

Tax Evasion and Public Expenditures on Tax Collection Services in an Endogenous Growth Model

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Abstract

This paper analyzes the relationship between tax evasion and the two main policy instruments affecting evasion rates, namely, the announced tax rate and the share of tax revenues allocated to tax monitoring mechanisms. For doing so, we adopt a simple one-sector endogenous growth model modified under tax evasion following Roubini and Sala-i-Martin (1993) analysis on income taxes and tax evasion. Our model confirms Barro's (1990) theoretical finding stating that the optimal tax rate is equal to the elasticity of private capital. However, when tax evasion matters for the central government, the effective tax rate is lower than the output elasticity in line with Futagami *et al.*, (1993) and Turnovsky (1997) theoretical results. Finally, our model is calibrated using data from 145 developed and developing countries for 2011. Simulation results suggest that both tax evasion and output growth are decreasing with the share of tax revenues allocated to monitoring expenses, while maximizing government's welfare imply an announced tax rate lower from the elasticity of public capital and a share of monitoring expenses around 6.0%.

Keywords: tax evasion, tax monitoring, effective tax rate.

JEL Codes: *H21, H26, H54.*

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1 Introduction

Income or corporate profit taxation matters for economic growth since taxes distort the accumulation of capital. Standard economic growth models with infinite horizon suggest that the rate at which physical capital is accumulated increases with their private return and, hence, high tax rates on income or corporate profits are typically associated with low growth rates (Lucas, 1988; Rebelo, 1991). Moreover, in endogenous growth models with overlapping generations, private capital accumulation is obtained through savings of individuals who rent their labor to the firms earning a wage in exchange of that. Hence, an increase in the income tax rates reduces the disposable income of individuals resulting to even slower private capital accumulation.

However, on the other hand, taxation generates resources to finance the supply of the productive inputs provided by the government including public goods and infrastructure (Barro, 1990; Turnovsky, 1997). Since individuals are not charged by the use of these public goods, government spending plays the role of an externality for the private sector. Such an externality ends up being an engine of endogenous growth since the resulting aggregate production function could display an uniformly high marginal productivity from private capital, and this makes perpetual capital accumulation possible (see Jones and Manuelli (1990)). Therefore, as pointed out by Barro (1990), there is a tension between the role of taxation in disincentiving the accumulation of capital and the role of the public spending financed by these taxes in raising the return from private capital and, hence, the speed of accumulation.

An effective tax system though must be efficient, that is, it must provide incentives to the tax payers (individuals or corporate firms) for tax compliance. Without these incentives nobody would pay taxes voluntarily in a competitive economy. Indeed empirical evidence suggests that tax evasion and fiscal corruption has been a general and persistent problem in virtually every country with serious negative consequences not only in transition and developing countries, but also in countries with developed tax systems. Tax evasion, which constitute a sizable share of the shadow economy, is prevailing even in advanced industrialized countries around the globe. Slemrod and Yitzaki (2000) estimated that about the 17 percent of income taxes are unpaid in the US, while the Tax Justice Network (2011) estimated that on average tax evasion rates in 119 developed and developing countries around the world was more than the 50 percent of their healthcare spendings. Furthermore, Schneider (2000) reports that the shadow output equals 39 percent of the actual magnitude of reported GDP in developing countries, 23 percent in transition countries and 14 percent in OECD countries.

Starting from the seminal papers by Mirrlees (1971) and Allingham and Sandmo (1972), a large amount of literature relating to corruption and tax evasion has emerged aimed to analyze its determinants, magnitude, and effects on economic growth and welfare in both developed and developing economies (see Feige (1992) and Jung *et al.*, (1994) as well as the papers reviewed therein for a discussion on tax evasion and underground economies). More importantly though Schneider

and Enste (2000) and Bajada (2003) suggest that the underground economy and the associated tax evasion deepens recessions and increases the volatility of business cycles that makes the study and modeling of tax evasion of great interest particularly in nowadays.

Along these lines, we adopt a standard one-sector endogenous growth model in order to analyze how the statutory tax rates and tax compliance policy affects the rate of economic growth. The novel feature of our model is the inclusion of the tax evasion rate as a positive function of the announced tax rate and as a negative function of tax revenues allocated for tax monitoring purposes. This feature introduces a trade off between these two policy instruments into our model, which is analyzed by calculating both their growth-maximizing as well as their optimal values. Our analysis supports Barro's (1990) finding that the growth-maximizing tax rate is equal to the output elasticity of public capital, while, at the same time, it provides an explanation for some deviations from this finding in the relevant literature. Further, using a general objective function for central government we do not find evidence of Barro's (1990) result that the growth-maximizing tax rate also maximizes government's welfare. Finally, we calibrate our theoretical model to gain a better understanding of the relationship between the optimal values of our policy variables and the corresponding tax evasion rate and growth rate of the economy

The paper is organized as follows. Section 2 presents our model with effective taxation assuming that individuals have the incentive to evade taxes and government allocates a constant share of tax revenues to tax auditing. Section 3 determines the growth maximizing tax rate, while section 4 takes into consideration government's perceptions about tax evasion. In section 5 our theoretical model is calibrated using data from a sample of 145 developed and developing countries and section 5 concludes the paper

2 A Growth Model with Effective Taxation

2.1 Model Description

Following Kalaitzidakis and Kalyvitis (2004), we consider a closed economy populated by N identical agents who produce a single aggregate commodity, Y . Further we assume that there is no population growth and that the labor force is equal to the population, with labor supplied inelastically. The i^{th} representative firm produces its output, Y_i , using the following *Cobb-Douglas* production technology:

$$Y_i = AK_i^\alpha \left(\frac{K_g}{L} L_i \right)^{(1-\alpha)} \quad (1)$$

where $0 < \alpha < 1$ is the output elasticity of private capital, A is a technological parameter, K_i denotes the stock of private capital for firm i , L_i the labor used by the representative firm, K_g is the aggregate stock of public capital, and L is the total labor force. According to this production function, each individual firm in our economy benefits from an increase in economy-wide labor productivity, *i.e.*, $\frac{K_g}{L}$, triggered by a rise in the public capital stock available.

The net private capital stock accumulates at the following rate

$$\dot{K} = I - \delta_k K \quad (2)$$

where I denotes gross private investment and δ_k is the constant depreciation rate of private capital.

New output may be transformed to any type of capital (*i.e.*, private or public), but in the case of private capital this process involves adjustment costs. The cost of investment faced by all firms in the economy is defined by

$$\Psi(I, K) = \left(1 + \frac{\varphi}{2} \frac{I}{K}\right) I \quad (3)$$

where $\varphi > 0$ is the adjustment cost parameter. As it is typically assumed in the relevant literature, the adjustment cost of private capital is proportional to the rate of investment per unit of installed capital.

Similarly, the stock of public capital depreciates at a constant rate δ_g . If G denotes gross public investment, then the net public capital stock accumulates as follows:

$$\dot{K}_g = G - \delta_g K_g \quad (4)$$

The government finances its total expenditures through tax revenues collected via a tax rate τ imposed on total output produced by firms. We allow the possibility of tax evasion by assuming that the effective income tax rate is different from the official announced rate. A history of public waste and inefficient provision of public services may lead private agents less willing to pay taxes. Further, government may have access to an inferior technology for tax collection that detect tax evaders or even the legislation framework is not strict in prosecuting evaders. Hence, government may announce a tax rate τ , but local firms may pay taxes that correspond to a lower actual or effective tax rate denoted by τ_e .

The difference between the announced and the effective tax rate is the tax evasion rate ($\tau - \tau_e$) which, following Roubini and Sala-i-Martin (1995), is assumed to be a negative function of government expenditure allocated to tax monitoring as a percentage of total taxes collected, and a positive function of the announced tax rate (see Appendix A.1 for a proof of these monotonicity conditions under a more structural optimizing behaviour by individual firms). Public expenditures for improving the technology and, thus, the efficiency of the tax collection mechanism may improve the ability of tax authorities to detect tax evaders and control tax evasion. On the other hand, the incentive for tax evasion may increase as the announced tax rate increases because, for a given

state of tax monitoring, the marginal benefit of tax evasion increases.¹ Therefore it holds:

$$\tau - \tau_e = h(\mu, \tau) \quad (5)$$

with

$$\frac{\partial h}{\partial \mu} < 0 \quad \text{and} \quad 0 < \frac{\partial h}{\partial \tau} < 1$$

where $\tau_e \leq \tau$ is the effective tax rate, and $\mu = \frac{M}{T}$ is the share of tax revenues (T) that goes to monitoring tax evasion (M).

Accordingly, the share of tax revenues directed towards public capital investment is $(1 - \mu)$. Under these assumptions, it holds that:

$$M = \mu \tau_e Y \quad \text{and} \quad G = (1 - \mu) \tau_e Y \quad (6)$$

and therefore, the government budget constraint is given from the following

$$T = G + M = \tau_e Y \quad (7)$$

We assume, for the moment, that the announced tax rate, τ , and the tax auditing share, μ , of tax revenues are both fixed and constant over time. So the government can set both variables arbitrarily. Since, however, these policy instruments are going to affect the long-run growth rate of the economy, the optimal tax rate and the component shares that maximize the growth rate will also be derived later on.

2.2 Model Solution

The representative firm i in our economy solves the following infinite horizon profit maximization problem:

$$\begin{aligned} \max \quad & \int_0^{\infty} e^{-rt} \left[(1 - \tau_e) Y_i - w L_i - \left(1 + \frac{\varphi}{2} \frac{I_i}{K_i} \right) I_i \right] dt \\ \text{s.t.} \quad & \dot{K}_i = I_i - \delta_k K_i \end{aligned}$$

where r is the real interest rate, w is the real wage rate while the price of the aggregate output is set equal to one (*i.e.*, $p_y = 1$). The familiar optimality conditions with respect to I_i , and K_i are

¹It should be noted here, that in the Allingham and Sandmo (1972) model the result of a tax rate change on evasion is ambiguous due to the opposite income and substitution effects. Yitzaki (1974), on the other hand, proved that if the penalty of tax evasion is exclusively on the evaded tax, then the substitution effect is absent and the increase on tax rate decreases evasion. However, empirical evidence suggest that higher statutory tax rates encourage rather than repress tax evasion (see Dhimi and al-Nowaihi, 2007 for details).

given, respectively:

$$q = 1 + \varphi \frac{I_i}{K_i} \quad (8)$$

$$r = \frac{1}{q} \left[\dot{q} + (1 - \tau_e) \alpha A \left(\frac{K_i}{L_i} \right)^{(\alpha-1)} \left(\frac{K_g}{L} \right)^{(1-\alpha)} + \frac{\varphi}{2} \left(\frac{I_i}{K_i} \right)^2 \right] - \delta_k \quad (9)$$

where q is the shadow value of the private capital stock.

Equation (8) equates the marginal cost of investment to the shadow value of capital, while equation (9) is the arbitrage condition that equates the interest rate to the rate of return of private capital, net of physical depreciation. The rate of return to private capital consists of three components: the change in its shadow value, the value of its marginal product, and its effect on the cost of investment.

Using equations (2), (4), (5), and (8), the growth rates of private and public capital are provided by the following relations:

$$\frac{\dot{K}}{K} = \frac{(q-1)}{\varphi} - \delta_k \quad (10)$$

$$\frac{\dot{K}_g}{K_g} = (1 - \mu) \tau_e \left(\frac{K}{K_g} \right)^\alpha - \delta_g \quad (11)$$

since the aggregate production function can be written as $Y = AK^\alpha K_g^{1-\alpha}$.

Defining the ratio of public to private capital stock as $z = \frac{K_g}{K}$ and using relations (8), (10) and (11), we can express the growth rate of public to private capital stock and relation (9) as:

$$\frac{\dot{z}}{z} = -\delta_g - \frac{(q-1)}{\varphi} + (1 - \mu) \tau_e A z^{-\alpha} + \delta_k \quad (12)$$

$$\dot{q} = (r + \delta_k)q - (1 - \tau_e) \alpha A z^{(1-\alpha)} - \frac{(q-1)^2}{2\varphi} \quad (13)$$

2.3 Steady State

Equations (12) and (13) form a system of two differential equations given the independent policy parameters τ and μ . The stationary solution (*i.e.*, $\dot{z} = \dot{q} = 0$) of the system must have at least one real solution, in order for output and the capital stocks, K and K_g , to follow a balanced growth path. From equation (8) and from the fact that, at the steady state, output and private capital grow at the same rate, the steady-state value of private capital is given by:

$$q^* = 1 + \varphi(g_y + \delta_k) \quad (14)$$

where q^* denotes the steady-state value of private capital stock and g_y the steady-state growth rate of aggregate output.

The steady-state shadow price of private capital is a positive function of the growth rate, as

higher growth rates are associated with increased output and profits. The depreciation rate of private capital also affects positively its shadow price because a higher depreciation rate requires a higher shadow price of private capital due to larger associated adjustment costs.

To simplify our analysis we assume that $\delta_k = \delta_g = \delta$. Then, from equation (14) and the equilibrium conditions $\dot{z} = \dot{q} = 0$ we get the following expression for the steady-state growth rate of the economy:

$$(1 - \tau_e) \alpha A^{\frac{1}{\alpha}} \left[\frac{(1 - \mu)\tau_e}{(g_y + \delta)} \right]^{\frac{(1-\alpha)}{\alpha}} = (r + \delta) [1 + \varphi(g_y + \delta)] - \frac{\varphi(g_y + \delta)^2}{2} \quad (15)$$

The above equation shows that both the announced tax rate and the share of tax monitoring expenditure affect the long-run growth rate of the economy. The same result can be obtained if a household sector is included in the model solution (see Appendix A.2 for a proof). In the next section, we address the question of growth-maximizing policy by considering the growth-maximizing values of these two policy variables.

3 Growth-Maximizing Policies

The determination of the growth-maximizing policies is achieved in two steps: the government determines the growth maximizing steady-state tax rate for a given allocation of government expenditure, and then derives the growth-maximizing steady-state share of tax monitoring expenditure at the given optimal tax rate.

In our framework, taxation affects the growth of the economy through two channels. Taxation affects negatively the marginal product of private capital, while government expenditure for public capital formation increases the productivity of labor. At low values of τ the positive effect of government expenditure dominates, and, hence, the growth rate of the economy rises with the tax rate. At higher tax rates, however, the negative impact of taxation eventually dominates, and the growth rate declines as τ rises. The tax rate that maximizes the growth rate is the one that equates the marginal cost of government expenditure to its marginal benefit. The following proposition determines the growth maximizing tax rate.

Proposition 1 *The tax rate that maximizes the growth rate of the economy is*

$$\tau = 1 - \alpha + h(\mu, \tau) \Rightarrow \tau_e = 1 - \alpha$$

Proof. From (15) we estimate the partial derivative of the growth rate with respect to the tax rate and we set it equal to zero to provide the result. ■

This result is similar to the typical finding obtained by standard endogenous growth models, which states that the growth maximizing tax rate is equal to the elasticity of public capital in the

aggregate production function (see Barro, 1990). Here, Proposition 1 shows that in the presence of tax monitoring cost, the optimal tax rate is greater than the elasticity of public capital in the aggregate production function. However, the optimal tax rate has to be such that the effective tax rate is equal to the elasticity of public capital in the aggregate production function.

There has been a lot of discussion in the relevant literature about Barro's (1990) theoretical finding on optimal taxation. Even though most of the literature supports Barro's (1990) result, some findings deviate from it by calculating an optimal tax rate greater than the output elasticity of public capital. The interpretation of these conflicting findings is not always convincing. Trying to gain a better understanding of this puzzle, we compare our analysis with that of Chen (2003) who uses a similar approach with ours, suggesting though that the optimal effective tax rate should be greater than the corresponding elasticity of private capital.

Taking a closer look into these two models, we see that the essential difference between them is the following. In our model tax revenues are allocated between tax monitoring and public capital formation so that both expenditures are some constant shares of total tax revenues, as shown in equation (6). Chen (2003), on the other hand, defines tax monitoring expenditure as a constant share of total income (output). In order to show that this assumption is responsible for the conflicting results on optimal taxation, we embody Chen's (2003) assumption into our model, which modifies equation (6) as following:

$$M = \lambda Y \quad \text{and} \quad G = (\tau_e - \lambda) Y \quad (16)$$

where $0 < \lambda < \tau_e$ is a constant denoting the share of total output allocated for tax auditing purposes.

Notice that from equation (15), the steady-state growth rate of the economy, under both assumptions on the share of tax monitoring expenses, can be written as a general function

$$g_y = f \left((1 - \tau_e) \left(\frac{G}{Y} \right)^{\frac{1-\alpha}{\alpha}} \right) = \begin{cases} f \left((1 - \tau_e) ((1 - \mu)\tau_e)^{\frac{1-\alpha}{\alpha}} \right) & \text{under relation (6)} \\ f \left((1 - \tau_e)(\tau_e - \lambda)^{\frac{1-\alpha}{\alpha}} \right) & \text{under relation (16)} \end{cases} \quad (17)$$

since the growth rate is monotonic to the expression $(1 - \tau_e) \left(\frac{G}{Y} \right)^{\frac{1-\alpha}{\alpha}}$. The first term of this expression captures the negative effect of taxation on growth through its negative effect on the marginal product of private capital. Accordingly, the second term captures the positive effect of taxation on growth through higher public expenditures for public capital formation.

Assuming that tax monitoring expenses are a constant share of total output (*i.e.*, equation (16)), the following proposition holds:

Proposition 2 *If tax monitoring expenditures are a constant share of total income, λ , then the*

effective tax rate that maximizes the growth rate of the economy is

$$\tau_e = 1 - \alpha(1 - \lambda) > (1 - \alpha)$$

Proof. From (17) we observe that maximizing the steady-state growth rate with respect to the effective tax rate is equivalent to maximizing $(1 - \tau_e)(\tau_e - \lambda)^{\frac{1-\alpha}{\alpha}}$ with respect to the effective tax rate. ■

The above proposition implies that, when tax monitoring expenditure is proportional to total income rather than to total tax revenues, the growth-maximizing effective tax rate is greater than the output elasticity of public capital. The intuition behind this result is quite simple. When tax revenues are allocated proportionally among tax monitoring and public capital formation, an increase in the tax revenues by one dollar will raise government expenditure for public capital formation by less than a dollar. However, when tax monitoring expenditure is a constant share of output, the whole increase in the tax revenues is allocated exclusively for public capital formation. In the latter case the marginal benefit of an increase in the effective tax rate is greater than in the former case, leading to a higher growth-maximizing effective tax rate.

4 Output Growth vs Tax Evasion

Given the growth maximizing effective tax rate, the growth rate of the economy becomes a decreasing function of the share of government expenditure for tax monitoring. This result is not surprising since tax monitoring absorbs productive resources to reduce tax evasion that could be costlessly achieved by an increase in the announced tax rate. A reduction in the share of public expenditure allocated to tax monitoring raises the steady-state growth of the economy but, at the same time, the announced tax rate has to increase in order for the effective tax rate to remain at the growth maximizing level. As a result, the tax evasion rate increases. Notice, however, that since in our one sector model there is no any cost associated with tax evasion, the optimal reaction of the government is to reduce the share of tax monitoring expenditure as much as possible, which will increase both the announced tax rate and the tax evasion rate at extremely high levels.

To solve this problem we assume that the government cares not only about the growth of output but also about tax evasion due to income distribution and resource allocation concerns. High announced tax rates may bring the economy closer to the steady-state growth rate but at the same time they increase income inequality when tax evaders are not uniformly distributed among population. As noted by Roubini and Sala-i-Martin (1993), governments cannot distinguish between good and bad citizens. Hence, as tax evasion increases, it cannot increase official tax rates as the good citizens will be unable to pay. Furthermore, in real world tax evasion actually implies a loss of resources as people make an extra effort to evade taxes reducing thus, the amount of output available.

In this case an optimum share of tax monitoring may exist since the effects of tax monitoring expenditure on growth and tax evasion are of opposite directions. Hence, we assume, that government's objective function has the following general form:

$$W = f_w(g_y, \tau - \tau_e) \quad (18)$$

with $\partial f_w / \partial g_y > 0$ and $\partial f_w / \partial (\tau - \tau_e) < 0$, that is, it is increasing with respect to the growth rate of the economy and decreasing with respect to tax evasion.

Maximizing the above government's objective function with respect to the share of tax monitoring and the announced tax rate, we get:

$$\frac{\partial W}{\partial \mu} = 0 \Rightarrow \frac{\partial f_w}{\partial g_y} \frac{\partial g_y}{\partial \mu} = - \frac{\partial f_w}{\partial (\tau - \tau_e)} \frac{\partial (\tau - \tau_e)}{\partial \mu} \quad (19)$$

$$\frac{\partial W}{\partial \tau} = 0 \Rightarrow \frac{\partial f_w}{\partial g_y} \frac{\partial g_y}{\partial \tau} = - \frac{\partial f_w}{\partial (\tau - \tau_e)} \frac{\partial (\tau - \tau_e)}{\partial \tau} \quad (20)$$

In other words, the last dollar spent on tax monitoring should have the same contribution to the decrease in the growth rate of the economy as the decrease in the tax evasion rate. Similarly, the marginal contribution of announced tax rate on output growth should be the same with its marginal contribution in tax evasion.

Proposition 3 *The effective tax rate that maximizes government's objective function is lower than the output elasticity of public capital:*

$$\tau_e < (1 - \alpha)$$

Proof. Dividing equation (19) by (20) and using equation (17), we get:

$$\begin{aligned} \frac{\frac{\partial g_y}{\partial \mu}}{\frac{\partial g_y}{\partial \tau}} &= \frac{\frac{\partial (\tau - \tau_e)}{\partial \mu}}{\frac{\partial (\tau - \tau_e)}{\partial \tau}} \Rightarrow \frac{\partial \left((1 - \tau_e) ((1 - \mu) \tau_e)^{\frac{1-\alpha}{\alpha}} \right) / \partial \mu}{\partial \left((1 - \tau_e) ((1 - \mu) \tau_e)^{\frac{1-\alpha}{\alpha}} \right) / \partial \tau} = \frac{\frac{\partial (\tau - \tau_e)}{\partial \mu}}{\frac{\partial (\tau - \tau_e)}{\partial \tau}} \\ &\Rightarrow \tau_e = (1 - \alpha) + \frac{(1 - \alpha) (1 - \tau_e) \tau_e}{(1 - \mu)} \frac{\frac{\partial (\tau - \tau_e)}{\partial \mu}}{\frac{\partial (\tau - \tau_e)}{\partial \tau}} < (1 - \alpha) \end{aligned} \quad (21)$$

which provides the result. ■

This result is similar to the results by Futagami *et al.*, (1993) and Turnovsky (1997). These two papers derive, in the case of the decentralized economy, a growth-maximizing tax rate equal to the output elasticity of public capital. However, in the social planner's case, the optimum tax rate is less than the output elasticity of public capital due to an externality associated with the accumulation of public capital. As a result, Barro's (1990) finding that the growth-maximizing tax rate also maximizes government's welfare does not hold when public capital rather than public expenditure enters into the production function.

Proposition 3 above derives a similar result with respect to our effective tax rate, even though the mechanism that generates our result is different from that of Futagami *et al.*, (1993) and Turnovsky (1997). In our model the social planner's problem produces a no tax evasion equilibrium, which cannot be replicated by any policy measures in the decentralized economy. For that reason, we employ an objective function that introduces a trade off between growth of output and tax evasion, leading to an optimum effective tax rate lower than the one that maximizes the growth rate of the economy.

5 Model Simulation

In this section the theoretical model is simulated to qualitatively illustrate the long-run effects of the two policy variables, *i.e.*, the optimal tax rate and the optimal allocation of public expenditure between tax auditing and public capital formation.

First, we start by specifying a functional specification for the tax evasion function defined in (5). Keeping that simple, we choose the following parametric form that satisfies its curvature properties:

$$\ln h_i = \ln \beta_0 + \beta_\tau \ln \tau_i - \beta_\mu \ln \mu_i \quad (22)$$

where i denotes observations (countries in our case), h is the tax evasion expressed as the share of tax revenues that are evaded, τ is the announced tax rate by the government, μ is the share of tax revenues that goes for monitoring tax collection, and β 's are the parameters to be estimated.

The necessary data for the econometric estimation of (22) were obtained from the *Tax Justice Network* covering 145 developed and developing countries for the year 2011.² This report provides data on GDP, overall tax rate (including both income and indirect taxes), tax revenues lost as a result of the shadow economy and the share of government spendings to GDP.³ Government spendings have been used as a proxy of tax revenues in order to construct together with tax losses the dependent variable in (22). Monitoring expenses were not provided and, hence, there were proxied indirectly using data on public expenditures published by the *Global Development Network*

²The 145 countries in the sample are the following: Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Belarus, Belgium, Belize, Benin, Bhutan, Bolivia, Bosnia, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Central African Republic, Chad, Chile, China, Colombia, Comoros, Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Congo, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Guinea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Laos, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Luxemburg, FYROM, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Mauritius, Mexico, Mongolia, Morocco, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Norway, Oman, Pakistan, Papua, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Republic of Congo, Romania, Russia, Saudi Arabia, Senegal, Sierra Leone, Singapore, Slovakia, Slovenia, Solomon, South Africa, South Korea, Spain, Sri Lanka, Suriname, Sweden, Switzerland, Syria, Taiwan, Tajikistan, Tanzania, Thailand, Trinidad, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, UK, USA, Uruguay, Venezuela, Vietnam, Yemen, and Zambia.

³See <http://www.taxjustice.net>. In summary, the absolute size of the shadow economy in each country is calculated using recently reported data by the *World Bank*. Then, assuming that the economic activity in the shadow economy in each country is tax evading they calculate the amount of taxes lost based on the average tax burden in each country.

Growth Database developed by the *World Bank*. Specifically from total government spendings, spendings on public infrastructure, health care, military and education expenses were subtracted to develop a proxy of monitoring expenses for tax evasion. Since specific data on tax services and monitoring infrastructure are not available from any known source for this broad set of countries, the proposed variable constructed residually from all other public spendings can be used as a reasonably proxy of the share of tax revenues allocated in monitoring tax evasion. Summary statistics of the variables used in the econometric estimation are provided in the lower panel of Table 1.

In the upper panel of the same Table the parameter estimates of (22) are also presented. The overall fit of the econometric model is satisfactory as the adjusted- R^2 was sufficiently large for a cross-section setting. Both parameter estimates are having the correct sign and size as the announced tax rate increases tax evasion, while monitoring expenses decreases willingness to evade taxes. The corresponding tax evasion elasticity values are 0.8403 and -0.1223 for tax rate and monitoring expenses, respectively. We tried to fit the model discriminating between developed and developing countries but the results were unsatisfactory and statistically insignificant for the sample of developed nations due to insufficient degrees of freedom.⁴

Next we need to specify a specific functional form for government's objective function in (18). Following the relevant literature, we introduce a function that penalizes deviations of both the output growth rate and the effective tax rate from their corresponding no evasion values:⁵

$$W_L = (g_y - \bar{g}_y)^2 + \gamma(\tau - \tau_e)^2 \quad (23)$$

where \bar{g}_y is the steady-state growth rate in the absence of tax evasion, and $0 < \gamma \leq 1$ is a positive parameter indicating the importance of tax evasion relative to the economy's loss in the growth rate due to greater tax monitoring expenditure. The above loss function is penalizing, thus, deviations from the target values (no tax evasion) more than absolute deviations.

Minimizing the above function with respect to the share of tax monitoring and the announced tax rate, we get:

$$\frac{\partial W_L}{\partial \mu} = 0 \Rightarrow (g_y - \bar{g}_y) \frac{\partial g_y}{\partial \mu} = -\gamma(\tau - \tau_e) \frac{\partial (\tau - \tau_e)}{\partial \mu} \quad (24)$$

$$\frac{\partial W_L}{\partial \tau} = 0 \Rightarrow (g_y - \bar{g}_y) \frac{\partial g_y}{\partial \tau} = -\gamma(\tau - \tau_e) \frac{\partial (\tau - \tau_e)}{\partial \tau} \quad (25)$$

which are similar with relations (19) and (20) above satisfying Proposition 3.

Finally, we assigned specific values for the structural parameters in (15) necessary to simulate the long-run effects of the two policy variables. First, the output elasticity of private capital in the aggregate production function in (1) was set to $\alpha = 0.670$ calculated as the average value of the relevant growth literature in both developed and developing nations (see Table 2). Performing a

⁴Unfortunately we only had a cross-section of 145 observations limiting our flexibility in fitting the tax evasion function for different group of countries.

⁵Sala, *et al.*, (2008) used the same quadratic specification in their study of labor market frictions in the US.

sensitivity analysis within the range of 0.50-0.90, simulation results showed a decrease of 1.5% in tax monitoring expenses without affecting qualitatively the results. For the real interest rate we used the average spread of government bonds during the 2005-12 period obtained from *Datastream* and it was set at $r = 0.055$. The steady-state growth rate, \bar{g}_y , was set to 5.0% obtained as an average value of the corresponding estimates reported by Zimmerman (1997) for both developed and developing countries. Accordingly, the coefficient of productivity in (1) was set to $A = 0.155$ so that the steady-state output growth rate equals 5.0%.⁶

For the depreciation rate (δ) we assume that capital stock last 10 years on average. Then, following Acemoglu and Zilibotti (2001), we assume a constant annual depreciation rate of physical capital at 8.0%. In order to test the robustness of our results, we also used depreciation rates of 4% and 6% with the simulation results not presenting any qualitative differences compared with those reported here. The adjustment rate of investments was set to $\varphi = 0.10$ following Rungsuriyawiboon and Stefanou (2007). Their estimate is based on a linear accelerator model assuming a high level of aggregation in capital stock. The reported results do not change significantly when an adjustment rate of 5% and 15% was used.

Using these parameter values and the econometric estimates of the tax evasion function in (22), the announced tax rate was obtained from relation (21) in Proposition 3 under different values of monitoring expenses (a pace of 0.25% in the share of monitoring expenses was used in the simulation). Then, both effective tax rate, τ_e , and tax evasion levels, $\tau - \tau_e$, were calculated using the econometric estimate of relation (22). Plugging these values into the equilibrium condition in (15) we obtain the steady-state output growth rates in the presence of that tax evasion in the economy. The equilibrium values of monitoring expenses, announced tax rate, tax evasion and output growth are illustrated in Table 3.

Both tax evasion and output growth are decreasing with the share of tax revenues allocated to monitoring expenses. Monitoring mechanisms against tax evaders seems to be less effective at low levels of tax evasion. In high levels of tax evasion government efforts towards reducing tax losses is more effective. This effectiveness though is lessened as the tax evasion levels decrease. On the other hand, increasing expenditures against tax evasion absorbs public expenditures from productive investments reducing thus, the growth rates in aggregate output. More importantly, as the effectiveness of monitoring expenses decreases at low levels of tax evasion, the negative effect on growth rates is getting higher. As expected, announced tax rates are getting lower as tax evasion levels are reduced in the economy. However, the effect of announced tax rate on output growth rates and tax evasion levels is the opposite. Aggregate output increases as the announced tax rate increases but at a decreasing rate. In high levels of official tax rates, tax evasion is getting higher reducing governments' revenues and therefore public capital formation. Similarly, high announced tax rates by the government, provide strong incentives to tax payers to evade taxes. These incentives

⁶This was calculated by solving (15) assuming a steady-state rate of growth in aggregate output of 5% in the absence of tax evasion by setting $\mu = 0$ and $\tau = \tau_e$.

are getting larger at high levels of taxation.

Finally, using relations (24) and (25) we simulate the government's loss with respect to both tax evasion and forgone output growth under different assumptions on the relative importance of tax evasion in the economy. Specifically, we assign four different values for the γ parameter in (23), $\gamma = 1$, $\gamma = 0.75$, $\gamma = 0.50$ and $\gamma = 0.25$, reflecting a wider range of the importance assigned to tax evasion by the government. Changes in both output growth differential and tax evasion are presented in Table 3 and Figure 1. When both forgone output growth and tax evasion have the same relative importance for the economy, $\gamma = 1$, government's loss is minimized when the share of monitoring expenses on total tax revenues is 6.93%. At this level of tax auditing, announced tax rate is 30.42%, tax evasion 6.85% and output growth 3.11%. Reducing the relative importance of tax evasion for central government to $\gamma = 0.75$, tax auditing reduces to 6.48% while both announced tax rates and tax evasion levels increase to 30.92% and 7.15%, respectively. At the same time, output growth increases to 3.32%. If the relative importance of tax evasion is reduced to the one half of forgone output growth, $\gamma = 0.5$, the share of monitoring expenses is decreased to 5.91%, announced tax rate is increased to 32.11%, tax evasion goes up to 7.48% and output growth is increased to 3.53%. Reducing further γ to 0.25, monitoring expenses are reduced to 5.05%, the announced tax rate goes to 34.30%, tax evasion is increased to 8.01% and output growth to 3.85%.

Comparing our simulation results with the sample of 145 countries used in the estimation of the tax evasion function in (22) we see that for the subsample of developed countries our simulation results under the last scenario (*i.e.*, $\gamma = 0.25$), are very close to the reported values of monitoring expenses and announced tax rates. On the average, governments in industrial and developed countries spend 5.51% in tax auditing with an announced tax rate of 35.06%. Although governments care about the growth maximizing output levels, it seems that tax evasion constitute an important public policy concern. Increasing official tax rates may bring the economy close to the steady state output growth, but at the same time it raises income equality concerns that should be taken into account. In all developed and industrialized countries, announced tax rates are considerably higher, imposing constraints against growth maximizing policies. On the other hand, in less developed countries, announced tax rate is only 17.80% on the average, but with considerably lower monitoring expenses, 1.90%, resulting to high levels of tax evasion.

6 Concluding Remarks

In this paper the relationship between tax evasion and the official tax rate announced by the government together with the share of tax revenues allocated to monitoring tax evasion was analyzed using a standard one-sector endogenous growth model. In this simple modeling setup, we confirm Barro's (1990) theoretical finding posing that governments want the effective tax rate close to its degree of expenditure externality. In the presence of tax evasion the statutory tax rate has to be such that the effective one is equal to the elasticity of public capital. The contradiction with some

parts of the relevant literature is due to the definition of tax auditing expenses in government's budget constraint. If tax monitoring expenses are a constant share of total income then the optimal tax rate should be greater than the governments' externality as reported by Lin and Yang (2001) and Chen (2003). However, if tax auditing expenses are defined as a constant share of tax revenues, Barro's (1990) outcome is confirmed. In both cases though the optimal reaction of government involves the reduction of tax auditing expenses and an increase in the announced tax rate in order the effective has rate to remain at it's optimal level.

However, as noted by Roubini and Sala-i-Martin (1995), governments do care about the extent of tax evasion and therefore the formal tax rate cannot be higher than a certain threshold. In this case an optimal share of tax monitoring expenses exists as on the one hand tax evasion matters inducing income inequality but, on the other, governments' externality is lessened. Based on this assertion a government objective function is defined and optimized with respect to both the announced tax rate and the share of tax revenues absorbed by tax auditing. We proved that in this case the effective tax rate should be lower than the output elasticity of public capital, due to the externality associated with public capital accumulation, confirming the theoretical results reported by Futagami *et al.*, (1993) and Turnovsky (1997).

In the last part of the paper our theoretical model was calibrated using data from a sample of 145 developed and developing countries for the year 2011 to quantify the growth maximizing effects of these policies. Our results suggest that both tax evasion and output growth are decreasing with the share of tax revenues allocated to monitoring expenses. Tax auditing is less effective at low levels of tax evasion, while it's negative effect on aggregate output growth is high. At the same time monitoring expenses are reducing the announced tax rate particularly at high levels of statutory tax rates. The government's welfare maximizing policies imply an announced tax rate close to the elasticity of public capital and a share of monitoring expenses around 6.0% which is confirmed by the data on developed countries.

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A Appendix

A.1 Derivation of the Tax Evasion Function

Following Chen (2003), we may assume that firms evade taxes reporting only a fraction β of their produced output. At the same time, tax evasion involves transaction costs for firms equal to $\zeta(1-\beta)^2$, where ζ is a positive cost parameter. We further assume that the probability of detecting tax evasion, denoted by $p(\mu)$, is a positive and concave function of the share of government spending allocated for tax monitoring purposes (μ). Finally, if firms are convicted for tax evasion they will have to pay evaded taxes plus a penalty imposed on these taxes at a fix rate $\pi - 1 > 0$.

Under the above assumptions, the expected revenues for firm i are given by:

$$\begin{aligned} E(R) &= [1 - p(\mu)] [(1 - \tau\beta) - \zeta(1 - \beta)^2] Y_i + p(\mu) [(1 - \tau\beta) - \zeta(1 - \beta)^2 - \pi\tau(1 - \beta)] Y_i \\ &= (1 - \tau_e) Y_i \end{aligned}$$

where

$$\tau_e = \tau \left[1 - (1 - \beta)(1 - p(\mu)\pi) \right] + \zeta(1 - \beta)^2$$

is the effective tax rate and τ the announced tax rate.

Given the values of the two policy variables (*i.e.*, tax monitoring expenses, μ , and announced tax rate, τ), the representative firm determines the optimal share of reported output, β , so that it's profits are maximised. In other words, it determines the share of output that minimizes the effective tax rate:

$$\frac{\partial \tau_e}{\partial \beta} = 0 \Rightarrow (1 - \beta) = \frac{1 - p(\mu)\pi}{2\zeta}$$

Hence, the optimal effective tax rate is given by

$$\tau_e^* = \tau - \tau \frac{[1 - p(\mu)\pi]^2}{4\zeta}$$

and therefore, the tax evasion function is equal with

$$h(\tau, \mu) = \tau - \tau_e = \tau \frac{[1 - p(\mu)\pi]^2}{4\zeta}$$

which is a positive function of the announced tax rate and a negative function of the share of the government spending allocated for tax monitoring purposes as relation (5) implies.

A.2 The Steady-State Growth Rate of the Economy with Utility Maximization

Let's start assuming that the instant utility function is given by the following relation

$$u = \frac{C^{1-\theta} - 1}{1 - \theta}$$

where $0 < \theta < 1$ is a utility parameter and, C is the per capita consumption in the economy.

Then the solution to the standard infinite horizon utility maximization problem is given by:

$$\frac{\dot{C}}{C} = \frac{1}{\theta} (r - \rho) = \frac{1}{\theta} \left[(1 - \tau_e) \alpha \left(\frac{K_g}{K} \right)^{1-\alpha} - \delta - \rho \right] \quad (26)$$

where r is the real interest rate, and ρ is the rate of time preference.

In order to calculate the endogenous ratio of public to private capital stock in the above equation, we proceed as follows. At the steady-state all the basic variables of the model (*i.e.*, aggregate output, per capita consumption, private and public capital stock) grow at the same rate. By setting the growth rate of per capita consumption equal with the growth rate of public capital stock, we get:

$$\frac{1}{\theta} \left[(1 - \tau_e) \alpha \left(\frac{K_g}{K} \right)^{1-\alpha} - \delta - \rho \right] = (1 - \mu) \tau_e \left(\frac{K_g}{K} \right)^{-\alpha} - \delta \Rightarrow \left(\frac{K_g}{K} \right) = \frac{\theta(1 - \mu) \tau_e}{\alpha(1 - \tau_e)}$$

Assuming that both the rate of time preference and the depreciation rate of private and public capital are zero ($\rho = \delta = 0$)⁷ and, substituting the above into (26), we derive the steady-state growth rate of the economy as:

$$g_y = \frac{1}{\theta \alpha} \left[\left(\alpha (1 - \tau_e) \right)^\alpha \left((1 - \mu) \tau_e \right)^{1-\alpha} \right]$$

This result is qualitatively the same as the one derived in the main body of the paper (see relation (17)), using only the production side of the economy.

⁷The result will be the same, but less evident, if ρ and δ are different than zero.

Tables and Figures

Table 1: Econometric Estimates of the Tax Evasion Function and Summary Statistics of the Variables Used

<u>Econometric Estimates</u>			
Variable	Parameter	Estimate	StdError
Constant	β_0	-1.9889	0.1641
Tax rate	β_τ	0.8403	0.0496
Monitoring expenses	β_μ	-0.1223	0.0321
\bar{R}^2		68.69	
<u>Summary Statistics of the Variables</u>			
Variable Definition	Mean	Maximum	Minimum
Taxes lost as % of Government spendings ¹	6.60	19.23	0.29
Average tax burden (in %) ¹	22.09	63.10	0.90
Monitoring expenses as % of Government spendings ²	3.21	7.11	0.82
Countries in the sample		145	

¹ Obtained from *Tax Justice Network*.

² Constructed from *Global Development Network Growth Database*.

Table 2: Benchmark Parameter Values

Definition	Parameter	Value	Source
Output elasticity of private capital	α	0.670	Obtained as an average value from Zimmerman (1997)
Real interest rate	r	0.055	Average value of spreads for the 2005-12 period obtained from <i>Datastream</i>
Depreciation rate of capital	δ	0.080	Adopted from Acemoglu and Zilibotti (2001)
Adjustment rate of investments	φ	0.010	Rungsuriyawiboon and Stefanou (2007) based on a linear accelerator model
Steady-state output growth	\bar{g}_y	0.050	Assumption
Coefficient of productivity	A	0.155	Set so that output growth equals 5.0%

Table 3: Equilibrium Values under Different Shares of Monitoring Expenses and Different Weights in the Loss Function

Monitoring (μ)	Announced Tax Rate (τ)	Tax Evasion ($\tau - \tau_e$)	Output Growth Rates (g_y)	Changes in Growth Differential	$\gamma = 1$	Changes in Tax Evasion $\gamma = 0.75$	$\gamma = 0.50$	$\gamma = 0.25$
0.0200	0.4106	0.1045	0.0464	0.0007	0.0668	0.0501	0.0334	0.0167
0.0225	0.4045	0.1017	0.0459	0.0008	0.0563	0.0422	0.0281	0.0141
0.0250	0.3986	0.0992	0.0454	0.0009	0.0481	0.0361	0.0241	0.0120
0.0275	0.3928	0.0969	0.0448	0.0011	0.0417	0.0313	0.0209	0.0104
0.0300	0.3872	0.0947	0.0443	0.0013	0.0365	0.0274	0.0183	0.0091
0.0325	0.3816	0.0926	0.0437	0.0015	0.0323	0.0242	0.0161	0.0081
0.0350	0.3761	0.0907	0.0431	0.0017	0.0287	0.0215	0.0144	0.0072
0.0375	0.3705	0.0888	0.0424	0.0020	0.0257	0.0193	0.0129	0.0064
0.0400	0.3650	0.0870	0.0418	0.0022	0.0231	0.0173	0.0116	0.0058
0.0425	0.3595	0.0852	0.0410	0.0025	0.0209	0.0157	0.0105	0.0052
0.0450	0.3540	0.0836	0.0403	0.0029	0.0190	0.0142	0.0095	0.0047
0.0475	0.3485	0.0819	0.0395	0.0033	0.0173	0.0130	0.0086	0.0043
0.0500	0.3429	0.0803	0.0387	0.0037	0.0158	0.0118	0.0079	0.0039
0.0525	0.3373	0.0787	0.0378	0.0042	0.0144	0.0108	0.0072	0.0036
0.0550	0.3317	0.0772	0.0369	0.0047	0.0133	0.0099	0.0066	0.0033
0.0575	0.3260	0.0757	0.0360	0.0053	0.0122	0.0091	0.0061	0.0030
0.0600	0.3203	0.0742	0.0350	0.0059	0.0112	0.0084	0.0056	0.0028
0.0625	0.3146	0.0727	0.0340	0.0066	0.0103	0.0078	0.0052	0.0026
0.0650	0.3087	0.0712	0.0329	0.0074	0.0095	0.0072	0.0048	0.0024
0.0675	0.3029	0.0697	0.0318	0.0082	0.0088	0.0066	0.0044	0.0022
0.0700	0.2969	0.0683	0.0306	0.0092	0.0081	0.0061	0.0041	0.0020
0.0725	0.2909	0.0668	0.0294	0.0102	0.0075	0.0057	0.0038	0.0019
0.0750	0.2848	0.0654	0.0281	0.0114	0.0070	0.0052	0.0035	0.0017
0.0775	0.2787	0.0639	0.0267	0.0127	0.0065	0.0048	0.0032	0.0016
0.0800	0.2725	0.0625	0.0253	0.0141	0.0060	0.0045	0.0030	0.0015
0.0825	0.2662	0.0611	0.0238	0.0156	0.0055	0.0041	0.0028	0.0014
0.0850	0.2598	0.0596	0.0222	0.0173	0.0051	0.0038	0.0026	0.0013
0.0875	0.2533	0.0581	0.0206	0.0191	0.0047	0.0035	0.0024	0.0012
0.0900	0.2468	0.0567	0.0189	0.0212	0.0044	0.0033	0.0022	0.0011
0.0925	0.2402	0.0552	0.0171	0.0234	0.0040	0.0030	0.0020	0.0010
0.0950	0.2335	0.0537	0.0153	0.0258	0.0037	0.0028	0.0019	0.0009
0.0975	0.2267	0.0523	0.0133	0.0285	0.0034	0.0026	0.0017	0.0009
0.1000	0.2198	0.0508	0.0113	0.0314	0.0032	0.0024	0.0016	0.0008

Figure 1: Changes in Growth Differential and Tax Evasion for Different Weights of the Loss Function

