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Economic growth, corruption and tax evasion

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Abstract

In this paper, we explore tax revenues in a regime of widespread corruption in a growth model. We develop a Ramsey model of economic growth with rival but non-excludable public good which is financed by taxes which can be evaded via corrupt tax inspector. We prove that the relationship between the tax rate and tax collection, in a dynamic framework, is not unique, but is different depending on the relevance of the shame effect. We show that growth rates - both of income and of tax revenues - decrease, as the tax rate increases, for all types of shame effect countries but they differ in how the growth rate decreases as the tax rate increases: the rate of decrease is higher in low shame countries than in high shame countries.

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1 Introduction

Tax evasion and fiscal corruption have been a general and persistent problem throughout history with serious economic consequences, not only in transition economies, but also in countries with developed tax systems. In general, tax evasion and corruption can have ambiguous effects on economic growth: tax evasion increases the amount of resources accumulated by entrepreneurs, but it also reduces the amount of public services supplied by the government, thus leading to negative consequences for economic growth. Although there is extensive literature investigating the origins, effects and extent of tax evasion and corruption, from both theoretical and empirical points of view, interaction between them has only been partially explored: only recently has this relationship been investigated in the literature. The analysis of tax evasion in the tax compliance literature dates back at least to the classic paper of Allingham and Sandmo (1972). Since then, a large amount of literature relating to corruption and tax evasion has emerged. In particular, only recently can we find theoretical models which study tax setting and evasion in a context of growth models (e.g. Lin and Yang (2001), Chen (2003) and Ellis and Fender (2006)).

Lin and Yang (2001) extended the portfolio choice model of tax evasion from a static to a dynamic setting, finding that, while growth is decreasing with respect to tax rate in absence of evasion, it is U-shaped with respect to tax rate in presence of tax evasion. In contrast to our model, in their work, the public goods are not productive, then diverting resources from the non-productive public sector to the productive private sector, fiscal evasion will be conducive to economic growth.

Chen (2003) integrates tax evasion into an AK model with public capital financed by income tax which can be evaded. In his model, individuals optimize tax evasion, while the government optimizes the tax rate, auditing and fine rate, given the evasion level decided by consumers. In general, these policies have ambiguous effects, but for some parameters the author finds that the growth rate decreases as tax evasion increases.

Ellis and Fender (2006) introduce endogenous corruption into a variant of the Ramsey growth model where a government taxes private producers and uses the resources to either supply public capital or simply consumes the taxes itself (corruption form).

In contrast to these papers, we deal not with bureaucratic but with fiscal corruption which establishes a direct impact of evasion/corruption on tax revenues, and thus on economic growth.

In our model, we develop a Ramsey model of economic growth with rival but non-excludable public good which is financed by a percentage of taxes. In line with Chander and Wilde (1992), Hindricks, Keen and Muthoo (1999) and Sanyal, Gang and Goswami (2000), we also assume that tax auditing may be performed by a corruptible tax inspector, who takes a bribe in exchange for not reporting the detected evasion. Thus, in our model, evasion goes hand in hand with the corruption of the tax inspector. In particular, we analyze the implications of endogenous evasion and corruption at a micro level and then we use the results of our static game as a framework for the growth model. In fact, taxation and tax evasion, in turn, influence both the provision of the public good and capital accumulation, affecting output and economic growth in a different way: on one hand, higher tax evasion implies more capital accumulation and thus more economic growth; on the other hand, higher tax evasion leads to lower tax revenues, less provision of public good and thus, a lower economic growth rate.

In contrast with some lines of research on tax evasion, we do not consider the issue of optimal remuneration of tax inspectors by assuming that the inspector is paid a fixed wage¹.

We prove that the relationship between the tax rate and tax collection is not unique but is different depending on the relevance of the “shame effect” and depending on the static or dynamic context of the analysis.

Our work is part of one of two lines of research taken by literature on tax evasion (Feld and Frey, 2007), i.e. the line of research which considers tax morale as the key factor to explain the fact that, contrary to the results of Allingham and Sandmo (1972), “people who exhibit empirically observed levels of risk aversion normally pay their taxes, although there is a low probability of getting caught and being penalized” (Frey and Torgler, 2007). In particular, we consider a growth model where the aggregate tax evasion is determined by non-pecuniary costs which depend upon the entrepreneurs’ attitude to social stigma². In fact, like Dell’Anno (2009), we analyze a dynamic model, where the aggregate tax evasion is microfounded on non-pecuniary costs.

Several empirical studies highlight the importance of non-economic factors on tax evasion. For example Alm and Torgler (2006) find that the tax morale can explain more than 20 percent of the total variance of the variable size of the shadow economy (used as a measure of tax evasion): thus, if tax morale is declining, the shadow economy is likely to increase. Richardson’s work (2006) shows, in an empirical analysis based on data for 45 countries, that non-economic determinants have the strongest impact on tax evasion: in particular, tax morale is an important determinant of tax evasion.

Unlike Dell’Anno (2009), but following the line taken by Kim (2003), we assume that people may fear social stigma (shame effect) only if they are detected as cheaters/corrupted. In this paper, we have extended the static analysis of Cerqueti and Coppier (2009), in a long run context incorporating the presence of a public sector. Indeed, in the short-run, it is a plausible assumption that governments can be completely opportunistic, that is, they provide nothing for the citizenry, not even national defense. But, in the long run, even taxpayers who are initially ashamed of cheating will eventually change their minds and become less ashamed. It is doubtful that the citizenry will have a strong sense of loyalty to an opportunistic government, especially one that offers no productive output to its citizens. Following Barro and Sala-I-Martin (1992), we incorporate a public good into a growth model.

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 go on to analyze the relationship between the tax rate, dynamic tax revenues and income growth rate. We conclude in Section 4.

¹For example Besley and McLaren (1993), Hindriks et al. (1999) and Mookherjee and Png (1995), deal with the issue of optimal remuneration of inspectors. Besley and McLaren (1993) compare three distinct remuneration schemes which provide different incentives to the inspectors: efficiency wages, reservation wages and capitulation wages. Hindriks et al. (1999) consider a model where all the actors are dishonest. Mookherjee and Png (1995) also consider only corruptible agents, but they remove the exogenous matching of the auditor and the evader: they consider it a moral hazard problem, since, for evasion to be disclosed, the inspector has to exert a costly non-observable effort.

²For a complete review of the main hypothesis proposed in literature on the different types of non-pecuniary costs that influence tax morale see Dell’Anno (2009).

2 The model

In line with Cerqueti and Coppier (2009), we consider an economy which produces a single homogeneous good, with quantity $y \in [0, +\infty)$. There are three players in the economy: controllers, tax inspectors and entrepreneurs. We consider that the private good is produced by using two production factors, capital k and the public good with quantity $G \in [0, +\infty)$. The provision of the public good allows us to have a rationale for the existence of a government which uses tax revenues to finance the public good. Following Barro and Sala-I-Martin (1992), we consider a rival but non-excludable public good G in order to take the problem of congestion of the public good into account. In this case, the public good available to an individual entrepreneur is the ratio of total public purchases G to the aggregate private capital. Like Barro and Sala-I-Martin (1992), we define the number of entrepreneurs as n , K is the aggregate capital of entrepreneurs, A is the productivity parameter summarizing the level of technology and G is the public good. Entrepreneurs use their available per capita quantity of capital $k \in [0, +\infty)$ in the production sector. Following Lin and Yang (2001), the capital per person k is fixed and is equal for each entrepreneur, in a static setting. For simplicity, we assume that capital does not depreciate. Then, the production function of the good only depends on the capital, public good and the natural state which may occur: we consider $\alpha \in (0, 1)$ and $\delta \in (0, 1)$ such that production will be $y = Ak(G/K)^\alpha$ with a probability $(1 - \delta)$, while with a probability δ an adverse natural state will occur, production will not take place and the corresponding production will be $y = 0$. By definition, we can write $K = n \cdot k$, and the production function in the good natural state can be rewritten as $y = An^{-\alpha}k^{1-\alpha}G^\alpha$. Tax inspectors cannot invest in the production activity and earn a fixed salary $w \in [0, +\infty)$. Following Barro (1990), we assume that the public good is financed contemporaneously by a percentage η of tax revenues $E \in [0, +\infty)$ ³. The tax inspector, who checks whether tax payment is correct, is able to tell which of the two natural states have occurred for each entrepreneur. It is common knowledge that the tax inspector⁴ is corruptible, in the sense that s/he pursues her/his own interest and not necessarily that of the State; in other words, the tax inspector is open to bribery. The tax inspector, in the case of the “good” natural state and in exchange for a bribe $b \in [0, +\infty)$, can offer the entrepreneur the opportunity of reporting that the “bad” natural state has arisen. In this case, the entrepreneur could refuse to pay the bribe or agree to pay the bribe and negotiate the amount with the inspector. The State monitors entrepreneurs’ and tax inspectors’ behavior through controllers, in order to weed out or reduce corruption and fixes the level of the tax rate $t \in [0, 1]$ on the product y . Let $q \in [0, 1]$ be the exogenous monitoring level implemented by the State; then q is the probability of being detected, given that corruption has taken place. Following Allingham and Sandmo (1972), we assume that the entrepreneurs incur a punishment rate $c \in [0, 1]$ on unreported income⁵. In addition we consider that the

³Conversely, Blackburn et. al. (2006) assume that the public good is provided as a fixed proportion of output, while revenues consist of the tax collected by the bureaucrat from high-income households, plus any fines imposed on the bureaucrat detected in a corrupt transaction.

⁴We assume that an entrepreneur is seen by only one inspector and cannot turn to other inspectors to be treated differently.

⁵Conversely, Yitzhaki (1974) first consider the penalty as a proportion of the amount of evaded taxes, Caballé and Panadés (2007) show that when penalties are imposed proportionally to the amount of evaded taxes, the rate of capital accumulation cannot increase with the tax rate, while if the penalties are imposed

entrepreneurs are not homogeneous agents, and to be more precise, the j -th entrepreneur attributes a subjective value c_j to the objective punishment – depending on her/his own “shame effect” – when the corrupt transaction is detected⁶. The entrepreneur, if detected, must pay taxes ty , her/his “shame cost”, but s/he is refunded the cost of the bribe paid to the tax inspector⁷.

2.1 The game: description and solution

Given the new assumptions, the Cerqueti and Coppier (2009) game becomes the following two-period game. In what follows, we refer to the entrepreneur payoff by a superscript (1) and to the inspector payoff by a superscript (2): they represent respectively the first and the second element of the payoff vector $\underline{\pi}_i = (\pi_i^{(1)}, \pi_i^{(2)})$, $i = 1, 2$.

- (1) At stage one, 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 may ask for the bribe b^d and 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 game ends without corruption and with the following payoff vector:

$$(1) \quad \underline{\pi}_1 = (An^{-\alpha}G^\alpha k^{1-\alpha}(1-t), w).$$

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

- (2) At stage two, the entrepreneur decides whether to negotiate the bribe or not.

- (2.1) If the entrepreneur refuses the bribe, then the payoff vector is given by $\underline{\pi}_1$ defined as in (1). Then in this case, the game ends. There is no penalty for the tax inspector.

- (2.2) If the entrepreneur decides to agree to pay the bribe, the negotiation starts and the two parties will negotiate the bribe. In this case, the payoffs will depend on whether the inspector and the entrepreneur are detected (with probability q) or not detected (with probability $(1-q)$). There is no penalty for the tax inspector who is detected⁸. In this case, the game ends with corruption and evasion and the expected payoff vector is given by:

$$(2) \quad \underline{\pi}_2 = (An^{-\alpha}G^\alpha k^{1-\alpha}(1-qt - c_jq) - (1-q)b, w + (1-q)b)$$

on the amount of unreported income, the amount of income concealed increases with the tax rate.

⁶In fact, as Alm and Torgler (2006) said, if taxpayers values are influenced by cultural factors, then tax morale may be an important determinant of taxpayer compliance and other forms of behavior.

⁷This assumption can be more easily understood when, rather than corruption, there is extortion by the tax inspector, even though, in many countries, the relevant provisions or laws stipulate that the bribe shall, in any case, be returned to the entrepreneur, and that combined minor punishment, (penal and/or pecuniary), be inflicted to her/him.

⁸The results do not depend on the existence of a cost for the tax inspector who is corrupt and detected.

We first determine the equilibrium bribe b^{NB9} .

Proposition 2.1. *Let $q \neq 1$. Then there exists a unique non negative bribe (b^{NB}), as the Nash solution to a bargaining game, given by:*

$$(3) \quad b^{NB} = \mu \left[An^{-\alpha} G^\alpha k^{1-\alpha} \left(t - \frac{qc_j}{1-q} \right) \right].$$

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 which can be interpreted as the bargaining strength measures of the entrepreneur and the tax inspector respectively.

We assume that the tax inspector and the entrepreneur share the surplus on an equal basis, arriving at the standard Nash case, when $\varepsilon = \beta = 1$. In this case the bribe is:

$$(4) \quad b^{NB} = \frac{1}{2} \left[An^{-\alpha} G^\alpha k^{1-\alpha} \left(t - \frac{qc_j}{1-q} \right) \right].$$

In other words, the bribe represents 50 percent of the saving which comes from not paying taxes, net of the entrepreneur's "shame cost", if s/he is found out.

In this case, the payoff vector is given by:

$$(5) \quad \underline{\pi}_4 = \left(An^{-\alpha} G^\alpha k^{1-\alpha} \left(1 - \frac{qt + t + c_j q}{2} \right), w + An^{-\alpha} G^\alpha k^{1-\alpha} \cdot \frac{t - qt - c_j q}{2} \right).$$

By solving the static game, we can prove the following proposition:¹⁰

Proposition 2.2. *Let $0 \leq \frac{t(1-q)}{q} = c^* \leq 1$. Then,*

- (a) *if $c_j \in [0, c^*)$ the j -th entrepreneur will find it worthwhile to be corrupt and then the game ends with the payoff vector $\underline{\pi}_4$;*
- (b) *if $c_j \in [c^*, 1]$ the j -th entrepreneur will find it worthwhile to be honest and then the game ends with the payoff vector $\underline{\pi}_2$.*

The threshold c^* can be interpreted as an *honesty threshold*.

This assumption about c^* in Proposition 3.1 holds true when we assume the existence of a minimal threshold of monitoring activity

$$(6) \quad q^\circ := \frac{t}{1+t}.$$

Thus, the honesty threshold c^* is well defined when $q \geq q^\circ$, e.g. the monitoring level is great enough. We will suppose $q \geq q^\circ$ in the remaining part of the paper.

Tax revenues depend on the hypothesis made about the distribution of the "shame cost": if the specific j -th "shame cost" is lower than c^* , the entrepreneur finds it worthwhile to evade all taxes; vice versa, if the j -th entrepreneur's "shame cost" is greater than c^* , then

⁹See Appendix A for the proof.

¹⁰See Appendix B for the proof.

the entrepreneur will be honest.

The cumulative probability density defines the distribution of individual costs $F(c_j)$, where j is the specific entrepreneur. The fraction of corrupted entrepreneurs, i.e. with a “shame cost” $c_j \leq c^*$, is given by $F(c^*)$; analogously, the fraction of honest entrepreneurs, with a “shame cost” $c_j > c^*$, is given by $1 - F(c^*)$.

On an aggregate level, the tax 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 a “shame cost” which leads them to be honest, and those who are corrupt, but are discovered in the act of corruption:

$$(7) \quad E(t, q) = An^{-\alpha}G^\alpha k^{1-\alpha}tF(c^*)(1 - \delta)q + An^{-\alpha}G^\alpha k^{1-\alpha}t(1 - F(c^*))(1 - \delta).$$

We assume that the amount of public good G is a proportion $\eta \in (0, 1)$ of tax revenues, thus $\eta E(t, q) = G$. The shape of the function F gives good information about the general level of entrepreneurs honesty. We analyze three cases, in order to describe three different types of entrepreneur behavior.

- *F symmetric and uniform: “uniform shame” countries.*

In this case, the entrepreneurs are assumed to be uniformly distributed between the honest and the corrupt. The sense of shame varies accordingly to an uniform distribution, i.e.

$$(8) \quad F(c) = c, \quad \forall c \in [0, 1].$$

By substituting c^* with its expression in (7), a straightforward computation allows us to rewrite $E(t, q)$ as follows:

$$(9) \quad E(t, q) = (1 - \delta)An^{-\alpha}G_U^\alpha k^{1-\alpha}t \left[\frac{(1 + q)(1 - q)t}{q} - 1 \right].$$

By solving $\eta E(t, q) = G_U$, we find:

$$(10) \quad G_U = \left[\eta(1 - \delta)An^{-\alpha}k^{1-\alpha}t \left(\frac{(1 + q)(1 - q)t}{q} - 1 \right) \right]^{\frac{1}{1-\alpha}}.$$

- *F asymmetric to the left: “low shame” countries.*

The number of corrupt entrepreneurs is assumed to be greater than that of the honest. From the probability distributions with support in $[0, 1]$, we choose a particular Kumaraswamy-type law as follows.

$$(11) \quad F(c) = 1 - (1 - c)^2, \quad \forall c \in [0, 1].$$

As in the previous case, we substitute c^* with its expression in (7) and rewrite $E(t, q)$ as follows:

$$(12) \quad E(t, q) = (1 - \delta)An^{-\alpha}tk^{1-\alpha}G_L^\alpha \left\{ (q + 1) \left[1 - \left(1 - \frac{t(1 - q)}{q} \right)^2 \right] - 1 \right\}.$$

By solving $\eta E(t, q) = G_L$, we have:

$$(13) \quad G_L = \left[\eta(1 - \delta) A n^{-\alpha} t k^{1-\alpha} \left\{ (q + 1) \left(1 - \left(1 - \frac{t(1-q)}{q} \right)^2 \right) - 1 \right\} \right]^{\frac{1}{1-\alpha}}.$$

- *F asymmetric to the right: "high shame" countries.*

This is the converse case with respect to the previous one. The number of honest entrepreneurs is greater than that of the corrupt. Also in this case, we synthesize the costs with a Kumaraswamy-type law as follows.

$$(14) \quad F(c) = 1 - (1 - c^2) = c^2, \quad \forall c \in [0, 1].$$

We rewrite $E(t, q)$ in (7) as follows:

$$(15) \quad E(t, q) = (1 - \delta) A n^{-\alpha} t k^{1-\alpha} G_R^\alpha \left\{ (q + 1) \left(\frac{t(1-q)}{q} \right)^2 - 1 \right\}.$$

By solving $G_R = \eta E(t, q)$ we have

$$(16) \quad G_R = \left[\eta(1 - \delta) A n^{-\alpha} t k^{1-\alpha} \left\{ (q + 1) \left(\frac{t(1-q)}{q} \right)^2 - 1 \right\} \right]^{\frac{1}{1-\alpha}}.$$

The solutions G 's explicitly derived in (10), (13) and (16) will be denoted hereafter with $G^*(t, q, k)$ with the subscripts U, L, R , to highlight the explicit dependence with respect to t, q and k and maintain an explicit reference to the level of corruption of the country.

3 Dynamic Analysis

The game perspective is now expanded to review the consequences of the tax rate on dynamic revenues and on economic growth. The entrepreneur can use her/his payoff $\pi_i^{(1)}$, $i = 1, 2$, either to consume or invest. We consider a simple constant elasticity utility function:

$$(17) \quad U = \frac{C^{1-\sigma} - 1}{1 - \sigma}$$

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

$$(18) \quad \max_{c \in \mathbb{R}^+} \int_0^\infty e^{-\rho t} U(C) dt$$

sub

$$(19) \quad \dot{k} = \pi_i^{(1)} - C, \quad i = 1, 2.$$

where C is per capita consumption, ρ is the discount rate in time, and $\pi_i^{(1)}$ is the payoff for the entrepreneur.

We now substitute the values $G^*(t, q, k)$'s in the equilibria with corruption and without corruption (see Proposition 3.1). Indeed, since the return on the investment for the entrepreneur is different in each of the two equilibria found (with $-\pi_2^{(1)}$ – and without corruption $\pi_1^{(1)}$), the problem is solved for the two cases.

By solving the dynamic game, we can prove the following proposition:¹¹

Proposition 3.1. *Let $0 \leq c^* \leq 1$ defined as in Proposition 3.1. Then,*

(a) *if $c_j \leq c^*$ the growth rate, for the j -th entrepreneur, is*

$$(20) \quad \gamma_j^C = \frac{1}{\sigma} \left\{ An^{-\alpha} [G^*(t, q, k)]^\alpha k^{-\alpha} \left(1 - \frac{qt + t + c_j q}{2} \right) - \rho \right\};$$

(b) *if $c_j > c^*$ the growth rate, for the j -th entrepreneur, is*

$$(21) \quad \gamma_j^{NC} = \gamma^{NC} = \frac{1}{\sigma} \left\{ An^{-\alpha} [G^*(t, q, k)]^\alpha k^{-\alpha} (1 - t) - \rho \right\},$$

where the G^* 's have to be intended with the subscripts U, L, R .

Equilibrium depends, therefore, on the individual “shame cost”:

- for a given tax rate t , the entrepreneurs with a “shame cost” of $c_j \leq c^*$, will find it worthwhile to be corrupt and so their optimal equilibrium will be with corruption. In such an equilibrium, the j -th entrepreneur will obtain a growth rate of γ_j^C ;
- for a given level of tax rate t , entrepreneurs with a “shame cost” $c_j > c^*$ will find it worthwhile to be honest and their optimal equilibrium will be without corruption. In such an equilibrium, the j -th entrepreneur will obtain a growth rate of γ^{NC} .

It may be further demonstrated that capital and income also have the same growth rate of consumption and, therefore, equilibrium without corruption, from the dynamic viewpoint, is the equilibrium which allows greater economic growth¹². In addition, since the tax rate influences the accumulation of capital, the provision of the public good and, as a consequence, economic growth, it will also increase fiscal revenues at a steady state. We would like to remind readers that the static tax revenues are (7):

$$E(t, q) = An^{-\alpha} G^\alpha k^{1-\alpha} t F(c^*) (1 - \delta) q + An^{-\alpha} G^\alpha k^{1-\alpha} t (1 - F(c^*)) (1 - \delta).$$

In a steady state, the growth rate of tax revenues should also be constant and, therefore, $E(t, q)$ and k grow at the same rate. Indeed, lower revenues today due to evasion, can bring

¹¹See Appendix C for the proof.

¹²In fact, at a steady state, everything grows at the same rate and therefore $\frac{\dot{k}}{k}$ is constant. At equilibrium with corruption we know that $\frac{\dot{k}}{k} = \frac{An^{-\alpha} [G^*(t, q, k)]^\alpha k^{-\alpha} [2-t(1+q)] - \frac{qc_j}{2} - \frac{C}{k}}{2}$. Since $\frac{\dot{k}}{k}$ is constant, then the difference between both terms on the right should also be constant, and because A, n, α, c_j, q and t are constant and $G_U^*(t, q, k) \sim G_L^*(t, q, k) \sim G_R^*(t, q, k) \sim k$, then C and k should grow at the same rate. Similarly, since $y = a[G^*(t, q, k)]^\alpha k^{1-\alpha}$, at a steady state, income grows at the same rate as capital. The same applies in the case of equilibrium without corruption.

greater growth through greater capital accumulation and, consequently, greater revenues tomorrow.

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

Define ξ the fraction of honest entrepreneurs. In the equilibrium with corruption there will be $(1 - \xi)$ entrepreneurs, each with her/his own growth rate γ_j^C , in the equilibrium without corruption there will be ξ entrepreneurs, each with the same growth rate γ^{NC} .

We perform the distinction for the “shame costs” introduced in the previous section.

At the aggregate level, we can prove the following proposition:¹³

Proposition 3.2. *The aggregate growth rate is:*

- *F symmetric and uniform: “uniform shame” countries*

(22)

$$\gamma_U(t, q) = \frac{1}{\sigma} \left\{ An^{-\alpha} k^{-\alpha} [G_U^*(t, q, k)]^\alpha \left[\frac{c^* t(q-1) - t(q+1) + 1}{2} \right] - \rho - \frac{t^2(1-q)^2}{4q} \right\};$$

- *F asymmetric to the left: “low shame” countries*

(23)

$$\gamma_L(t, q) = \frac{1}{\sigma} \left\{ An^{-\alpha} k^{-\alpha} [G_L^*(t, q, k)]^\alpha \left[\frac{(1 - (1 - c^*)^2)t(q-1) - t(q+1) + 1}{2} \right] - \rho - \frac{t^2(1-q)^2}{4q} \right\};$$

- *F asymmetric to the right: “high shame” countries*

(24)

$$\gamma_R(t, q) = \frac{1}{\sigma} \left\{ An^{-\alpha} k^{-\alpha} [G_R^*(t, q, k)]^\alpha \left[\frac{(c^*)^2 t(q-1) - t(q+1) + 1}{2} \right] - \rho - \frac{t^2(1-q)^2}{4q} \right\}.$$

We would now like to provide a sensitivity analysis of γ with respect to t and q .

We proceed by performing a numerical analysis of the behavior of γ with respect to t and q , since the complexity of the dynamics involved does not allow closed-form results. Hence, a more intuitive description of the real situation is also provided.

We refer to the cases discussed above, with low, high and middle shame countries. We set $\delta = 0.5$, $\sigma = 0.5$, $\rho = 0.03$, $\eta = 0.5$, $n = 10$, $k = 1$ and three different values for the technology parameter $A = 0.5; 1; 2$.

We can detect four different effects in the behavior growth rate both of the income and of tax revenues with respect to t .

- (1) As the tax rate increases, the remaining number of honest individuals pay more taxes and so accumulate less, depressing growth.
- (2) As the tax rate increases, the number of dishonest entrepreneurs increases and, therefore, growth increases inasmuch as the number of undiscovered corrupt entrepreneurs increases. The corrupt entrepreneur now pays a bribe and the bribe is lower than the tax amount s/he would have paid if s/he had remained honest. A greater amount of resources will be allocated to investment and generate higher growth.

¹³See Appendix D for the proof.

- (3) As the tax rate increases, the number of dishonest entrepreneurs increases and, therefore, growth is reduced inasmuch as the number of discovered corrupt entrepreneurs increases. The newly corrupt entrepreneur, when discovered (as s/he will be forced to pay taxes but will receive the bribe back), is tantamount to an entrepreneur whose tax burden has increased.
- (4) As the tax rate increases, then the amount of public good G^* , obtained via balance constraints, increases as well, and so does the growth rate.

If we take into account the behavior of the growth rate with respect to q , three different remarks can be detected.

- (1') As the monitoring level increases, the remaining number of corrupt individuals are easily detected and pay more taxes. So they accumulate less, depressing growth.
- (2') As the monitoring level increases, the number of honest entrepreneurs increases and, therefore, the tax revenues increase, reducing capital accumulation and consequently economic growth.
- (3') As the monitoring level increases, then G^* increases. As a consequence, the growth rate increases.

In order to discuss how the behavior of growth rate changes as a consequence of variations in the tax rate, we should vary the analysis depending on whether the level of monitoring is high or low. In particular, the effect of the tax rate on the growth rate is less relevant for growing values of q , and the growth rate has a very low sensitivity with respect to t when the monitoring value tends to 1. This is reasonable, since exasperate monitoring activity removes the differences between honest and corrupt individuals.

For very high levels of monitoring, the differences in behavior of the growth rate to changes of tax rate are very small. Specifically, in all three cases - low, middle and high- shame countries, the growth rate increases as the tax rate increases up to a threshold value, after which the growth rate begins to decrease as the tax rate increases. In fact, for low tax rates, the increase in growth due to (2) and (4) is stronger than the negative effect due to (1) and (3). Let us explain the meaning of this behavior: when the tax rate grows, the number of corrupted entrepreneurs detected who pay more taxes increases. Therefore, the provision of the public good grows and thus economic growth increases. Conversely, when the tax rate is high, the increase in growth due to (2) and (4) is weaker than the negative effect due to (1) and (3). In this case, the higher taxes paid by honest and by entrepreneurs who have been discovered, depress economic growth, via lower capital accumulation. When the monitoring level is high in all countries, the growth rate behaves analogously, even if, in the "low shame" countries (see Figure 1), this happens with more sensitivity with respect to the tax rate variations.

When the monitoring level is low, the behavior of the growth rate is very different compared to when the monitoring level is high. In particular, all countries show that, where a monitoring level q is fixed, the growth rate decreases with respect to the tax rate level, and this aspect becomes more relevant when t is high. The expansion due to (2) and (4) is less than the decrease in the growth rate due to (1) and (3). This result is grounded

on the fact that the tax revenues increase alongside the monitoring level, and a consequent reduction in economic growth takes place.

The three types of countries considered, however, differ in how the growth rate decreases with the increase in the tax rate: the rate of decrease is higher in “low shame” countries than in “high shame” countries. For “high shame” countries (see Figure 2), where a low monitoring level q is fixed, the growth rate decreases very slowly as the tax rate increases up to an intermediate level: after that level, the growth rate decreases at an increasing rate. This result can be interpreted as follows: if the population is generally honest, the honest and entrepreneurs detected in corrupt transactions who pay more taxes, depressing growth rate, are a limited phenomenon when compared to “low and middle shame” countries. In particular, in “low shame” countries, the decrease in the growth rate becomes very pronounced from lower levels of the tax rate. This result derives from the fact that, in a very corrupt country, as the tax rate increases, the number of entrepreneurs detected in corruption grows consistently. Therefore, the tax revenues increase, depressing the growth rate consistently.

The analysis of the behavior of the growth rate with respect to q agrees with previous results. In particular, when a tax rate is fixed, the behavior of the growth rate is very different depending on whether the tax rate is low or high. For a low tax rate level, the growth rate is roughly constant with the level of the monitoring: the growth rate does not depend on the monitoring activity. We have an equilibrium situation, where the aggregate negative effects of (1') and (2') balance the expansion of the growth due to (3') perfectly.

When a high tax rate t is fixed, the growth rate increases with respect to the monitoring activity level. The positive effect (3') is greater than the tendency to depression due to (1') and (2'). We interpret these findings by noticing that the most important effect of monitoring activity is to increase the amount of the public goods due to greater tax revenues.

If we rely on technology parameter A we have that, *ceteris paribus*, when we consider A higher, the growth rate surface behaviors described above are amplified and the values of the growth rates are bigger when A is higher, since the growth rate increases when entrepreneurs invest their resources. The argument of the amplification of the effects due to a greater value of A applies hereafter, for the entire set of numerical analyses we will perform throughout the paper. Figures 1 and 2 refer to the case of $A = 2$.

We now analyze the corner-solutions. In particular, we focus on the extremal values of the monitoring activity level q and of the tax rate t .

- If $t = 0$, then there are no tax revenues for the country. The public good derived from tax revenues is therefore null, economic analysis becomes trivial and quite senseless.
- If $t = 1$, then the entire amount of each entrepreneur's production goes to the State. The presence of a monitoring activity level $q > q^o$ prevents the mass of entrepreneurs from becoming corrupt: indeed, in this case $c^* = \frac{1-q}{q} \in (0, 1)$. A closed-form analysis is not suitable, and we prefer to proceed numerically, by adopting the same set of parameters used in the global analysis performed above. Figure 3 shows our findings when $A = 2$. The growth rate increases with respect to q and it is concave in all situations of corruption within the countries. The positive effect (3') is more incisive than the negative impact on growth due to (1') and (2'). The most relevant effect of the monitoring activity is the large amount of public goods due to greater tax revenues.

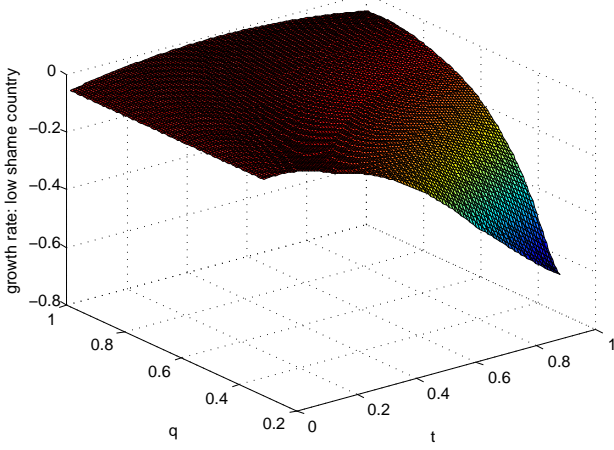


Figure 1: Growth rate in a "low shame" country

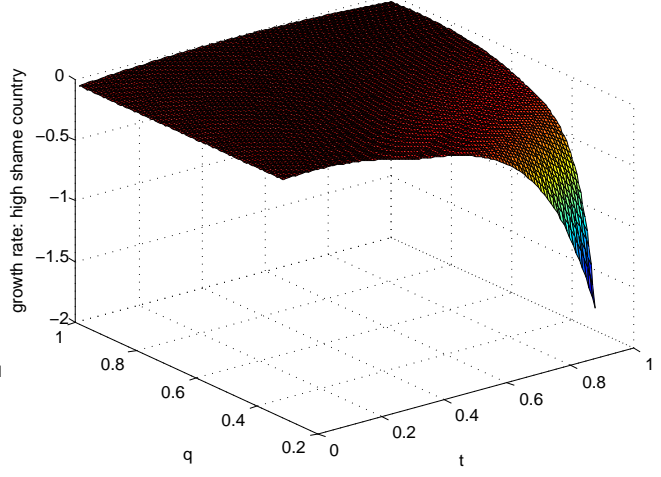


Figure 2: Growth rate in a "high shame" country

Nevertheless, as the monitoring activity level becomes bigger, an inverse tendency is observed, and the growth rate of the country stabilizes. We interpret this inversion by noticing that heavy tax rates and monitoring activities depress capital accumulation and, consequently, growth.

- If $q = 1$, then we have $c^* = 0$ i.e. the entire population is honest. The effects on the growth due to (2) and (3) disappear. In this case

$$G^*(t, 1, k) = G_U^*(t, 1, k) = G_L^*(t, 1, k) = G_R^*(t, 1, k) = [-\eta(1 - \delta)An^{-\alpha}k^{1-\alpha}t]^{\frac{1}{1-\alpha}}$$

and

$$\gamma(t, 1) = \gamma_U(t, 1) = \gamma_L(t, 1) = \gamma_R(t, 1) = \frac{1}{\sigma} \left\{ An^{-\alpha}k^{-\alpha}[G^*(t, 1, k)]^\alpha \left[\frac{1-2t}{2} \right] - \rho \right\}.$$

By applying the first order condition, we find a threshold for the tax rate $t_1^* = \alpha/2$ such that

$$(25) \quad \begin{cases} t \leq t_1^* & \Rightarrow \frac{\partial}{\partial t} \gamma(t, 1) > 0; \\ t > t_1^* & \Rightarrow \frac{\partial}{\partial t} \gamma(t, 1) < 0. \end{cases}$$

If the tax rate is low enough (below the critical threshold t_1^*), then the positive effect on growth due to (4) is more relevant than the negative effect due to (1). This behavior inverts for t greater than t_1^* . The economic key is grounded on two arguments: for low tax rates, capital accumulation is high for low tax rates, even when the State monitors actively. As a consequence, the country's growth increases. Conversely, when

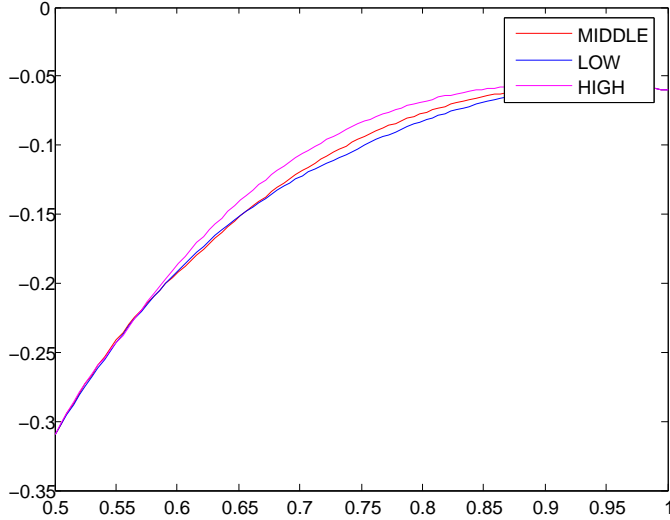


Figure 3: Growth rate when $t=1$

the monitoring activity is strong and the tax rate is high, then capital accumulation reduces, and growth reduces as well, even if the amount of public goods increases. We notice that the tax rate threshold t_1^* goes hand in hand with production y , since it is proportional to the parameter α .

- If $q = q^\circ$, then we have $c^* = 1$, and the entire population is corrupt. Also in this case, we prefer to proceed via numerical simulation, to provide a more intuitive analysis. The usual parameter set is used. Figure 4 shows our findings for $A = 2$. The growth rate decreases with respect to the tax rate t . Since the mass of the population is corrupt, the negative effect on growth due to (1) vanishes. Therefore, the negative term (3) is more evident than the positive effects due to (2) and (4). The growing number of individuals detected as corrupt pay more taxes as t increases, and this depresses capital accumulation and growth. The growth rate of tax revenues depends positively on economic growth in the sense that greater growth implies, all the rest being equal, greater revenues and negatively on corruption in that greater corruption implies, all the rest being equal, lower revenues. It follows that the policy maker must put different policies into action if s/he wants to maximize the growth rate in a “high shame” country or in a “low–uniform shame” country: a country with a high sense of honesty can set a medium-high rate before seeing substantial reductions in their tax revenues, while if the country has low “inner honesty”, the State must fix a very low tax rate in order to avoid a relevant reduction in the amount of tax collected.

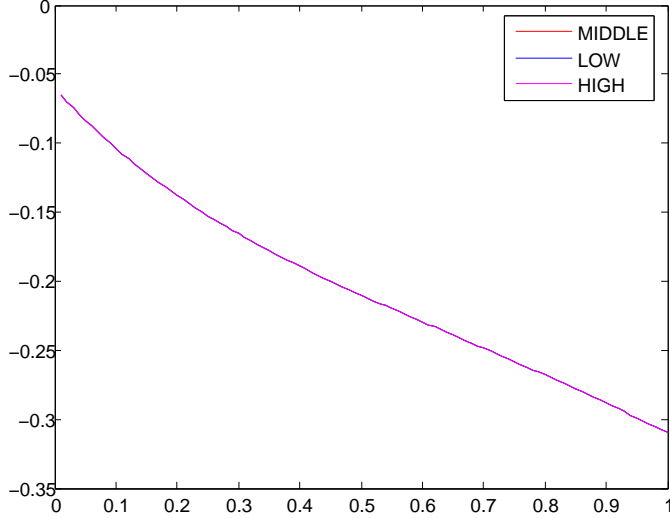


Figure 4: Growth rate when $q = q^\circ$

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:

$$(26) \quad b^{NB} = \mu \left[An^{-\alpha} [G^*(t, q, k)]^\alpha k^{1-\alpha} \left(t - \frac{qc_j}{(1-q)} \right) \right].$$

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

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

$$(27) \quad \frac{\partial b^{NB}}{\partial \mu} = An^{-\alpha} [G^*(t, q, k)]^\alpha k^{1-\alpha} \left(t - \frac{qc_j}{(1-q)} \right) > 0$$

Increasing the bargaining power of the tax inspector increases the bribe which s/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, the number of corrupt entrepreneurs is not dependent on the parameters β and ε . On the contrary, such parameters affect any rates of income growth 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 Proposition 3.1, we see that if $c_j > c^*$, the growth rate for the j -th

entrepreneur is:

$$(28) \quad \gamma^{NC} = \frac{1}{\sigma} [An^{-\alpha}(1-t)[G^*(t, q, k)]^\alpha k^{-\alpha} - \rho]$$

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

$$(29) \quad \gamma_j^C = \frac{1}{\sigma} [An^{-\alpha}[G^*(t, q, k)]^\alpha k^{-\alpha}[1 - \mu t + q(t + c_j)(\mu - 1)] - \rho].$$

As a result, the aggregate growth rate will also be affected by the bargaining strength of the inspector and the evader. We denote it as $\gamma(\mu)$. In particular, the aggregate growth rate is linear with respect to μ .

We can detect two opposite effects in the behavior growth rate both of the income and of tax revenues with respect to μ :

- (1'') As the bargaining strength of the inspector increases, the entrepreneur must give a greater share of evasion to corruption, i.e. to the tax inspector. In this case, *ceteris paribus*, as the bargaining strength of the inspector increases, a lesser amount of resources will be allocated to investment and generate lower growth;
- (2'') As the bargaining strength of the inspector increases, the entrepreneur is able to transfer a greater part (μqc_j) of her/his "shame cost" to the tax inspector. In this case, *ceteris paribus*, as the bargaining strength of the inspector increases, a greater amount of resources will be allocated to investment and generate higher growth.

In order to describe the constant rate of decay of $\gamma(\mu)$, we introduce the subscripts U, L, R and proceed numerically adopting the usual parameter set.

- "Middle shame" countries

$$\gamma'_U(\mu) = \frac{1 - c^*}{\sigma} \cdot An^{-\alpha}[G_U^*(t, q, k)]^\alpha k^{-\alpha} t(q - 1) + \frac{q(c^*)^2}{2\sigma}.$$

- "Low shame" countries

$$\gamma'_L(\mu) = \frac{(1 - c^*)^2}{\sigma} \cdot An^{-\alpha}[G_U^*(t, q, k)]^\alpha k^{-\alpha} t(q - 1) + \frac{q(c^*)^2}{2\sigma}.$$

- "High shame" countries

$$\gamma'_L(\mu) = \frac{(c^*)^2}{\sigma} \cdot An^{-\alpha}[G_U^*(t, q, k)]^\alpha k^{-\alpha} t(q - 1) + \frac{q(c^*)^2}{2\sigma}.$$

In the three cases, the same findings are obtained, and Figure 5 shows our results for $A = 2$. We see that the growth rate does not increase at all when the monitoring level is high and the tax rate is low. In contrast, the growth rate increases with respect to the parameter μ

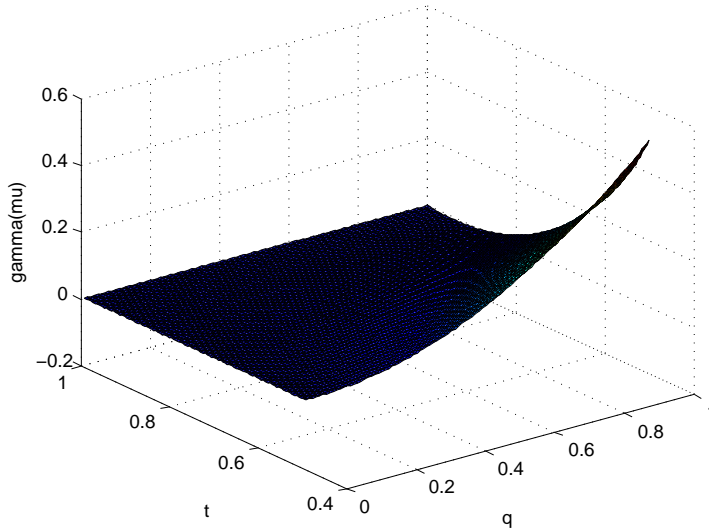


Figure 5: Growth rate(μ)

when either the monitoring level or the tax rate are high. In this case, the aggregate effect of (1'') is weaker than the positive effect due to (2''). Therefore, as the bargaining strength of the inspector increases, the growth rates increases as well.

This result is compatible with the economic evidence that, when the tax rate and the monitoring activity level are high enough, a proportion of a country's surplus going towards incentivizing the action of tax inspectors has a positive impact on the country's growth rate. The size of such a positive impact varies according to the tax rate which has been applied, the capital productivity, the monitoring level and the marginal utility elasticity. Even if the presence of a part of surplus for the inspectors subtracts resources from the entrepreneurs' investments, the larger amount of taxes paid under a stronger monitoring regime allows for a larger amount of public goods via balance constraints, and this, in turn, permits growth to become higher.

4 Conclusions

The present paper provides a study of the problem of the optimal tax rate, where there is corruption. In this paper, we have extended the static analysis of Cerqueti and Coppier (2009), in a dynamic context, incorporating the presence of a public sector. Like Ellis and Fender (2006), we introduce endogenous corruption into a variant of the Ramsey growth model where a government taxes private producers and uses the resources to either supply public capital. Our model is different from theirs, in that we deal with fiscal rather bureaucratic corruption. We show, that the relationship between the tax rate and tax

revenues depends not only on the dynamic or static context, but also on the “inner honesty” of society. In fact, like Dell’Anno (2009), we analyze a dynamic model, where the aggregate tax evasion is microfounded on non-pecuniary costs and we prove that the relationship between the tax rate and tax collection is not unique but is different depending on the relevance of the “shame effect”. In a long run analysis, given the basic tenet of our model that evasion on one hand stimulates investment, accumulation and thereby growth but, on the other hand, reduces tax revenues and therefore the provision of the public good, the optimal tax rate depends on “shame costs”. We show that growth rates - both of income and of tax revenues - decrease, as the tax rate increases, for all types of “shame effect” countries but they differ in how the growth rate decreases as the tax rate increases: the rate of decrease is higher in “low shame” countries than in “high shame” countries. It follows that the policy maker must put different policies into action if s/he wants to maximize the growth rate in a “high shame” country or in a “low-uniform shame” country: a country with a high sense of honesty can set a medium-high rate before seeing substantial reductions in their tax revenues while, in a country with low “inner honesty”, the State must fix a very low tax rate in order to avoid a relevant reduction in tax revenues. This result is different from the U-shaped curve between growth rate and tax rate shown by Lin and Yang (2001), as they simply consider public consumer goods and then economic growth can increase as the tax rate increases because resources are diverted from the unproductive public sector to the productive private sector. In addition, we find that a high probability of auditing increases the growth rate; conversely, Chen (2003) finds that this measure has ambiguous effect on economic growth, due mainly to its indirect effect upon tax compliance and the tax rate.

A Appendix: The Nash Bargaining bribe

Let $\pi_\Delta = \pi_2 - \pi_1 = (\pi_\Delta^{(1)}, \pi_\Delta^{(2)})$ be the vector of the differences in the payoffs between the case of agreement and disagreement about the bribe, between inspector and entrepreneur. In accordance with generalized Nash bargaining theory, the division between two agents will solve:

$$(30) \quad \max_{b \in \mathbb{R}^+} [\pi_\Delta^{(1)}]^\beta \cdot [\pi_\Delta^{(2)}]^\varepsilon$$

in formula

$$(31) \quad \max_{b \in \mathbb{R}^+} [An^{-\alpha}G^\alpha k^{1-\alpha}(t - tq - c_jq) - (1 - q)b]^\beta [w + (1 - q)b - w]^\varepsilon$$

that is the maximum of the product between the elements of π_Δ and where $[An^{-\alpha}G^\alpha k^{1-\alpha}(1 - t), w]$ 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 which comes from not paying taxes, net of “shame cost”, which awaits the entrepreneur if s/he is found out: $\tau = An^{-\alpha}G^\alpha k^{1-\alpha} \left(t - \frac{qc_j}{(1-q)} \right)$.

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

$$(32) \quad b^{NB} = \mu \left[An^{-\alpha}G^\alpha k^{1-\alpha} \left(t - \frac{qc_j}{(1-q)} \right) \right]$$

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

B Appendix: Solution to the static game

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

$$(33) \quad \pi_2^{(1)} \geq \pi_1^{(1)} \Rightarrow$$

$$\left[An^{-\alpha}G^\alpha k^{1-\alpha} \left[1 - \frac{t(1+q)}{2} \right] - \frac{kqc_j}{2} \right] \geq An^{-\alpha}G^\alpha k^{1-\alpha}(1 - t) \Rightarrow$$

$$(34) \quad \Rightarrow t \geq \frac{qc_j}{An^{-\alpha}G^\alpha k^{1-\alpha}(1 - q)} = t^*$$

(1) Going up the decision-making tree, at stage one the tax inspector decides whether to ask for a positive bribe or not.

- Let $t \geq t^*$ defined in (34). Then the tax inspector knows that if s/he asks for a positive bribe, the entrepreneur will agree to negotiate and the final bribe will be b^{NB} . Then at stage one, the tax inspector asks for a bribe if, and only if

$$(35) \quad \begin{aligned} & \pi_2^{(2)} > \pi_1^{(2)} \Rightarrow \\ & \Rightarrow w + \frac{An^{-\alpha}G^\alpha k^{1-\alpha}t(1-q)}{2} - \frac{qkc_j}{2} > w \end{aligned}$$

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

- Let $t < t^*$. Then the tax inspector knows that the entrepreneurs will not accept any possible bribe, so s/he will be honest and will ask the entrepreneurs for tax payment.

C Appendix: Solution to the dynamic game

In the equilibrium with corruption, the entrepreneur's profit is:

$$(36) \quad \pi_2^{(1)} = An^{-\alpha}[G^*(t, q, k)]^\alpha k^{1-\alpha} \left(1 - \frac{qt + t + c_j q}{2}\right)$$

thus the constraint is:

$$(37) \quad \dot{k} = An^{-\alpha}[G^*(t, q, k)]^\alpha k^{1-\alpha} \left(1 - \frac{qt + t + c_j q}{2}\right) - C$$

The Hamiltonian function is:

$$(38) \quad H = e^{-\rho t} \frac{C^{1-\sigma} - 1}{1-\sigma} + \lambda \left[An^{-\alpha}[G^*(t, q, k)]^\alpha k^{1-\alpha} \left(1 - \frac{qt + t + c_j q}{2}\right) - C \right]$$

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

$$(39) \quad e^{-\rho t} C^{-\sigma} - \lambda = 0$$

and

$$(40) \quad \dot{\lambda} = -\lambda \left\{ An^{-\alpha}[G^*(t, q, k)]^\alpha k^{-\alpha} \left(1 - \frac{qt + t + c_j q}{2}\right) \right\}$$

By the first condition, the consumption growth rate is obtained:

$$(41) \quad \gamma_{c_j}^C = \frac{1}{\sigma} \left\{ An^{-\alpha}[G^*(t, q, k)]^\alpha k^{-\alpha} \left(1 - \frac{qt + t + c_j q}{2}\right) - rho \right\}.$$

In the equilibrium without corruption, the entrepreneur's profit is:

$$(42) \quad \pi_1^{(1)} = An^{-\alpha}[G^*(t, q, k)]^\alpha k^{1-\alpha}(1-t)$$

Thus the constraint is:

$$(43) \quad \dot{k} = An^{-\alpha}[G^*(t, q, k)]^\alpha k^{1-\alpha}(1-t) - C$$

The Hamiltonian function is:

$$(44) \quad H = e^{-\rho t} \frac{C^{1-\sigma} - 1}{1-\sigma} + \lambda [An^{-\alpha}[G^*(t, q, k)]^\alpha k^{1-\alpha}(1-t) - C]$$

Optimization provides the consumer growth rate:

$$(45) \quad \gamma^{NC} = \frac{1}{\sigma} \{ An^{-\alpha}[G^*(t, q, k)]^\alpha k^{-\alpha}(1-t) - \rho \}.$$

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 the equilibrium with corruption, there will be $(1 - \xi)$ entrepreneurs while at the equilibrium without corruption, there will be ξ entrepreneurs.

At the equilibrium without corruption, the growth rate γ^{NC} in (45) is independent of reputation costs and will therefore be equal for each entrepreneur with reputation costs $c_j > c^*$; at the equilibrium with corruption, the growth rate γ_j^C in (41) is dependent on reputation costs for which reason each entrepreneur, with a reputation cost of $c_j \leq c^*$, will have a different growth rate. Thus

$$(46) \quad \begin{aligned} \gamma(t, q) = & (1 - \xi) \frac{1}{\sigma} \left\{ An^{-\alpha}[G^*(t, q, k)]^\alpha k^{-\alpha} \left(1 - \frac{qt+t}{2} \right) - \rho \right\} - \frac{1}{2\sigma} \left[q \int_0^{c^*} c_j dc_j \right] + \\ & + \xi \cdot \frac{1}{\sigma} \{ An^{-\alpha}[G^*(t, q, k)]^\alpha k^{-\alpha}(1-t) - \rho \}. \end{aligned}$$

Substituting $\xi = F(c^*)$, where F has the three expressions in (8), (11) and (14) into (46) and after some simplifications we obtain the aggregate growth rate in the three cases.

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