Corruption, tax revenue and growth: a non linear relationship?

Raffaella Coppier

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Abstract

In this paper we explore tax revenue in a regime of widespread corruption in a static and dynamic framework. We prove that the relationship between the tax rate and tax collection is not linear. In a static context, this may bring about a Laffer–like behavior of overall tax revenue; a higher tax rate, via higher corruption, may reduce revenues. In a dynamic context, this relationship is inverted: tax revenues are high for low and high tax rates, while low for intermediate tax rates. Furthermore we prove that the relationship between the tax rate and growth is not linear: at low levels of the tax rate, any increase in it leads to a decreasing growth rate; after a certain threshold, increases in the tax rate lead to an increase in economic growth.

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1 Introduction

Tax evasion is a serious problem not only in transition economies but also in countries with developed tax systems. An important aspect of the work of the tax authority is dealing with the possibility of corruption. Dishonest taxpayers who under–report their income may bribe inspectors. It is widely agreed that the presence of tax evasion and corruption of public officials are social phenomena whose pervasive effect can significantly reduce tax revenue and seriously hurt economic growth (Rose - Akerman, 1975,1978; Shleifer and Vishny 1993 etc.). Therefore, in determining its auditing strategy, the tax authority should take into account the possibility of corruption of its inspectors. Although an extensive literature has investigated their origins, effects, and size on both theoretical and empirical aspects, the interaction between tax evasion and corruption has been only partially explored. In fact only recently the this relationship has been investigated in literature.

In general, agents should have funds at their disposal that they can afford to spend without the recompense that would come from registering the expense, in order to pay a bribe, whatever the reason. Such funds are, therefore, "off-balance sheet" and usually make up the compensation from the tax evasion that has previously occurred. Furthermore, since bribery agreements can dilute deterrence of underlying violation, it is desirable for society to detect and weed out corruption in order to preserve a given degree of deterrence.

In the pioneering model of Allingham and Sandmo (1972), the relationship between tax rates and evasion is ambiguous, and depends on the third derivative of the utility function. A broader review of the literature reports that, more generally, theoretical predictions of the effect of tax rates on evasion are dependent on modeling assumptions (Slemrod and Yitzhaki, 2000). Fisman and Wei (2001) present a case study of tax evasion in China: they find that on average, a 1 percent increase in the tax rate results in a 3 percent increase in evasion and furthermore this relationship is not linear: the evasion elasticity is larger at a high tax rate.

Chander and Wilde (1992) take into account the possibility of collusion between a tax evader and an official auditor whose cost of dishonesty is (relatively) low. In Besley and McLaren (1993), Hindriks et al. (1999), and Mookherjee and Png (1995) the deal with the issue of optimal remuneration of the inspectors. Besley and McLaren (1993) compare three distinct remuneration schemes, which provide different incentives to the inspectors: efficiency wages, reservation wages, and capitulation wages. They characterize the conditions under which each scheme generates the greatest amount of

tax revenues net of administration costs. They show that the efficiency wage strategy may not be a good idea much of the time. In our model we not consider the issue of optimal remuneration of the inspectors, by assuming that the inspector is paid a fixed wage. Hindriks et al. (1999) consider a model where all the actors are dishonest. They, however, allow for general remuneration schemes and more importantly for extortion. They show that in addition to loss in tax collection, the more bribes are collected, the more a tax inspector can resort to extortion in order to collect even more. In this case, the authors show that distributional effects of evasion and corruption are regressive because the richest taxpayers have most to gain from evading taxes and are least vulnerable to extortion (because it is harder to credibly over–report their income). Finally, Mookherjee and Pngs (1995) paper also consider only corruptible agents but they remove the exogenous matching of the auditor and the evader (polluter in their case) often assumed in the literature. They consider a moral hazard problem since, for evasion to be disclosed, the inspector has to exert a costly non observable effort.

All the models described analyze the relationship between tax revenues and tax rate only in a static context[1] and some of them (see Chander and Wilde, 1992 and Sanyal et al., 2000) show, as in our model, that the possibility may exist that an increase in the tax rate or the fine rate could actually decrease government revenue.

The present paper provides a theoretical study of the problem of the optimal tax rate in the presence of corruption in a static and dynamic context. When bureaucracy is corrupt, a rise in tax rate sets about complicated strategic moves by both taxpayers and inspectors. In fact, in a corrupt administration, a higher tax rate presents the possibility of a higher negotiated bribe rate and may also increase the number of corrupt tax inspectors by overcoming moral cost while for the taxpayers a higher tax rate creates a greater incentive to pay bribes. In our model we endogenize the output production analyzing the relationship between tax rate and tax revenues in a dynamic framework and we prove that the relationship between the tax rate and tax collection is not linear and is very different in a static or dynamic context. In particular, in a static model, after a certain point, increases in the tax rate lead to a drop in tax revenue, generating a Laffer–curve even in absence of distortions regarding input provision. In a dynamic context the relationship between the tax rate and dynamic tax collection is not only non–linear, but is also inverted when compared with the static one. Therefore, an

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[1]Sanyal et al. (2000), e. g., evidence that, in their model, the outcome stems from redistribution of income among taxpayers, auditors and the government, at a given aggregate income level.

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increase in the tax rate generates initially lower revenues which increase as the tax rate increases above a certain threshold. In this case, also, the relationship between the tax rate and growth is not linear: at a low level of tax rate an increase in it leads to a lower growth rate; after a certain threshold, increases in the tax rate lead to an increase in economic growth. As, in the long term, fiscal revenues depend on the rate of capital accumulation, we will have a situation where tax revenues will go hand in hand with the growth rate.

The paper is organized as follows. In Section 2 we first present the model and then we formalize and solve the game describing the model in a static framework. In Section 3 we extend the analysis in a dynamic context, endogenizing output, and we demonstrate the non–linear relationship between the tax rate and dynamic tax revenues and between tax rate and growth. In Section 4 we discuss policy considerations. We conclude in Section 5.

2   The model

Consider an economy producing a single homogeneous good y. The economy is composed of three types of agents: a monitoring agency (monitors), a population of public officials (tax inspectors) and a population of taxpayers (entrepreneurs). Tax inspectors cannot invest in the production activity and earn a fixed salary w while entrepreneurs use their available capital in the productive sector. There is a continuum of tax inspectors and entrepreneurs and their number is normalized to 1 for both categories. The State controls entrepreneurs' and tax inspectors' behavior through monitors in order to weed out or reduce corruption and fix the level of the tax rate t on the product y. The State uses the tax revenues for pay the tax inspector's wages and there is no space for financing public productive expenditure. We assume that taxation is not distorsive regarding input provision. Economic agents are risk-neutral.

Firms manufacture the homogeneous product y with technology with constant returns to scale. Each entrepreneur is assumed below to have the same quantity of capital k. The product may be either manufactured for consumption purposes c or for investment purposes.

The production function of the good only depends on the capital and the natural state that may occur. In fact with a probability $(1 - \delta)$ production will be :

$$y = ak$$

while with a probability δ an adverse natural state will occur and production will not take place:

$$y = 0$$

Profits are taxed at a tax rate t. Each entrepreneur is monitored by a tax inspector who will check that tax payment is correct. The tax inspector is able to tell which of the two natural states has occurred for each entrepreneur only after exercising control. It is common knowledge that the tax inspector[2] is corruptible, in the sense that he pursues his own interest and not necessarily that of the State; in particular, the tax inspector is open to bribery. The tax inspector, in the case of the "good" natural state and in exchange for a bribe b, can offer the entrepreneur the opportunity of reporting to the State that the natural state that has arisen is the "bad" one.

Let b^d be the bribe asked by the tax inspector. Then the entrepreneur could refuse payment of the bribe, or accept to pay the bribe opening negotiation on the bribe with the inspector.

The State checks on the behavior of entrepreneurs and tax inspectors. Let $q \in [0, 1]$ be the monitoring level implemented by the State. There is an exogenous probability q of being detected given that corruption has takes place. The entrepreneurs incur a cost (either monetary, moral, or criminal) equal to ck where $c \in [0, 1]$.[3] The entrepreneur, if detected, must pay taxes ty, moral cost but he is refunded the cost of the bribe paid to the tax inspector.

2.1 The game: description and solution

Given the model just described, the economic problem can be formalized by the following two-period dynamic game with perfect and complete information (see figure 1).

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[2]The inspector is assumed to have monopolistic power in the sense that an entrepreneur is seen by only one inspector and cannot turn to other inspectors to get a different treatment.

[3]The punishment for the entrepreneur is not a constant, but rather a function of the investment. In this case too, based on the statements of Rose - Ackerman (1999): *"On the other side of the corrupt transaction, a fixed penalty levied on bribers will lower both the demand for corrupt services and the level of bribes. However, it will have no marginal impact once the briber passes the corruption threshold. To have a marginal effect, the penalties imposed on bribe payers should be tied to their gains (their excess profits, for example)"*.pp. 55.
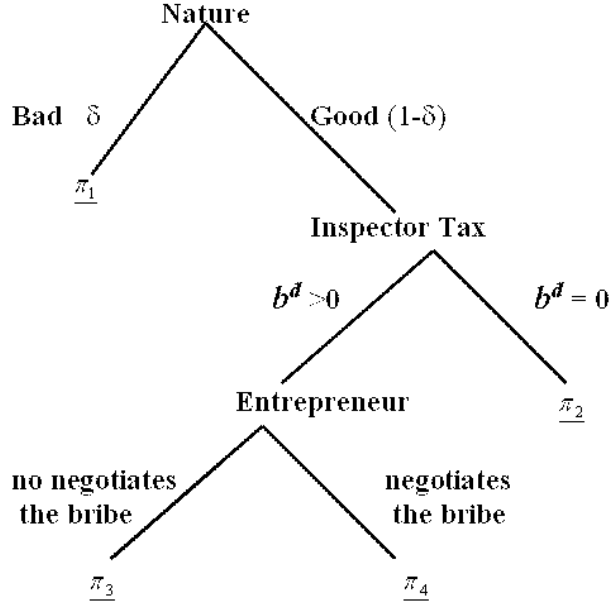
Figure 1: The game tree

At the outset of the game, Nature decides in which state the entrepreneurs find themselves with their consequent level of activity.

(1) In the first stage of the game, the tax inspector checks the entrepreneurs' production. If a "bad" natural state occurs, then the tax inspector reports that no tax is owed and, in this case, the game ends. Otherwise, if there is a "good" natural state, the tax inspector decides whether to ask for the bribe b^d (or not) to report that the "bad" natural state has arisen and that the entrepreneur need not pay any tax.

(1.1) If $b^d = 0$ no bribe is asked for, the payoff vector for the entrepreneurs and tax inspectors is:

$$\underline{\pi}_2 = (ak(1 - t), w)$$

The game ends in the equilibrium **NC** (No Corruption).

(1.2) Otherwise, let $b^d > 0$ be the positive bribe asked for by the tax inspector. The game continues to stage two.

(2) At stage two the entrepreneur decides whether to negotiate the bribe or turn it down.

(2.1) If the entrepreneur refuses bribe, then the payoff vector is given by:
$$\underline{\pi}_3 = (ak(1-t), w)$$

Then, in this case the game ends. No penalty results for the tax inspector.

(2.2) Otherwise the negotiation starts and the two parties will find the bribe corresponding to the Nash solution to a bargaining game (b^{NB}) and the game ends. This bribe is the outcome of a negotiation between the inspector and the entrepreneur, who will be assumed to share a given surplus. The payoffs will depend on whether the inspector and the entrepreneur are detected (with probability q) or not detected (with probability $(1-q)$). No penalty results for the tax inspector detected.[4]

If the entrepreneur decides to pay the bribe, the expected payoff vector is given by:
$$\underline{\pi}_4 = (ak(1-qt) - ckq - (1-q)b, w + (1-q)b)$$

The game ends in the equilibrium **C** (Corruption).

In what follows we refer to the entrepreneur payoff by a superscript (1), to the inspector payoff by a superscript (2): they represent respectively the first and the second element of the payoff vector $\underline{\pi}_i, i = 1, 2, 3, 4$.

We first determine the equilibrium bribe (b^{NB}) (see Appendix A for the proof).

Proposition 2.1 *Let $q \neq 1$.[5] Then there exists a unique non negative bribe (b^{NB}), as the Nash solution to a bargaining game, given by:*
$$b^{NB} = \mu \left[akt - \frac{qkc}{(1-q)} \right].$$

where $\mu \equiv \frac{\varepsilon}{\varepsilon + \beta}$ is the share of the surplus that goes to the tax inspector and β and ε are the parameters that can be interpreted as measures of bargaining strength of the entrepreneur and the tax inspector respectively.

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[4]The results do not depend on the existence of a cost for the tax inspector corrupted and detected. To simplify the results we have preferred to omit this.

[5]If $q = 1$ this stage of the game is never reached.

As a consequence of the model, let us assume that the tax inspector and the entrepreneur share the surplus on an equal basis. This is the standard Nash case, when $\varepsilon = \beta = 1$ and tax inspector and taxpayer get equal shares[6]. In this case the bribe is:

$$b^{NB} = \frac{akt}{2} - \frac{qkc}{2(1-q)}.$$

in other words, the bribe represents half of the saving coming from not paying taxes, net of moral costs that await the entrepreneur if he is found out.

The payoff vector is given by:

$$\pi_4 = \left(ak - \frac{akt(1+q)}{2} - \frac{ckq}{2}, w + \frac{akt(1-q)}{2} - \frac{cqk}{2} \right)$$

Comparative statics

(1) By computing this derivate we observe that:

$$\frac{\partial b^{NB}}{\partial t} = \frac{ak}{2} > 0$$

Increasing the tax rate also increases the potential surplus that the tax inspector and entrepreneur can share and therefore increases the bribe;

(2) Also computing:

$$\frac{\partial b^{NB}}{\partial q} = -\frac{kc}{2(1-q)^2} < 0$$

Increasing monitoring reduces the potential surplus that the tax inspector and entrepreneur can share, therefore reducing the bribe.

By solving the static game, we can prove the following proposition:[7]

Proposition 2.2 *Let* $0 \leq \frac{qc}{a(1-q)} = t^* \leq 1.$[8] *Then,*

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[6]The generalized (or asymmetric) Nash bargaining solution will be analyzed in paragraph 3.1.

[7]See Appendix B for the proof.

[8]We are assuming that $qc \leq a(1-q)$ rather that the cost expected by the entrepreneur from corruption is lesser than the benefit that might be expected from the said corruption. Therefore if $t = 1$, $\pi_4 > \pi_3$ for all moral cost c and then all entrepreneurs are corrupted. If $t = 0$, $\pi_4 < \pi_3$ for all moral cost c and then all entrepreneurs are honesty.

(a) if $t \in [0, t^*)$ the payoff vector is

$$\underline{\pi}_2 = (ak(1 - t), w)$$

(b) if $t \in [t^*, 1]$ the payoff vector is

$$\underline{\pi}_4 = \left(ak - \frac{akt(1 + q)}{2} \right) - \frac{ckq}{2}, w + \frac{akt(1 - q)}{2} - \frac{cqk}{2} \right).$$

Depending on the value of the tax rate t, two sub–game perfect Nash equilibria can be found (see Table 1):

- If $t < t^*$ (equilibrium **NC**), what the entrepreneur obtains evading taxes is not enough to make up for the expected cost for the entrepreneur of risking detection. With this in mind, the tax inspector will not ask the entrepreneur for a bribe. The game therefore finishes with the entrepreneur paying taxes. There is no sufficient margin for agreeing on a positive bribe with the tax inspector.

- If $t \geq t^*$ (equilibrium **C**), the entrepreneur finds it worthwhile to start a negotiation with the tax inspector. Thus the surplus to be shared between the entrepreneur and the inspector will keep a negotiation going, whose outcome is the bribe corresponding to the Nash solution to a bargaining game.

Therefore, in a given country, corruption arises when tax rates are sufficiently high.

2.2   Tax revenues with heterogeneous moral costs

In order to extend our considerations, we also analyze the solution of the game with respect to moral cost c. If $t \geq t^*$, then

$$c \leq \frac{at(1 - q)}{q} = c^*$$

If $t < t^*$, then

$$c > \frac{at(1 - q)}{q} = c^*$$

Table 1: **Parameter conditions: the two Nash equilibria.**

t value	$t < t^*$	$t \geq t^*$
Stage 1	The inspector does not ask for a bribe	The inspector asks for a bribe
Stage 2	The entrepreneur does not start a negotiation	The entrepreneur starts a negotiation
Equilibrium	NC	C
Corruption	None	Widespread
Resulting output	$y = (1 - \delta)ak$	$y = (1 - \delta)ak$
Entrepreneur's payoff	$ak(1 - t)$	$ak\left[1 - \frac{t(1+q)}{2}\right] - \frac{ckq}{2}$
Inspector's payoff	w	$w + \frac{akt(1-q)}{2} - \frac{cqk}{2}$
Tax revenues	akt	$qakt$

If all entrepreneurs incur the same moral costs, this leads to a corner-solutions: in fact, once a taxation level equal to t is set, if the moral cost is lower than $c^* = \frac{at(1-q)}{q}$, then all the entrepreneurs will be corrupt at that level of taxation. If moral cost c is greater than c^* then all the entrepreneurs will be honest. Tax revenues depend on the hypothesis made on the distributional cost. If moral cost is lower than c^*, the State, therefore, will receive revenues $(E(t))$ that are equal to the taxes obtained if the corruption is detected (with probability q) and if the positive natural state occur (with probability $(1-\delta)$):

$$E = (1-\delta)akqt^*$$

Vice versa, if the entrepreneurs' level of cost is greater than c^* then all the entrepreneurs will be honest and the State will therefore have revenues equal to:

$$E = ak(1-\delta)t^*$$

Moral cost equal for each entrepreneur is a convenient assumption, but non necessarily a realistic one. Under this hypothesis, taxpayer optimization yields corner–solutions and this is not an accurate description of taxpayers' behavior. For this reason we introduce the hypothesis that these costs may end up different for the various entrepreneurs (let c_i being the entrepreneur i-cost), mirroring different ethical, moral and religious values or denoting a greater or lesser sense of their own impunity.

The distribution of individual costs is defined by the cumulative density of probability $F(c_i)$. This function represents the proportion of entrepreneurs who agree to be corrupted when the tax rate is t. If, as we will assume, the distribution of entrepreneurs' costs is uniform in the interval $[c_{min}, c_{max}]$, then the cumulative density of probability is linear:

$$F(c_i) = \int_{c_{min}}^{c_i} \frac{1}{c_{max} - c_{min}} dc_i = \frac{c_i - c_{min}}{c_{max} - c_{min}}$$

assume $c_{min} = 0$ and $c_{max} = 1$ from which the density function derived is:

$$F(c_i) = c_i$$

Given the heterogeneity of entrepreneurs, we have that each their way of behaving will be influenced by their own moral cost c_i. On an aggregate level, the tax revenues is no longer a corner solution. We have a situation

where State revenues, with a tax rate fixed at t, will be equal to the tax paid by those who find themselves in a positive natural state (with probability $(1 - \delta)$) and who have moral cost that induce them into being honest and/or those are corrupt but are discovered in the act of corruption:

$$E(t) = atk\alpha(1 - \delta) + atk(1 - \alpha)(1 - \delta)q$$

where $\alpha = \left[1 - \int_0^{c^*} f(c_i)dc_i\right]$ is the fraction of the entrepreneurs with moral costs that are high enough to qualify them as honest and pay taxes. As we have already said, if moral costs has a uniform distribution, then $\alpha = (1 - c) = 1 - \frac{at(1-q)}{q}$ out of which State revenues become:[9]

$$E(t) = (1 - \delta)\left[atk(1 - \frac{at(1 - q)}{q}) + atkq(\frac{at(1 - q)}{q})\right] =$$

$$atk(1 - \delta) - \frac{a^2t^2k(1 - \delta)(1 - q)^2}{q}$$

There is therefore a parabolic relationship between the tax rate t and the tax revenues $E(t)$. In particular, since $\frac{a^2t^2k(1-\delta)(1-q)^2}{q} < 0$, the parabola is backward–bending. As we can see in figure 2, an increase of the tax rate increases revenues up to $t = \frac{q}{2a(1-q)^2} = t_1$, after which an increase of the tax rate reduces revenues. Then this relationship in not linear: for low tax rates an increase in the tax rate leads to an increase in revenues while, from a certain threshold, an increase in the tax rate leads to a reduction in revenues. This Laffer–curve is generally justified by the effect on factor supplies resulting from the incentive of higher post–tax income per unit of supply. In our model, this relationship finds instead its justification in widespread corruption that encourages entrepreneurs into evasion when the tax rate increases.

Comparative statics

(1) By computing this derivate we observe that:

$$\frac{\partial E(t)}{\partial t} = (1 - \delta)\left[ak - \frac{2a^2tk(1 - q)}{q} + 2a^2tk(1 - q)\right]$$

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[9]If $t = 1$, all entrepreneurs are corrupt and then the tax revenues are pay only by entrepreneurs discovered:
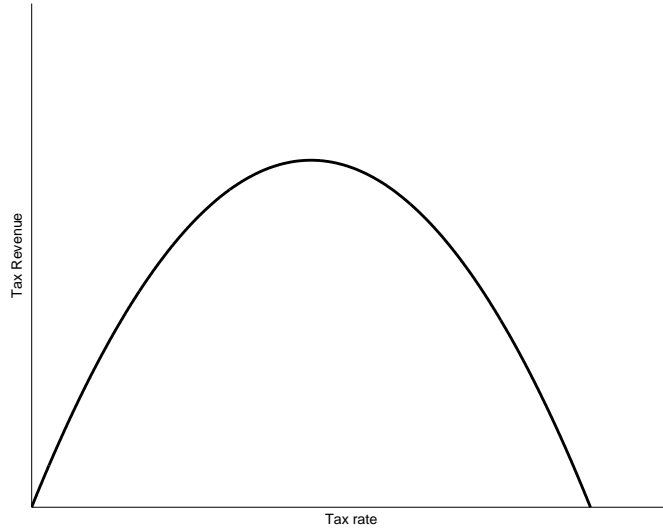
$$E(t = 1) = (1 - \delta)akq$$

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Figure 2: Relationship between tax rate t and static revenues $E(t)$

as the tax rate increases, revenues increases up to $t = t_1$, after which an increase of the tax rate reduces revenues. This happens as a result of the combination of three effects:

1) As the tax rate increases, revenues increase because of those who are still honest pay more taxes: $(1 - \delta)ak > 0$;

With an increase of the tax rate, the number of honest entrepreneurs increases. This leads to two effects:

2a) As the tax rate increases, revenues go down in that the number of undiscovered corrupt entrepreneurs increases and therefore the number of entrepreneurs paying tax is reduced: $-\frac{2a^2k(1-q)(1-\delta)}{q} < 0$;

2b) As the tax rate increases, revenues from those discovered in corrupt transactions increase: $2a^2k(1 - q)(1 - \delta) > 0$.

(2) Also computing:

$$\frac{\partial E(t)}{\partial q} = \frac{a^2 t^2 k(1 - \delta)(1 - q^2)}{q^2} > 0$$

This means that increasing monitoring reduces the potential surplus that the tax inspector and the entrepreneur can share. Therefore corruption reduces and revenues increase.

The existence of a Laffer–curve, thus, is justified by the presence of widespread corruption in public administration. In such a static context, corruption only has a redistributive effect (between taxpayers, tax inspector and government) while it causes lower revenues when compared to the absence of corruption. The conclusions change radically if we pass from static to dynamic analysis so incorporating the negative effect (distortion) of taxation on accumulation and so on economic growth and the repercussions this could have in terms of fiscal revenues.

3 Dynamic Analysis

The game perspective is now expanded to review the dynamic consequences of tax rate on dynamic revenues, on growth and, therefore, on investment, while analyzing the entrepreneurs' behavior in this respect.

As noted, a manufactured product y may be either consumed C or invested, $\overset{\bullet}{k}$.

Agents derive satisfaction from consumption according to a simple constant elasticity utility function:

$$U = \frac{C^{1-\sigma} - 1}{1 - \sigma}$$

Each entrepreneur maximizes utility over an infinite period of time subject to a budget.

$$\max_{c \in \Re^+} \int_0^\infty e^{-\rho t} U(C) dt$$

sub

$$\overset{\bullet}{k} = \Pi_I - C$$

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where C is consumption, ρ is the discount rate in time and Π_I is the return of investment for entrepreneur.

Since the return on the investment for the entrepreneur Π_I is different in each of the two equilibria **C** (Corruption) and **NC** (No Corruption), the problem is solved for the two cases.

By solving the dynamic game, we can prove the following proposition:[10]

Proposition 3.1 *Let $\frac{at(1-q)}{q} = c^*$. Then,*

(a) *if $c_i \leq c^*$ the growth rate is*

$$\gamma_i^C = \frac{1}{\sigma}\left[a - \frac{[at(1+q)]}{2} - \frac{qc_i}{2} - \rho\right]$$

(b) *if $c_i > c^*$ the growth rate is*

$$\gamma^{NC} = \frac{1}{\sigma}[a(1-t) - \rho].$$

Equilibrium depends therefore on individual moral cost except in the case in which $t = 1$ or $t = 0$. In fact, if $t = 1$, all entrepreneurs are corrupt and if $t = 0$ all entrepreneurs are honest a irrespective of the moral cost.

- for a given tax rate t, the entrepreneurs with a moral cost of $c_i \leq c*$, will find it worthwhile to be corrupted and so their optimal equilibrium will be that with corruption **C**. In such an equilibrium, the entrepreneur i–cost will experiment a growth rate of:

$$\gamma_i^C = \frac{1}{\sigma}\left[a - \frac{[at(1+q)]}{2} - \frac{qc_i}{2} - \rho\right]$$

- for a given level of tax rate t, entrepreneurs with a moral cost of $c_i > c*$ will find it worthwhile to be honest and their optimal equilibrium will be that without corruption **NC**. In such an equilibrium, the entrepreneurs will obtain a growth rate of:

$$\gamma^{NC} = \frac{1}{\sigma}[a(1-t) - \rho]$$

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[10]See Appendix C for the proof.

It may be further demonstrated that capital and income also have the same growth rate of the consumption and therefore equilibrium **NC**, from the dynamic viewpoint, is the equilibrium that allows greater economic growth. In fact, at a steady state, everything grows at the same rate and therefore $\frac{\dot{k}}{k}$ is constant. At equilibrium **C** we know that $\frac{\dot{k}}{k} = a - \frac{at(1+q)}{2} - \frac{qc_i}{2} - \frac{C}{k}$.

Since $\frac{\dot{k}}{k}$ is constant, then the difference between both terms on the right should also be constant, and because a, c_i, q and t are constant, then C and k should grow at the same rate. Similarly, since $y = ak(1-t)$, at a steady state the income grows at the same rate as the capital. The same applies in the case of equilibrium **NC**.

At the aggregate level, we will have a growth rate obtained by considering the different growth rates for the corresponding entrepreneurs.

Thus in equilibrium **C** there will be $(1-\alpha)$ entrepreneurs, each with his own growth rate γ_i^C, in the equilibrium **NC** there will be (α) entrepreneurs, each with the same growth rate γ^A.

At the aggregate level, we can prove the following proposition:[11]

Proposition 3.2 *Let* $\alpha = (1-c) = 1 - \frac{at(1-q)}{q}$. *Then,*

$$\gamma_y = \frac{(1-\delta)}{\sigma} \left[\frac{a^2 t^2 (1-q)^2}{4q} + a(1-t) - \rho \right]$$

There is therefore a parabolic relationship between the tax rate t and the rate of growth γ_y. In particular, since $\frac{a^2(1-q)^2}{4q} > 0$, the parabola is convex. In addition, the abscissa of the vertex of this parabola is easily calculated:

$$V = \frac{2q}{a(1-q)^2} = t_2 > 0$$

This relationship is represented in figure 3.

We analyze now the corner–solutions:

- if $t = 1$, all entrepreneurs are corrupt and then the growth rate is:
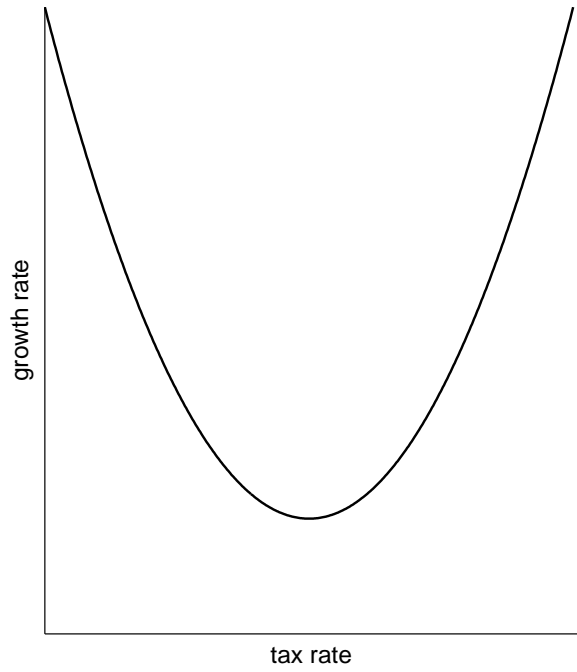
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[11]See Appendix D for the proof.

Figure 3: Relationship between tax rate and growth

$$\gamma_y(t=1) = \frac{(1-\delta)}{\sigma} \left[\frac{a(1-q)}{2} - \frac{a^2(1-q)^2}{4q} - \rho \right]$$

- if $t=0$, all entrepreneurs are honest and then the growth rate are:

$$\gamma_y(t=0) = \frac{1-\delta}{\sigma}[a-\rho]$$

Therefore the aggregate growth rate for $t=0$ are greater of growth rate for $t=1$.

Comparative statics

(1) By computing this derivate we observe that:

$$\frac{\partial \gamma_y}{\partial t} = \frac{(1-\delta)}{\sigma} \left[\frac{2a^2 t(1-q)^2}{4q} - a \right]$$

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we note that as the tax rate increases toward $t = t_2$, growth declines. After the threshold, as the tax rate increases, so growth begins to increase. This happens due to the combination of three effects:

1) with an increase of the tax rate, the remaining number of honest individuals pay more taxes and so accumulate less, depressing growth; With an increase of the tax rate, the number of honest entrepreneurs increases. This leads to two effects:

2a) growth increases inasmuch as the number of undiscovered corrupt entrepreneurs increases. As the corrupt entrepreneur now pays a bribe, and the bribe is lower than the tax amount he would have paid having remained honest. A greater amount of resources will be allocated to investment and generate higher growth;

2b) growth is reduced inasmuch as the number of discovered corrupt entrepreneurs increases. The newly corrupt entrepreneur when discovered is tantamount (given that he will be forced to pay taxes but will receive the bribe back) to an entrepreneur whose tax burden has increased. The usual effect shown in 1) will apply.

2 Also computing

$$\frac{\partial \gamma_y}{\partial q} = -\frac{a^2 t^2 (1 - \delta)(1 - q^2)}{4 \sigma q^2} < 0$$

We conclude that increasing monitoring activities increases the amount of tax collected and therefore reduces accumulation and economic growth.

Therefore, on the growth of the tax rate t, the rate of growth in the economy initially falls only then to increase in growth at a taxation point $t > t_2$. As the rate t grows initially, static revenue grows and so growth slows in that the entrepreneurs accumulate less. As the rate grows further beyond a certain level, the greater taxes paid by the honest and by the corrupt who have been found out are more than equalled by the taxes not paid by corrupt entrepreneurs the number of whom grows as the tax rate grows. Since the entrepreneurs evade tax insofar as the bribe paid is less than the amount of tax due to the State, it follows that greater corruption implies less tax revenue and greater economic growth, via greater accumulation.

Since the tax rate influences the accumulation of capital and, as a consequence, economic growth, it will also increase fiscal revenues at steady state. In fact, if the static tax revenues are:

$$E(t) = atk(1 - \delta) - \frac{a^2 t^2 k(1 - \delta)(1 - q)^2}{q}$$

In a steady state, everything grows at the rate and therefore $\frac{\dot{k}}{k}$ is constant. In equilibrium the rate of tax revenues, $\gamma_E(t)$ should also be constant, and because a, δ, q and t are constant, then $E(t)$ and k should grow at the same rate. Thus, we have found a non-linear relationship between the tax rate and dynamic revenues in a dynamic context (see figure 4), which is however inverted when compared to the static context.
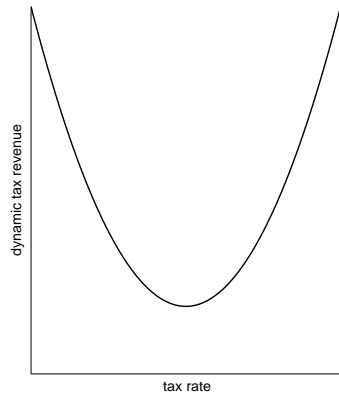

Figure 4: Relationship between dynamic tax rate and tax revenues

Lesser revenues today due to evasion can bring greater growth through greater capital accumulation and consequently greater revenues tomorrow. In the corner–solutions we can see that:

- if $t = 1$, all entrepreneurs are corrupt and then the revenues rate is:

$$\gamma_E(t = 1) = \frac{(1 - \delta)}{\sigma} \left[\frac{a(1 - q)}{2} - \frac{a^2(1 - q)^2}{4q} - \rho \right]$$

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This happens inasmuch as if $t = 1$, all entrepreneurs are corrupt and then evade tax. But with probability q are detected and forced to pay taxes;

- if $t = 0$, all entrepreneurs are honest and then the revenues rate are:

$$\gamma_E(t = 0) = 0$$

3.1 Bargaining strength

In an asymmetric Nash bargaining solution, the surplus is shared unequally between the tax inspector and the taxpayer and the equilibrium bribe (b^{NB}) is:

$$b^{NB} = \mu \left[akt - \frac{qkc}{(1-q)} \right].$$

where $\mu \equiv \frac{\varepsilon}{\varepsilon+\beta}$ is the share of the surplus that goes to the tax inspector and β and ε bargaining strength respectively of the entrepreneur and the tax inspector.

Thus the bribe paid to the inspector increases as the inspector's bargaining strength increases, expressed as ε. In fact, by computing this derivate we observe that:

$$\frac{\partial b^{NB}}{\partial \mu} = akt - \frac{qkc}{(1-q)} > 0$$

Increasing the bargaining power of the tax inspector increases the bribe that he can obtain. In the model we also see that corruption does not depend on the distribution of the surplus between the inspector and the tax evader, but only on the amount of the surplus τ. In fact, $(1 - \alpha) = \frac{at(1-q)}{q}$ is the number of entrepreneurs corrupted and it is not dependent on the parameters β and ε. On the contrary, such parameters affect any rates of growth of income and tax revenue in that a different distribution of power in the area of bargaining affects accumulation by the entrepreneur and hence the growth rate.

In particular, in the proposition 3.1, we see that if $c_i > c^*$ the growth rate is:

$$\gamma^{NC} = \frac{1}{\sigma}[a(1-t) - \rho]$$

And it is not dependent on the parameters β and ε. On the contrary, if $c_i \leq c^*$, the growth rate is dependent on the parameters β and ε in that this is the equilibrium where the entrepreneur pays a bribe and the value of this bribe depends on β and ε. The growth rate, if $c_i \leq c^*$, will be:

$$\gamma_i^C = \frac{1}{\sigma} \left[a - at[q + (1-q)\mu] - qc_i(1-\mu) - \rho \right]$$

As a result, the aggregate growth rate will also be affected by the bargaining strength of the inspector and the evader. In fact the growth rate will be:

$$\gamma_y = \frac{(1-\delta)}{\sigma} \left[\frac{a^2 t^2 (1-\mu)(1-q)^2}{2q} + a(1-t) - \rho \right]$$

As the inspector's bargaining power increases, the economy's growth rate will decrease in that fewer resources will be at the entrepreneur's

disposal for the process of accumulation. In fact by computing this derivate we observe that:

$$\frac{\partial \gamma_y}{\partial \mu} = -\frac{(1-\delta)}{\sigma} \left[\frac{a^2 t^2 (1-q)^2}{2q} \right] < 0$$

Then, if the taxpayer gets much of the evaded taxes, growth will surely suffer in that fewer resources will be given over to the process of accumulation. The bargaining strength between the tax inspector and the taxpayer may be influenced by other forces (or, variables), such as the tactics employed by the bargainers, the procedure through which negotiations are conducted, the information structure and the players' discount rate. If, for example, the discount rate for the taxpayer were greater than the tax inspector's, this would give greater power to the inspector in that the entrepreneur would be inclined to accept a smaller proportion of the surplus than the inspector would get in order not to pay taxes. Therefore, offering ε ad infinitum, the aggregate growth of income and of tax revenues reduces to form a parabola that is more "flattened" towards the bottom as far as parity of the other variables $(a, q, c_i, \sigma, \delta, t)$ is concerned, the growth rate will be the lower, the greater the bargaining power of the bureaucrat. Therefore, where there is corruption, and therefore evasion, countries which have entrepreneurs with greater bargaining power will succeed in obtaining higher growth rates.

4 Policy consideration

In this section we use the results derived above to assess the normative implications of our model of tax evasion, corruption and growth in a static and dynamic context. Let us briefly summarize the findings obtained so far. Increases in the tax rate change tax revenues and the growth rate and while increasing corruption because the number of entrepreneurs corrupted increases.

The State could choose to achieve different policy objectives in a static or dynamic context. If the State is operating over the short term, its goals could to maximize static tax revenues, aggregate income or eradicate corruption. In a static model, the tax rate does not influence aggregate income, but revenues and the level of corruption. In fact we have shown that if tax revenue are increased by raising t to a threshold level, while corruption increased as the tax rate increases. Therefore, the State could choose to achieve the following policy objectives: maximize tax revenue or weed out corruption.

In order to take into account the level of well-being when designing or evaluating social policies, one needs to use a social welfare function. Unfortunately, one can have cases in which one public policy does not dominate the others, and vice versa as in our quite general framework. This means that there are some legitimate objective functions that would show that an equilibrium results in higher welfare than another equilibrium, and other legitimate objective functions that would show exactly the opposite. Since it is impossible to rank them, we have an incomplete ordering of alternative policies. In fact, well–being will grow as fiscal revenues grow (if this leads to greater productive spending) and as the level of corruption decreases. As there is no equilibrium that maximizes tax revenue with zero corruption, the State must choose what, on the basis of its own preferences, is best for society:

- if the State wants to maximize tax revenues it has to set the tax rate at $t = t_1$. In this case there is corruption in the economy;

- if the State wants to weed–out corruption it has to set the tax rate at $t = 0$. In this way there are no incentives to corruption. In such an equilibrium, the State does not receive revenues and there is no space for financing public productive expenditure.

If, on the other hand, the State chooses long term options, its policy objectives will be to maximize growth, tax revenues and weed–out corruption. As we have said, the dynamic revenues go hand in hand with the rate of

growth: they are high for low and for high rates of tax, while corruption increases alongside the tax rate.

In a dynamic context, because $\gamma_y(t = 0) > \gamma_y(t = 1)$, therefore there is an equilibrium $(t = 0)$ that maximizes growth rate with zero corruption, but also with zero tax revenues. If the State sets low tax rate, then we obtain higth growth rate, low corruption and higth tax revenues.

Tax revenues depend positively on economic growth in the sense that greater growth implies, all the rest being equal, greater revenue and negatively on corruption in that greater corruption implies all the rest being equal, lesser revenue. As the rate t grows initially, static revenue grows, corruption grows but growth in corruption is lower than growth in tax revenues so accumulation reduces as does economic growth; beyond a certain level, the increase in rate implies an increase in corruption that more than compensates for the higher taxes paid by the honest entrepreneurs so accumulation grows as does economic growth.

5   Conclusions

The present paper provides a theoretical study of the problem of the optimal tax rate in the presence of corruption in a static and dynamic context. In the presence of taxation and corruption, tax rate increases do not lead to lower revenues provided that the tax rate is lower than a given threshold. The greater the efficiency and pervasiveness of monitoring of corruption, the greater the "inner honesty" of society and the lower the returns on investment the higher the threshold that will be needed to depress revenues through a tax rate increase. If one is willing to subscribe to the hypothesis that "Less Developed Countries" (LDC's) have poor monitoring institutions, less "inner honesty" and/or higher productivity of capital, then it would appear that these countries would have a harder time to raise revenues. If revenues are needed to stimulate the build–up of institutions and foster education, this points to the possibility of a "poverty trap", that has already been emphasized by some growth expert (see Easterly, 2002). These conclusions are completely reversed in a dynamic framework, if one is willing to subscribe to the basic tenet of our model that evasion among entrepreneurs stimulates investment, accumulation and thereby growth. These conclusions should however (with respect to existing literature) be understood as an additional recommendation for lowering taxes on capital and/or investment rather than stimulating evasion.

An empirical investigation of the implications of this model would allow to discover whether indeed:

– for a given "inner honesty" of society, one can distinguish between high–growth countries with extreme degrees of taxation and corruption (either high taxation and high corruption or low taxation and low corruption) and low–performance countries with intermediate degrees of corruption and taxation. Similarly one could analyze the impact on growth of the evolution over time of taxation and corruption;

– the degree of "inner honesty" of a country, if at all measurable and leaving aside the relevant issue of its endogeneity, affects the position of the "taxation–growth" curve. Scandinavian countries are usually thought of as high–growth countries with high tax rate and low corruption. While this may seem incompatible with the results of our model, it need not be so if one considers that these countries are also thought of as very transparent.[12] If indeed Scandinavian countries are empowered with a higher degree of "inner honesty", they may be characterized by a U–curve (in the "tax rate–growth rate" space) more shifted to the right. In this case a high tax rate may be compatible with high growth rate and low corruption.

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[12]For details, see Transparency International (TI). In the 2004 the CPI (Corruption Perceptions Index) for Finland is 9,7 (the country lesser corrupt in the TI ranking), 9,5 for Denmark, 9,2 for Sweden and 8,9 for Norway. CPI Score relates to perceptions of the degree of corruption as seen by business people and country analysts and ranges between 10 (highly clean) and 0 (highly corrupt).

A   Appendix: The Nash Bargaining bribe

Let $\underline{\pi}_\Delta = \underline{\pi}_4 - \underline{\pi}_3 = \pi_\Delta^{(1)}, \pi_\Delta^{(2)}$ be the vector of the differences in the payoffs between the case of agreement about the bribe and that in the case of disagreement for inspector and entrepreneur. In accordance with generalized Nash bargaining theory, the division between two agents will solve:

$$\max_{b \in \Re^+} [\pi_\Delta^{(1)}]^\beta \cdot [\pi_\Delta^{(2)}]^\varepsilon$$

in formula

$$\max_{b \in \Re^+} [ak(1 - tq) - ckq - (1 - q)b - ak(1 - t)]^\beta \, [w + (1 - q)b - w]^\varepsilon$$

that is the maximum of the product between the elements of $\underline{\pi}_\Delta$ and where $[(ak(1 - t)), w]$ is the point of disagreement, i.e. the payoffs that the entrepreneur and the inspector respectively would obtain if they did not come to an agreement. The parameters β and ε can be interpreted as measures of bargaining strength. It is now easy to check that the tax inspector gets a share $\mu = \frac{\varepsilon}{\varepsilon + \beta}$ of the surplus τ, i.e. the bribe is $b = \mu\tau$. More generally μ reflects the distribution of bargaining strength between two agents. The surplus τ is the saving coming from not paying taxes, net of moral cost that await the entrepreneur if he found out: $\tau = akt - \frac{qck}{(1-q)}$.

Then the bribe b^{NB} is an asymmetric (or generalized) Nash bargaining solution and is given by:

$$b^{NB} = \mu \left[akt - \frac{qkc)}{(1 - q)} \right]$$

that is the unique equilibrium bribe in the last subgame, $\forall q \neq 1$.

B   Appendix: Solution to the static game

Backward induction method. The static game is solved with the backward induction method, which allows identification at the equilibria. Starting from stage 2, the entrepreneur needs to decide whether to negotiate with the inspector. Both payoffs are then compared, because the inspector asked for a bribe.

(2) At stage two the entrepreneur negotiates the bribe if and only if

$$\underline{\pi}_4^{(1)} \geq \underline{\pi}_3^{(1)} \Rightarrow$$

$$\left[ak \left[1 - \frac{t(1+q)}{2} \right] - \frac{kqc}{2} \right] \geq ak(1-t) \Rightarrow$$

$$t \geq \frac{qc}{a(1-q)} = t^*$$

(1) Going up the decision-making tree, at stage one the tax inspector decides whether to ask for a positive bribe.

• Let $t \geq \frac{qc}{a(1-q)} = t^*$ then the tax inspector knows that if he asks for a positive bribe then the entrepreneur will accept the negotiation and the final bribe will be b^{NB}. Then at stage one the tax inspector asks for a bribe if and only if

$$\underline{\pi}_4^{(2)} > \underline{\pi}_2^{(2)} \Rightarrow$$

$$w + \frac{akt(1-q)}{2} - \frac{qkc}{2} > w$$

that is the tax inspector payoff if asking for a positive bribe is greater than his payoff if not asking the bribe:

$$t \geq \frac{qc}{a(1-q)} = t^*$$

If $t \geq t^*$, then tax inspector ask for the bribe b^{NB} that the entrepreneur will accept.

• Let $t < \frac{qc}{a(1-q)} = t^*$ then the tax inspector knows that the entrepreneurs will not accept any possible bribe, so he will be honest and he will ask the entrepreneurs for tax.

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C Appendix: Solution to the dynamic game

In the equilibrium with corruption (equilibrium **C**), the entrepreneur's profit is:

$$\Pi_I^C = ak\left[1 - \frac{t(1+q)}{2}\right] - \frac{kqc_i}{2}$$

thus the constraint is:

$$\overset{\bullet}{k} = ak\left[1 - \frac{t(1+q)}{2}\right] - \frac{kqc_i}{2} - C$$

The Hamiltonian function is:

$$H = e^{-\rho t}\frac{C^{1-\sigma} - 1}{1-\sigma} + \lambda\left[ak\left[1 - \frac{t(1+q)}{2}\right] - \frac{kqc_i}{2} - C\right]$$

where λ is a costate variable. Optimization provides the following first-order conditions:

$$e^{-\rho t}C^{-\sigma} - \lambda = 0 \tag{1}$$

and

$$\overset{\bullet}{\lambda} = -\lambda\left[a - \frac{at(1+q)}{2} - \frac{qc_i}{2}\right] \tag{2}$$

By deriving the first condition (1) and substituting it into the second one (2), the consumption growth rate is obtained:

$$\gamma_{c_i}^C = \frac{1}{\sigma}\left[a - \frac{at(1+q)}{2} - \frac{qc_i}{2} - \rho\right]$$

In equilibrium **NC**, the entrepreneur's profit is:

$$\Pi_I^{NC} = ak(1-t)$$

Thus the constraint is:

$$\overset{\bullet}{k} = ak(1-t) - C$$

The Hamiltonian function is:

$$H = e^{-\rho t} \frac{C^{1-\sigma} - 1}{1 - \sigma} + \lambda[ak(1 - t) - C]$$

Optimization provides the following first-order conditions that allow us to obtain the consumer growth rate:

$$\gamma^{NC} = \frac{1}{\sigma}[a(1 - t) - \rho]$$

D   Appendix: Aggregate growth

Aggregate growth γ is given by the sum of the rates of obtainable growth considered by the number of entrepreneurs who are positioned in that equilibrium. Thus at equilibrium **C** there will be $(1 - \alpha)$ entrepreneurs, at equilibrium **NC** there will be (α) entrepreneurs.
At the equilibrium **NC** the growth rate

$$\gamma^{NC} = \frac{1}{\sigma}[a(1 - t) - \rho]$$

is independent of moral costs and will therefore be equal for each entrepreneur with moral costs $c_i > c^*$; at the equilibrium **NC**

$$\gamma_i^C = \frac{1}{\sigma}\left[a - \frac{at(1 + q)}{2} - \frac{qc_i}{2} - \rho\right]$$

is dependent on moral costs for which reason each entrepreneur, with a moral cost of $c_i \leq c^*$, will have a different growth rate. Thus

$$\gamma = (1 - \alpha)\frac{1}{\sigma}\left[a - \frac{at(1 + q)}{2} - \rho\right] - \frac{1}{2\sigma}\left[q \int_0^{c^*} c_i dc_i\right] +$$

$$+ (\alpha)\frac{1}{\sigma}[a(1 - t) - \rho]$$

Substituting $1 - \alpha = \frac{at(1-q)}{q}$ and after some simplifications we obtain:

$$\gamma = \frac{1}{\sigma}\left[\frac{a^2 t^2 (1 - q)^2}{4q} + a(1 - t) - \rho\right]$$

Deriving the aggregate growth rate γ with respect to the level of tax rate t, we obtain:

$$\frac{\partial \gamma}{\partial t} = \frac{a^2 t (1-q)^2}{2q} - a$$

Thus:

- $\gamma(t)$ is decreasing or $\frac{\partial \gamma}{\partial t} < 0$, when $t < \frac{2}{a(1-q)^2}$;

- $\gamma(t)$ is minimal or $\frac{\partial \gamma}{\partial t} = 0$, when $t = \frac{2}{a(1-q)^2}$;

- $\gamma(t)$ is growing or $\frac{\partial \gamma}{\partial t} > 0$, when $t > \frac{2}{a(1-q)^2}$.

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