1-\frac{1-p\pi}{2h_0}\tau^*\right).\end{aligned} \tag{12}$$

While the left-hand side of (12) demonstrates the marginal benefit of taxation via increases in public expenditure, the right-hand side is the marginal cost of taxation due to reduction of disposable incomes and capital accumulation of individuals. At optimality, the government sets a statutory tax rate, so that marginal benefit equals marginal cost. Define $x = h_0^2 - h_0(1-\eta+f_0 p\eta)(1-p\pi)^2(1+\eta)$. Equation (12) has three roots:

$$\tau_1^* = \frac{h_0}{(1-p\pi)^2}, \qquad \tau_2^* = \frac{2[h_0-\sqrt{x}]}{(1-p\pi)^2(1+\eta)}, \qquad \tau_3^* = \frac{2[h_0+\sqrt{x}]}{(1-p\pi)^2(1+\eta)}. \tag{13}$$

Consider

Condition RR (Real roots). $h_0 > (1-\eta+f_0 p\eta)(1-p\pi)^2(1+\eta)$.

Under Condition RR, all three roots in (13) are real. Among them, τ_1 is independent of the externality parameter η, and is inconsistent with conventional results (e.g., Barro, 1990). Intuitively, a larger government externality upon private production will optimally need more tax revenues, and thus the optimal tax rate should be higher. Given the inconsistency, we rule out the root τ_1. For the remaining τ_2 and τ_3, we substitute each of them into (11), to determine economic growth. As the results turn out, the economic growth rate when $\tau = \tau_2^*$ is higher than that when $\tau = \tau_3^*$, implying that τ_2^* is globally maximized.[6] Under Condition RR, τ_2^* is always positive. Examining the optimal tax rate τ_2^*, we arrive at the following.

[6] Substituting τ_1^* into the economic growth rate, we also find that the growth rate is smaller than that under τ_2^*.

Lemma 2 (Optimal tax rate). *Under Condition RR, the optimal tax rate is always positive. The optimal tax rate increases in the government externality and the unit cost of tax enforcement, and decreases in the unit cost of tax evasion and punishment. A better detection policy would have ambiguous effects on tax rate.*

The properties of optimal tax rates may be intuitively explained as follows. First, a larger government expenditure externality on private production $(1-\eta)$ raises the efficiency of taxation through public spending, thus leading to a higher optimal tax rate. Second, a higher unit cost of tax enforcement (f_0) requires more government revenues and thus a higher tax, other things being equal. Third, a higher unit cost of tax evasion (h_0) and more severe punishment (π), both reduce the degree of tax evasion according to Lemma 1. Anticipating this, the government sets a smaller optimal tax rate. Finally, a higher certainty of punishment (p) deters tax evasion and leads to a smaller optimal tax rate, but the incurred cost of tax enforcement requires more tax revenues, resulting in a higher tax rate. The effect on the optimal tax rate is thus ambiguous. When the unit cost of tax evasion and the probability of enforcement are small, the former effect dominates, and a higher certainty of punishment leads to a smaller optimal tax rate.

2.3. Equilibrium

We are now ready to define the equilibrium.

Definition. A perfect foresight steady-state equilibrium (PFSSE) with tax evasion is a tuple $\{\beta^*, (g/k)^*, (\dot{k}/k)^*, (\dot{c}/c)^*, \tau_e^*\}$, such that

(i) the individual's budget is balanced, i.e., (4) is satisfied;
(ii) the representative household–firm optimizes, i.e., (7) and (8) are satisfied;
(iii) the government budget is balanced, i.e., (10) is satisfied;
(iv) the government optimizes, i.e., (13) is satisfied.

It is well known that there is no transitional dynamics in a standard one-sector endogenous growth model, whereby the equilibrium is always on a steady-state, balanced growth path. Thus, in this model equilibrium, β^*, τ_e^*, and $(g/k)^*$ are all constant, and c^*, k^*, g^*, and y^* all grow at a common rate. It follows that $(c/k)^*$ is constant in equilibrium. In light of this, the system is apparently block-recursive and easy to solve. We use Eqs. (7) and (13) to solve for the steady-state values of β^* and τ_e^*, and then use (4), (8) and (10), to solve for the values of $(g/k)^*$, $(\dot{k}/k)^*$, and $(\dot{c}/c)^*$, respectively. Specifically, for given parametric values of h_0, p, and π, relationship $\beta = 1-(1-p\pi)\tau_e/(2h_0)$ in (7) is negatively sloping on the (β, τ_e) plane. For convenience, it is referred to as locus TC (tax compliance). Next, optimal tax rate τ_2^* is solely determined by (13), given η, f_0, h_0, p, and π. The relationship is thus a horizontal curve on the (β, τ_e) plane, and is referred to as locus TS (tax setting) (see Fig. 1). Loci TC and TS uniquely determine steady state E^* in Fig. 1, with equilibrium values β^* and τ_2^* being the functions of exogenous parameters η, f_0, h_0, p, and π. Then, $(g/k)^*$, $(\dot{k}/k)^*$, and $(\dot{c}/c)^*$, can be solved by substituting optimal β^* and τ_2^* into (10), (4), and (4), respectively.

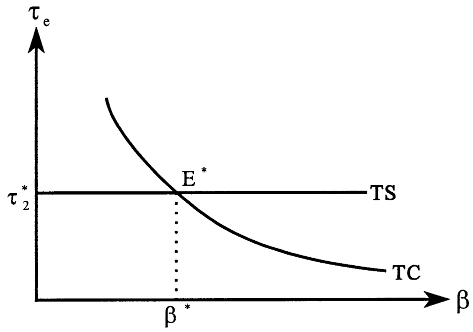

Fig. 1. Optimal tax compliance vs. tax setting in a steady-state equilibrium.

Given an optimal tax rate τ_2^*, as determined by (13), the equilibrium degree of tax evasion is

$$\beta^* = 1 - \frac{1 - \sqrt{1 - (1 - \eta + f_0 p\eta)(1 - p\pi)^2(1 + \eta)/h_0}}{(1 - p\pi)(1 + \eta)}, \tag{14}$$

the equilibrium effective tax rate is

$$\tau_E^* = \frac{\eta}{1+\eta} \frac{2\left[h_0 - \sqrt{h_0^2 - h_0(1 - \eta + f_0 p\eta)(1 - p\pi)^2(1 + \eta)}\right]}{(1 - p\pi)^2(1 + \eta)} + \frac{(1 - \eta + f_0 p\eta)}{1 + \eta}, \tag{15}$$

and finally, the equilibrium economic growth rate is

$$\frac{\dot{c}}{c} = \frac{1}{\sigma}\left\{A^{1/\eta}\eta\left[\left(\tau_E^* - \frac{(1 - p\pi)^2}{4h_0}(\tau_2^*)^2 - f_0 p\right)^{(1-\eta)/\eta}(1 - \tau_E^*)\right] - \rho\right\}. \tag{16}$$

Therefore, the unique PFSSE is fully solved. In order to rule out trivial cases, we focus on an economy, whose economic structure yields sustainable growth and bounded utilities. Consider

Condition PB (Positive growth and bounded utility).

$$\left(\frac{\rho}{\eta}\right)^{\eta} \frac{1}{[\tau_E^* - (1 - p\pi)^2(\tau_2^*)^2/(4h_0) - f_0 p]^{1-\eta}[1 - \tau_E^*]^{\eta}}$$
$$< A < \left(\frac{\rho}{(1-\sigma)\eta}\right)^{\eta} \frac{1}{[\tau_E^* - (1 - p\pi)^2(\tau_2^*)^2/(4h_0) - f_0 p]^{1-\eta}[1 - \tau_E^*]^{\eta}},$$

where τ_2^* and τ_E^* are determined parametrically by η, f_0, h_0, p, and π as in (13) and (15), respectively.

While the first part of Condition PB implies $\dot{c}/c > 0$ in (16), the second part assures that the attainable utility in (1) is bounded and that the transversality condition holds. Our above analysis leads to the following.

Theorem (Existence and uniqueness of PFSSE). *Under Conditions RR and PB, there exists a unique perfect-foresight, steady-state equilibrium.*

3. Characteristics in equilibrium

We now examine the properties in PFSSE. We start by comparing two otherwise identical economies except for their tax evasion. Then, we analyze the effects of three enforcement policies.

3.1. Tax evasion

When there is no tax evasion, the optimal tax rate is the degree of government externality; i.e., $\tau^* = 1 - \eta$. The gap of an optimal tax rate between tax evasion and no tax evasion is:

$$\tau_2^{*2} - (1-\eta)^2 = \left[\frac{[(1-\eta)(1-p\pi)^2(1+\eta)]^2}{4} + h_0 f_0 p\eta(1-p\pi)^2(1+\eta)\right] \equiv \Lambda > 0. \tag{17}$$

The above expression indicates that the optimal statutory tax rate under tax evasion is always higher than the tax rate without tax evasion. This result differs from Barro (1990), who obtains an optimal tax rate that equals the degree of government externality. Although our result is similar to Futagamin et al. (1993) and Turnovsky (1997), but the mechanism leading to the result differs. While the incentive to evade taxes results in the deviation of optimal statutory tax rate, from the degree of government externality in our model, the mechanism in existing studies is the accumulation of public services into stocks.

As in Barro (1990), taxation has two effects: (1) raising public spending to capital ratios, which enhances economic growth through external effect on production, and (2) reducing net marginal product of capital stock, which discourages economic growth. Different from Barro (1990), the tax evasion incentives bring two additional effects. First, tax evasion forces the government to set a lower tax rate, but in order to maintain optimal public services, the government needs to set a higher tax rate to collect enough tax revenues. As the latter effect dominates the former effect, the net effect is a higher tax rate, represented by the first term in big brackets of (17). Second, the costs to enforce taxes under tax evasion (p and f_0) crowd out productive services. This raises the tax rate further (represented by the second term). As a consequence, the tax rate under tax evasion is always higher than the tax rate without tax evasion.

What is the effect of externality on tax rate, tax evasion and gap of tax rates between tax evasion and no tax evasion? Since a larger government externality $(1-\eta)$ does not directly affect tax compliance of households, locus TC is unaffected, affecting tax compliance indirectly through raising the optimal tax rate, and hence, locus TS shifts upwards (see Fig. 2). As a result, the optimal statutory tax rate is higher, and the tax compliance is lower in the new steady-state equilibrium. Moreover, differentiating (17) with respect to the externality, yields a positive value, indicating that the optimal tax rate under tax evasion responds to the externality more sensitively. Intuitively, a larger

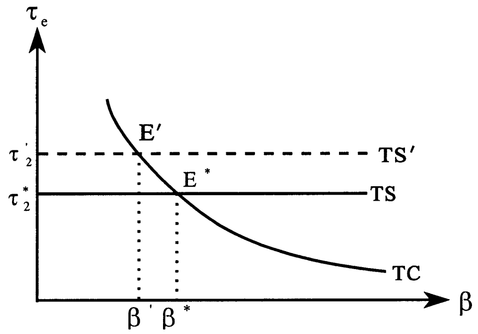

Fig. 2. Effects of a higher government expenditure externality.

externality renders government incentives of higher tax rates, in order to maximize the representative individual's welfare. With tax evasion, tax enforcement costs and larger optimal public services under a larger externality, the government is led to set an even higher tax rate, to secure more revenues.

Summarizing the above discussion, we obtain the following.

Proposition 1 (Tax rate and externality). *Under Conditions RR and PB, the optimal tax rate under tax evasion is higher than the degree of government externality. A higher externality leads to a higher tax rate, smaller tax compliance, and a bigger gap in the tax rate, between tax evasion and no tax evasion.*

3.2. Effects of three enforcement policies

We next envisage the effects of three policies upon tax rate, tax evasion, and rate of economic growth. These three policies are as follows: increasing the unit cost of tax evasion, raising punishment and fines, and increasing the probability of detection.

We begin by examining how a higher unit cost of tax evasion affects the optimal tax rate and tax compliance. Intuitively, a higher unit cost of tax evasion diminishes incentives of households to evade taxes, shifting locus TC rightward to TC′ in Fig. 3. Moreover, in anticipation of the resulting less tax evasion, a higher unit cost of tax evasion induces the government to set a smaller optimal tax rate, shifting locus TS downward to TS′. As a result, the optimal tax rate is smaller, and the tax compliance is higher. The growth effect is obtained as follows. Using relationship $\tau_E \equiv \tau_2[1-(1-\beta)(1-p\pi)] + h_0(1-\beta)^2$ to rewrite (16), yields:

$$\frac{\dot{c}}{c} = \frac{1}{\sigma}\Big\{A^{1/\eta}\eta\big\{\tau_2^*\big[1-(1-\beta^*)(1-p\pi)\big] - f_0 p\big\}^{(1-\eta)/\eta} \times \big\{1-\tau_2^*\big[1-(1-\beta^*)(1-p\pi)\big] - h_0(1-\beta^*)^2\big\} - \rho\Big\}. \tag{18}$$

The effect of a higher unit cost of tax evasion upon economic growth rate is

$$\underset{(?)}{\frac{d(\dot{c}/c)}{dh_0}} = \underset{(-)}{\frac{\partial(\dot{c}/c)}{\partial h_0}} + \underset{(?)}{\frac{\partial(\dot{c}/c)}{\partial(1-\beta^*)}}\,\underset{(-)}{\frac{d(1-\beta^*)}{dh_0}} + \underset{(?)}{\frac{\partial(\dot{c}/c)}{\partial\tau_2^*}}\,\underset{(-)}{\frac{d\tau_2^*}{dh_0}}. \tag{19}$$

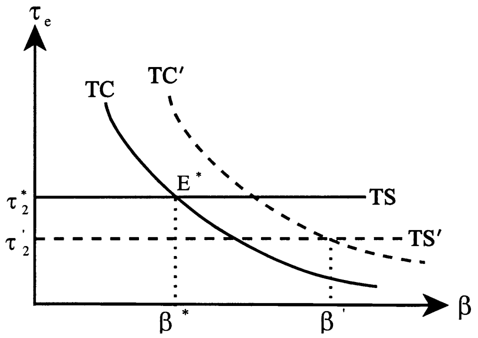

Fig. 3. Effect of a higher unit cost on tax evasion.

Table 1
Comparative statics under three policy changes

	$1-\beta^*$	τ_2^*	Direct effect on $\dot{c}/c$
Increase in unit cost of tax evasion, h_0	−	−	−
Increase in fine, π	−	−	?
Increase in tax enforcement, p	? or −[a]	? or −[a]	?

[a] Negative if $f_0 p$ is small.

There are three channels (one direct and two indirect effects, as shown in Table 1) for a higher unit cost of tax evasion, influencing the rate of economic growth. First, it has an adverse direct effect on economic growth (the first term on the right-hand side of (19)), as it directly reduces disposable income and thus capital accumulation. Second, it also affects economic growth indirectly through lowering tax evasion and tax rate. The first indirect effect, via lowering tax evasion, is ambiguous as, on the one hand, it raises public services to enhance economic growth and, on the other hand, it lowers disposable income to reduce disposable income and thus economic growth. The second indirect effect, through reducing the tax rate, is also ambiguous, as it lowers public services and raises disposable income, opposing to the first direct effect. As a result, the effect of a higher unit cost of tax evasion upon economic growth is ambiguous. In the Appendix (not reported), it has been shown the following sufficient condition to obtain a positive net growth effect.

Condition UG (Unit cost and growth). $\dfrac{(1-p\pi)^2}{h_0} \geqslant \dfrac{\eta}{(1+\eta)^2(1-\eta+f_0\eta)}$.

Under Condition UG, a higher unit cost of tax evasion results in a higher economic growth rate. This condition is easier to satisfy, if the unit cost of tax evasion (h_0), the expected unit fine $(p\pi)$, and the externality $(1-\eta)$ are smaller. Summarizing the above results, we obtain the following.

Proposition 2 (Unit cost of tax evasion). *Under Conditions RR and PB, a higher unit cost of tax evasion results in lower equilibrium tax rate, higher tax compliance, and an* *ambiguous effect on the economic growth rate. The economic growth effect is positive, if Condition UG is met.*

The ambiguous growth effect has the following implications. Consider two otherwise identical economies except for the unit costs of tax evasion. Tax evasion usually goes hand in hand with corruption.[7] An economy that is more fraudulent and corrupt has a smaller unit cost of tax evasion, as it is easier for households–firms to evade taxes by buying off the tax officials and the juridical administrators, or to cover tax evasion by employing CPAs and lawyers. The above result thus indicates that an economy with a higher degree of tax-related corruption (or a smaller unit cost of tax evasion), may not necessarily have a lower economic growth rate, albeit possessing a higher degree of tax evasion. The implied relationship between corruption in tax evasion and economic growth in this model may be related to existing literature, which describes those which obtain a positive relationship between corruption and economic growth (e.g., Huntington, 1968), and those which obtain a negative relationship (Mauro, 1995), although the concept of corruption in existing literature may be wider than the tax-related corruption. Our theoretically ambiguous relationship between corruption and economic growth corroborates that of Barreto (2000) who finds that corruption is neither efficiency enhancing nor efficiency detracting, with respect to growth.

The above results may have implications to East Asian economies. In these economies, some behave more corruptly than others. Moreover, countries that are corrupt definitely have a higher degree of tax evasion,[8] suggesting that the unit cost of tax evasion is smaller in these East Asian economies. This, together with the fact that East Asian economies have grown rapidly, may support the theoretically ambiguous relationship between the corruption–unit cost of tax evasion and economic growth. Moreover, it implies that more severe tax evasion resulting from a higher unit cost of tax evasion does not necessarily reduce economic growth in East Asia.

When there exists tax evasion, deterrence policies (instilling audits and increasing sanctions) are generally adopted, and are prevalent worldwide. The relative deterrence effect between increasing the certainty and raising the severity of punishment, has been studied extensively in partial-equilibrium settings (Becker, 1968; Davis, 1988; Leung, 1995). It is of importance to examine their effectiveness in a general-equilibrium framework, as this incorporates not only compliant responses of the individuals, but also government's optimal taxation and expenditure decisions.

[7] Chander and Wilde (1992), whose paper includes tax evasion in a game theoretic framework, find that when some auditors accept bribes, the tax evasion is higher so that a bigger fine or tax rate produce less expected government revenue. To give an example, in Taiwan, in the 54 CPAs interviewed by Chu (1990), 46 readily admitted of having the experiences of bribing the tax officials in charge. The CPAs, according to the survey, regularly under-reported the profits of the companies they represented, by counterfeiting records of sales, claiming non-existent expenses, inflating inventory damages, buying receipts from illegal sources, and performing other manipulations.

[8] According to the corruption index constructed by Business International Corporation (1981) and others, Hong Kong and Singapore have a better index than average countries under investigation, whereas South Korea and Taiwan have a worse index. Recall from footnote 2 that the tax evasion problem is more severe in South Korea and Taiwan and much less severe in Hong Kong and Singapore.

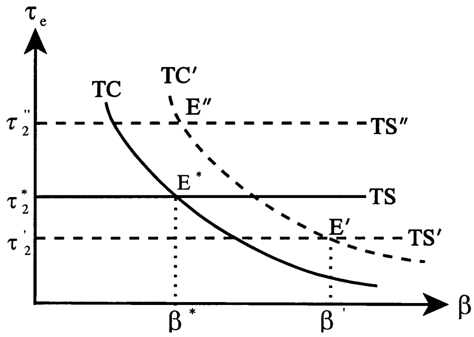

Fig. 4. Effect of deterrence policies.

To examine the effect upon tax compliance, both deterrence policies increase optimal tax compliance, rendering locus TC to shift rightward to TC′ (see Fig. 4). In anticipating this, while more severity of punishment leads the government to lower the optimal tax rate, inducing locus TS to shift downward to TS′ in Fig. 4, a higher probability of tax enforcement may lead the government either to lower or to raise the optimal tax rate, depending on tax enforcement costs and its crowding-out of the productive public services. To the extent that cost of tax enforcement is high enough for public services to be adversely affected, locus TS may shift highly upwards, so as to reduce tax compliance (see locus TS″ in Fig. 4 for this case). Therefore, while more severe punishment deters tax evasion, better detection may not be effective in reducing tax evasion.

To analyze the relative effectiveness of the two deterrence policies upon tax evasion, it is easier if we consider a proportional increase in either one of the two policies. We find that a proportional increase in fines is more effective in inducing tax compliance than a proportional increase in tax enforcement.[9] Intuitively, a proportional increase in either of the two deterrence policies shifts locus TC rightwards to the same level (see also Fig. 4). Yet, a proportional increase in fines shifts locus TS downwards more than a proportional increase in tax enforcement, due to the extra cost of the latter. As a consequence, raising fines is more effective than increasing enforcement in deterring tax evasion.

In summary, we have the following.

Proposition 3 (Deterrence effects). *Under Conditions RR and PB, while more severe punishment deters tax evasion, the effectiveness of detection increases only if the cost of detection is not too high. Moreover, the punishment policy is relatively more effective in deterring tax evasion than the detection policy.*

While the possible ineffectiveness of increasing penalties presented in the deterrence literature (e.g., Snyder, 1990; Andreoni, 1991), the possible ineffectiveness of increasing the

[9] Differentiation of (14) with respect to p and π yields

$$\frac{\mathrm{d}\beta}{(\mathrm{d}\pi/\pi)} - \frac{\mathrm{d}\beta}{(\mathrm{d}p/p)} = \frac{f_0 p\eta(1-p\pi)}{2\sqrt{h_0^2 - h_0(1-\eta+f_0p\eta)(1-p\pi)^2(1+\eta)}} > 0.$$

detection probability in our model is new. The mechanisms resulting in the ineffectiveness of raising penalties in existing works, are via either avoidance activities, or juror's adjustment in the levels of reasonable doubt, whereas this paper emphasizes the changing optimal tax rate and expenditure. These different mechanisms emerge, as existing works conduct partial-equilibrium frameworks, where only the responses of individuals are considered, whereas our model has a dynamic general-equilibrium setting, considering both individual and government responses. Moreover, even when both policies are effective in our model, the effect is smaller under raising detection probability than under increasing the fine, due to the fact that the former policy is more costly than the latter, and consequently optimal tax rate is higher. This result is contrary to one line of conventional wisdom on deterrence, which establishes that increasing the detection probability is more effective than increasing the penalties (Davis, 1988; Leung, 1995). Our result in this aspect corroborates another line of wisdom on deterrence pioneered by Becker (1968). Nevertheless, the possible ineffectiveness of deterrence policies in this paper, which works via a general-equilibrium effect of changing optimal tax rate, distinguishes our model from this line of wisdom.

Finally, what are the effects of the two deterrence policies upon economic growth? Since these two policies are popular, their effects on economic growth, and thus on welfare, are of significance.

First, the effect of a bigger fine upon economic growth is

$$\underset{(?)}{\frac{\mathrm{d}(\dot{c}/c)}{\mathrm{d}\pi}} = \underset{(?)}{\frac{\partial(\dot{c}/c)}{\partial\pi}} + \underset{(?)}{\frac{\partial(\dot{c}/c)}{\partial(1-\beta^*)}}\,\underset{(-)}{\frac{\mathrm{d}(1-\beta^*)}{\mathrm{d}\pi}} + \underset{(?)}{\frac{\partial(\dot{c}/c)}{\partial\tau_2^*}}\,\underset{(-)}{\frac{\mathrm{d}\tau_2^*}{\mathrm{d}\pi}}. \tag{20}$$

There are three channels for a bigger fine to influence the rate of economic growth in (20), as are for a higher unit cost of tax evasion in (19). As in (19), the two indirect effects are ambiguous. In contrast, the direct effect is different. A bigger fine has an ambiguous direct effect upon economic growth here, under a given tax rate, since it directly raises the effective tax rate which increases public services while decreasing disposable income. We have shown in an Appendix (not reported) that the net growth effect is positive if the following holds.

Condition DG (Deterrence and growth). $(-1+\sqrt{5})/2 \leqslant \eta$ and $\tau_2^*(\eta, h_0, f_0, \pi, p) \leqslant (6-2\sqrt{5})/(5-\sqrt{5})$.

Condition DG suggests that, if the externality $(1-\eta)$ is less than 38.19 percent and the statutory tax rate is less than 52.22 percent, then a bigger fine enhances economic growth. This condition is easily met.

Similarly, the effect of a higher detection probability upon the economic growth rate is

$$\underset{(?)}{\frac{\mathrm{d}(\dot{c}/c)}{\mathrm{d}p}} = \underset{(?)}{\frac{\partial(\dot{c}/c)}{\partial p}} + \underset{(?)}{\frac{\partial(\dot{c}/c)}{\partial(1-\beta^*)}}\,\underset{(?\text{ or }-)}{\frac{\mathrm{d}(1-\beta^*)}{\mathrm{d}p}} + \underset{(?)}{\frac{\partial(\dot{c}/c)}{\partial\tau_2^*}}\,\underset{(?\text{ or }-)}{\frac{\mathrm{d}\tau_2^*}{\mathrm{d}p}}. \tag{21}$$

The direct effect upon economic growth in (21) is ambiguous, similarly to that in (20).[10] The indirect effects in (21) are different from those in (20), due to the ambiguous effect of the detection probability upon both the tax rate and the tax evasion. However, in the case where a higher detection probability reduces the tax rate (i.e., $\mathrm{d}\tau_2^*/\mathrm{d}p < 0$), a higher detection probability definitely discourages tax evasion (i.e., $\mathrm{d}(1-\beta^*)/\mathrm{d}p < 0$). Under this situation, the indirect growth effect of a higher detection probability is similar to a bigger fine. When will a higher detection probability raise economic growth? In an Appendix, we totally differentiate economic growth with respect to p, and obtain an expression that is the same as that of totally differentiating economic growth with respect to π, with the exception that (i) the term $\mathrm{d}\tau_2^*/\mathrm{d}p$ is replaced by $\mathrm{d}\tau_2^*/\mathrm{d}\pi$, and (ii) two extra terms associated with $f_0 p$ emerge. Under the condition that $f_0 p$ is small, then $\mathrm{d}\tau_2^*/\mathrm{d}p$ is negative, and the Condition DG guaranteeing a positive sign for (20) must apply to (21).

Proposition 4 (Deterrence and growth). *Under Conditions RR and PB, a bigger fine and a higher detection probability have ambiguous effects upon economic growth. Under Condition DG, while a bigger fine raises economic growth, a higher detection probability raises economic growth if the enforcement is not costly.*

4. Calibration

This section calibrates the model to quantitatively illustrate the long-run effects of the three policies concerned in this paper. We start by assigning values for structural parameters. Since this paper is motivated by the stylized facts in East Asia, it is better if we could calibrate parameters using microdata from East Asia. However, since we cannot find proper microdata for East Asia for the parameters, except for f_0, we use instead the microdata for USA.

The unit cost of tax enforcement (f_0) is 0.0082, which is the average (direct and indirect) costs of national tax administration in Taipei in 1981–1990 (Ministry of Finance, 1990, p. 100). Probabilities of tax detection (p) and unity plus fines (π) are set at 0.089 and 1.5, respectively, following Fullerton and Karayannis (1994). Moreover, we follow Jones et al. (1993) by using 1.5 for the coefficient of risk aversion (σ) and 0.02 for the time preference rate (ρ). The government expenditure externality is set at 10% (i.e., $1-\eta = 0.1$). As some consider government externality to be very large (e.g., Aschauer, 1989) and some consider it very small (e.g., Barro and Sala-i-Martin, 1995), to examine the sensitivity in results we will change the externality to as high as 30%, and as low as only 1%.

It remains to specify the value for the unit cost of tax evasion, h_0, and the value for coefficient of productivity, A. A reasonable value for h_0 must satisfy Condition RR. Under the assigned parametric values of p, π and f_0, it requires $h_0 > 0.14359$ when $1-\eta = 0.1$. The required h_0 is larger when $1-\eta$ is larger, and is smaller when $1-\eta$ is smaller. We

[10] To be more precise, the direct effect of a higher detection probability upon economic growth is a little bit different from that of a bigger fine, as the former also increases the cost of tax enforcement (via $f_0 p$ term in (18)).

choose $h_0 = 0.15$ when $1 - \eta$ is equal to or smaller than 0.1, but must use a larger h_0 when $1 - \eta$ is larger than 0.1, to avoid an imaginary root for an optimal statutory tax rate. The chosen $h_0 = 0.15$ under $1 - \eta \leqslant 0.1$ implies that about 1 or less percent of national income is being transferred to corrupt officials and/or wasted in the process of evading taxes. Finally, we set a value for A. Given our motivation concerning East Asia, A is chosen in consistence with the real per capital economic growth rate of 5.8% between 1952–1998 in Taiwan (Council for Economic Planning and Development, 1999). Calibrating A consistently with economic growth rate of other countries, however, does not change the results, as A only affects the economic growth rate among the variables quantified below. These benchmark parameter values and their sources are listed in Table 2. Based on these benchmark parameter values, the effects of three policy changes are then simulated under different degrees of government externality.

The equilibrium values for tax rates, tax compliance and effective tax rates, and the implied A values for the 5.8% economic growth rate are illustrated in Table 3. In row 1 are results under benchmark case $1-\eta = 0.1$. In this case, the government sets the statutory tax rate at $\tau_2^* = 16.68\%$. As a result, economic agents, on average, report $\beta^* = 51.82\%$ of their income to the tax authority, and the effective tax rate, including the costs of tax evasion, is

Table 2
Benchmark parameter values

Definition	Parameter	Value	Source
Unit cost of tax punishment as a fraction of GDP	f_0	0.0082	Taiwan Ministry of Finance (1990)
Probability of tax detection	p	0.089	Fullerton and Karayannis (1994)
Punishment (including fines)	π	1.5	Fullerton and Karayannis (1994)
Coefficient of risk aversion	σ	1.5	Jones et al. (1993)
Time preference rate	ρ	0.02	Jones et al. (1993)
Degree of government externality	$1-\eta$	0.1	Assumption
Unit cost of tax evasion	h_0	0.15	Set to satisfy Condition RR
Coefficient of productivity	A	0.129228	Set so that the economic growth rate equals 5.8%

Table 3
Equilibrium values under different government externalities

Row	$1-\eta$	h_0	A	τ_2^*, %	β^*, %	τ_E^*, %	$\dot{c}/c$, %
1	10 (benchmark)	15 (14.359)	12.9228	16.68	51.82	13.20	5.8
2	5	15 (7.4)	14.6676	5.93	82.88	5.49	5.8
3	1	15 (1.602)	11.5823	1.10	96.82	1.09	5.8
4	15	21 (20.92)	24.6244	28.39	41.43	21.18	5.8
5	20	28 (27.108)	29.943	34.04	47.33	26.27	5.8
6	25	34 (33.57)	36.5006	42.53	45.80	32.54	5.8
7	30	39 (38.35)	44.6674	53.26	40.83	39.61	5.8
8	10	39	0.186459	11.12	87.54	10.61	5.8
9	15	39	0.232084	17.92	80.09	16.37	5.8
10	20	39	0.285331	25.85	71.29	22.63	5.8
11	25	39	0.350305	35.93	60.09	29.71	5.8

Note. Values in parentheses are critical values h_0, abiding by Condition RR.

Table 4
Effects of doubling the costs or enforcement policy parameters

Row	$1-\eta$		τ_2, %	β, %	τ_E, %	$\dot{c}/c$, %
1	10 (benchmark)	$2h_0$	11.69	83.12	10.84	5.98
		2π	12.89	68.49	11.40	5.94
		$2p$	13.01	68.21	11.50	5.93
2	5	$2h_0$	5.43	92.16	5.24	5.82
		2π	5.62	86.27	5.34	5.81
		$2p$	5.71	86.06	5.42	5.81
3	1	$2h_0$	1.09	98.43	1.08	5.80
		2π	1.09	97.33	1.08	5.80
		$2p$	1.17	97.14	1.16	5.80
4	15	$2h_0$	17.63	81.81	16.24	6.33
		2π	19.61	65.77	17.15	6.23
		$2p$	19.73	65.57	17.24	6.22
5	20	$2h_0$	23.35	81.94	21.52	6.38
		2π	25.81	66.22	22.62	6.25
		$2p$	25.88	66.20	22.68	6.24
6	25	$2h_0$	29.16	81.42	26.82	6.62
		2π	32.24	65.25	28.13	6.43
		$2p$	32.34	65.14	28.21	6.42
7	30	$2h_0$	35.69	80.51	32.13	7.10
		2π	38.92	63.42	33.70	6.82
		$2p$	38.95	63.34	33.75	6.81

$\tau_E^* = 13.20\%$ in equilibrium. These equilibrium values, together with $h_0 = 0.15$, indicate that 1.16 percent of national income are being transferred to officials and/or wasted to avoid taxes.

We then evaluate the effects of doubling the values of three policy variables; i.e., the unit cost of tax evasion, the fines, and the probability of detection. Under the benchmark parameter values, the effects of these changes on equilibrium are illustrated in row 1, Table 4. It is obvious that all three policies raise the tax compliance rate in equilibrium, which is effectively enhanced from 51.82% in Table 3 to 83.12%, 68.49%, or to 68.21%, when the unit cost of tax evasion, the fines, or the probability of detection are all doubled, respectively. These represent a 60.4 percent, 32.2 percent, and 31.6 percent increase in tax compliance, respectively. Given a higher tax compliance rate, the government lowers the tax rate from 16.68% to below 13.1% and, as a consequence, the effective tax rate is reduced from 13.2% to below 11.5%. Among these policies, doubling the unit cost of tax evasion is the most effective in inducing tax compliance. Moreover, the resources wasted or used for hiding taxes are also the lowest, under doubling the unit cost of tax evasion.[11] However, these policies have but a very minor effect on economic growth.

Since growth effect relies on the government externality, we change the magnitude for the degree of externality. First, we lower the degree of externality to 0.05, and then to 0.01. Their respective long-run equilibrium is illustrated in rows 2 and 3 in Table 3. A lower

[11] While only 0.85 percent of national income is used to hide taxes when the unit cost of tax evasion doubles, 1.49 and 1.5 percent are used for doubling fines and doubling detection probability, respectively.

government externality leads government to set a smaller tax rate, and consequently, the tax compliance rate is higher. We also conduct the comparative statics of doubling the three above-mentioned policies under these two lower degrees of government externality. We find that they are all effective in inducing tax compliance (rows 2 and 3 in Table 4). The resources used or wasted in evading taxes are very minor, at less than 0.1 percent of national income. Their growth effects are again negligible.

Next, we increase the degree of government externality from 0.1 to 0.15, 0.2, 0.25, and finally to 0.30. Their long-run equilibria are illustrated, respectively, in rows 4–7, Table 3. It is clear to observe that the statutory tax rate increases with the government externality. However, the tax compliance rate does not necessarily cause the decrease in the tax rate. For example, when the statutory tax rate increases from 28.39% (row 4) to 34.04% (row 5), the tax compliance rate increases from 41.43% to 47.33%. This otherwise counterintuitive result emerges, because the tax compliance here responds not only to different tax rates, but also to different unit costs of tax evasion. When controlling the unit cost of tax evasion, we find that the tax compliance rate consistently decreases in the tax rates (see rows 7–11, Table 3). From Table 3 we also observe that not only the optimal statutory tax rate (τ_2^*) deviates from, and is larger than, the corresponding degree of government externality $(1 - \eta)$, but also the effective tax rate (τ_{E}^*) is larger than the corresponding degree of government externality. As said, tax evasion is the mechanism for the deviation of the optimal tax rate from the government externality, which differs from existing literature which uses accumulated public capital stock as a mechanism (e.g., Turnovsky, 1997). From lower tax compliance, the resources transferred to corrupt officials and/or wasted in the process of evading taxes, increase in the government externality. For example, the equilibrium suggests that this accounts for about 13.8 percent of national income when $1 - \eta = 0.30$, and for about 6.1 percent when $1 - \eta = 0.25$.

Finally, we quantify the effects of doubling the three above-mentioned policies, and the results are illustrated in rows 4–7, Table 4. It is observed that these policies are all effective in inducing tax compliance, and accordingly, both the statutory tax rate and the effective tax rate are smaller. Comparing the effects upon increasing tax compliance, doubling the unit cost of tax evasion is the most effective, followed by doubling the fines and then doubling the detection probability, but the difference between the latter two is negligible. Comparing tax rates, doubling the unit cost of tax evasion is the most effective in reducing statutory tax rate and effective tax rate, followed again by doubling the fines and then doubling the detection probability. Finally, their growth effect increases in the degree of the government externality. When the externality is less than or equal to 0.2, economic growth increases by less than 0.58 percentage points, which is not very appealing. Yet, when the externality is 0.3, these policies are able to increase the economic growth rate at least by one percentage point, and in particular, when doubling the unit cost of tax evasion, raises the economic growth rate by appealing 1.3 percentage points. When comparing the growth effect, doubling the unit cost of tax evasion is most effective, followed by doubling the fines and then doubling the detection probability.

To summarize, we find that all three tax enforcement policies are effective in inducing tax compliance. Their growth effects are small when the degree of government externality is small. However, when the degree of government externality is higher than 0.2, their growth effects are stronger. Provided that the degree of government externality is moderate, the three enforcement policies quantitatively effecting heavily upon tax compliance, with small effects upon economic growth, seem to shed light on the stylized fact in East Asia, whose countries have quite different degrees of tax evasion, but have only slightly different rates of economic growth.

5. Concluding remarks

This paper integrates tax evasion into a standard one-sector, general-equilibrium model of economic growth. In the model the tax rate and the tax evasion are optimized. It studies the tax rate and economic growth for otherwise identical economies, except for tax evasion. It inquires into the effects of three government policies upon the tax rate, tax evasion and economic growth. It finds that a higher unit cost of tax evasion and a bigger punishment/fine both reduce the tax rate and tax evasion, whereas a higher auditing probability reduces tax evasion, if the cost of tax enforcement is not too high. All three policies have ambiguous effects on economic growth, due mainly to their indirect effects upon tax compliance and tax rate. The model is also calibrated to quantify the effects of these policies. All three enforcement policies are quantitatively effective in reducing tax evasion, but their growth effects are quantitatively minor, unless the degree of government externality is very high. These theoretical and quantitative results shed light on such stylized facts in East Asia, whose countries have larger tax evasion variations, but have few divergences in economic growth.

The model in this paper has some limitations. First, to simplify the complicated algebra, the auditing probability is not treated as an optimal choice of the government. If this assumption is relaxed, however, we believe the results will be qualitatively similar, particularly for the relative effectiveness of the deterrence policies. The relative effects in this model are driven by the fact that the auditing, whether predetermined or optimized, requires resources, whereas the punishment does not. As a result, the government may need to set up a higher tax rate, in event of higher auditing probability, in order to maintain a certain level of government expenditure.

Second, we only consider the channel of changing disposable income, and altering government expenditure through which the effects of tax evasion work. There are other channels via which the effects of tax evasion could work differently from those of ours. If, for example, the size of the government is not allowed to vary as in the case in Roubini and Sala-i-Martin (1995), other revenue sources are needed, such as issuing bonds, raising seigniorage taxes, repressing financial markets or other possible channels.

Third, we do not model how the government distributes the budget. Different ways of distribution may have distinct impacts on economic growth. Fiscal policy has a bearing on income distribution. With a representative agent model, however, the issue is obviously ruled out.

Finally, let assume the removal of the time inconsistency problem (Boldrin and Rustichini, 2000). Two of the three government policies are effective in reducing tax evasion in this model, and so is the increase in auditing, if the cost of auditing is not too high. Individuals are willing to report a bigger fraction of their income, mainly because the future tax rate will be lower when these policies are adopted. Should the time inconsistency issue be brought in, will the government deviate and set up a higher tax rate? Here, the government is believed not to do so, as the resulting lower tax rate will enhance the economic growth under mild conditions, and thus will improve the welfare of the representative individuals. Given this, the government has no reasons to deviate, and individuals have no reasons not to trust the government.

Our results may suggest at least two avenues for future research. First, our model generates no transitional dynamics as it includes only one sector. It would be interesting to extend the model into asymptotic AK models (Jones and Manuelli, 1990) or into two-sector models (Bond et al., 1996; Chen and Shimomura, 1998) to examine its dynamics. Indeed, if there are two sectors, one more productive with tax evasion difficulties while the other less productive with easier tax evasion as in Jung et al. (1994), interesting results are obtained. If the two sectors have different government-input intensities, introducing tax evasion will generate a relative price distortion. Then, it would be interesting to examine how the conditions of three government policies for deterring tax evasion change the relative price, expand the productive sector and enhance economic growth in the long run, and how the conditions of three policies may hurt economic growth in the long run.[12] How tax rates, the degree of tax evasion, and the rate of economic growth all move in transition, may also be examined.

Secondly, this work does not consider the issue of fairness which is emphasized by experts in law and sociology. To accomplish this, a representative individual setup is not enough. Rather, a heterogeneous agent setup is necessary. Moreover, the utility function may need to be modified to incorporate not only the quantity of consumption, but also the degree of fairness. This is a difficult issue. Alternatively, a "moral effect" *à la* Huang and Wu (1994) can be engaged, whereby a firm's propensity to dodge taxes is affected by a number of other firms which are already doing the same. That is, firms are more willing to pay their "fair" share of taxes, if they believe that others are not cheating the government. By extending the work in this direction, multiple steady states could arise. An economy with multiple steady states has rich transitional dynamics.

Acknowledgments

The author expresses gratitude especially to Michele Boldrin and Ping Wang for their insightful suggestions. He is also grateful to Shin-Hwan Chiang, Cyrus Chu, Edward Green, JangTing Guo, Sheng-Cheng Hu, Ching-Chong Lai, James Markusen, Prasanta Pattanaik, Koji Shimomura, Spiro Stefanou, Henry Wan, Alan Wood, and to workshop participants at Kobe University, Academia Sinica, Chinese University in Hong Kong, UC-Riverside, University of Colorado at Boulder, and to 1997 ASSA Meeting members for helpful suggestions. The comments of an anonymous referee and an associate editor have led to substantial improvements of this paper, and are also gratefully acknowledged. The usual disclaimer applies.

[12] We acknowledge an Associate Editor for suggesting an extension in this direction.

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