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Effect of a punishing tax on economic growth, corruption, and welfare

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Oscar Afonso; Ana Maria Bandeira

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EFFECT OF A PUNISHING TAX ON ECONOMIC GROWTH, CORRUPTION, AND WELFARE

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>> RESUMO

Este artigo analisa o efeito da penalização da corrupção existente no seio dos negócios sobre o crescimento económico, o nível de corrupção e bem-estar social. Para tal, inclui-se a corrupção no modelo de crescimento endógeno induzido por progresso técnico horizontal, considerando que a penalização da corrupção deprime lucros. Esta penalização provoca uma realocação do trabalho da produção para atividades de R&D pelo que aumenta o progresso técnico, o crescimento económico e o bem-estar social assim como reduz o nível de corrupção. Os resultados teóricos estão em conformidade com os dados observados em 15 países da UE.

>> ABSTRACT

This paper analyses the steady-state effect of the business-corruption penalty on economic growth, corruption, and welfare. To that end, the base-line horizontal R&D-growth model is extended to include corruption, which is generated in intermediate goods production. Taxation on corruption depresses pro ts in production. However, as profits depend positively on the labor reallocation from production to R&D, whenever there is a labor reallocation to R&D, innovative activity, economic growth, and welfare are improved and corruption is reduced. Results are in line with the data observed for 15 EU countries.

Keywords: Horizontal growth model; Consumer's welfare; Corruption.
JEL Classification: O31, O33, E62, D73.

>> INTRODUCTION

The corruption has been analyzed by a large number of authors (e.g., Huang 2016; Li 2016; Gutmann and Lucas 2017; Lisciandra and Millemaci 2017) and most of them show that is counter-productive for countries' economic performance due to a variety of channels (Mauro 1995; Rose-Ackerman 1997; Jain 2001; Li 2016; Lisciandra and Millemaci 2017). Considering that countries' laws and regulations promote the efficient allocation of scarce inputs, corruption penalizes the economic activity

- by changing the allocation of scarce inputs (human and physical capital, and technology) direct effect;
- by distorting competition, by changing incentives, costs, prices, and available opportunities, by leading to less trust from society in organizations, by putting at risk democracy, and by generating weaker institutions indirect effects , which together decrease the level of investment that is crucial for, for example, the economic growth and the consumer's welfare (Mauro 1995; Borensztein et al. 1998; Mo 2001; Jain 2001; Cuervo-Cazurra 2008; Sumanjeet 2015; Stevens and Newenham-Kahindi 2018; Blanc et al. 2019). However, when countries' laws and regulations hamper the smooth running of the economy, corrupting can be positive (Bardhan 1997; Williams and Martinez-Perez 2016). Thus, within the existing literature, there are also some studies that find no link between corruption and economic activity (e.g., Huang 2016) and there are even some other studies in which corruption benefits economic activity, by 'greasing the wheels' (Bangladesh, Paul 2010; South Korea, Huang 2016).[1]

In general, there are two main types of corruption business-corruption and government-corruption since it occurs when firms (business-corruption) or public officials (government-corruption) use and abuse of their power, thus acting outside the law and regulations, with the aim of gaining benefits. Countries that have higher levels of business-corruption are not necessarily the ones that have higher levels of government-corruption and vice-versa (Amir et al. 2019). Business-corruption is when the fraud and other illegal activities are performed in firms and is more perceived by the population in developed countries (Sumanjeet 2015; Zyglidopoulos et al. 2019). In turn, government-corruption is performed by government officials and is more

[1] The grease the wheels approach considers that corruption improves the country' economic growth when there are inefficiencies on the market created by incompetent bureaucratic and long-lasting processes that penalize the level of investment (Leys 1965; Moon and Sekkat 2005).

observed in less-developed countries (Amir et al. 2019). Since our focus is on developed countries, such as those belonging to the European Union (EU), here we just consider the business-corruption (hereinafter, corruption).

Often, firms choose locations knowing already that they will have to offer a bribe to install itself there, seeing it has a tax that the firms have to pay if it wants to operate in that market (Sumanjeet 2015). It is believed that firms do it because they think that they will not be discovered (Zyglidopoulos et al. 2019). Specifically, in developed countries, firms also practice corruption to save their business in such a powerful competitive market (Amir et al. 2019), considering that corruption is efficient since, through corruption, can accelerate bureaucratic and often slow processes, and corruption is a way to avoid multifaceted and expensive protocols (Aidt 2003; Stevens and Newenham-Kahindi 2018). However, those that perform and cooperate with corruption want to maximize their profitability and, thus, they will ask for higher bribes instead of the efficient ones; moreover, to prolong the time of bureaucracy, they ask for even more bribe (Jain 2001).

Countries around the world present different levels of economic growth and consumer's welfare (hereinafter, welfare). There are two main reasons for these differences. The proximate causes, involving human and physical capital as well as technology, and the institutional causes, involving attributes and codes of behavior and thus the level of corruption (Nugroho at al. 2019). Institutions dictate the rules, such as norms and property rights, of each society and they decide how economic individuals behave (Mahmood 2019), imposing restraints that de ne how political, social and economic aspects will interact with each other (White el al. 2019). The level of corruption is thus associated with the quality of institutions such that different institutions generate different levels of corruption. Ceteris paribus, institutions may increase or decrease economic growth and welfare (Nugroho et al. 2019); for example, in a country where institutions protect technology rights and eliminate corruption, firms will be stimulated to invest more in R&D and that will improve economic growth and welfare (Sumanjeet 2015). In countries where corruption is relatively high, it is harder to control the practice of corruption (Aidt 2003). However, there are several measures that can be taken with the aim of making corruption less attractive. First, it is important to increase the degree of disclosure of corruption (Blanc et al. 2019). Second, related to the previous, it is crucial to increase transparency at an institutional level, such that firms have clear activities and procedures are open to everyone who wants to consult them, as well as make sure who practices corruption is accounted for it (Sumanjeet 2015); when institutions have high levels of transparency, corruption is smaller and markets function in a more efficient manner. Typically, there are lower levels of transparency in countries where there is a higher level of the population living at risk of poverty and where there is a higher absence of respect for human rights (Sumanjeet 2015). Third, it is required for the creation of stronger legal penalties for firms that are enrolled in corrupt activities (Aidt 2003). Fourth, the wages should be sufficiently high that officials will not have the temptation of practicing corruption (Aidt 2003).

To sum up, most of the existing studies focus on corruption in general and, ceteris paribus, conclude that it penalizes economic activity; isto é, without distinguishing between types of corruption and types of countries in which the different types of corruption occur, the literature focuses on the relationship between the level of corruption and the economic-growth rate and on the relationship between the level of corruption and the welfare. To the best of our knowledge, there are no studies that focus on business--corruption, mostly observed in developed countries, and on the effects of increasing the penalty of corruption on the level of corruption, the economic-growth rate, and the welfare. This is the purpose of this paper.

In this regard, according to data for the 15 EU countries in d'Agostino and Scarlato (2016, 2019), detailed in the Appendix,[2] there are indeed positive relationships between the penalty of corruption and the economic-growth rate (Figure 1a) and the welfare level (Figure 1c), and that there is a negative relationship between the penalty of corruption and corruption level (Figure 1b).

The analysis is performed bearing in mind the endogenous R&D-growth literature and, in particular, the baseline horizontal R&D-growth model (e.g., Romer 1990; Grossman and Helpman 1991; Barro and Sala-i-Martin 2004, Ch. 6). This literature gives us the appropriate setup for understanding the effects of the corruption penalty on economic growth, welfare level, and corruption level. The analysis is performed taking into account the profitability effect, which represents the loss in the profits of the intermediate-goods sector due to taxation, and the general-equilibrium effect, which is connected to the country's resource constraint. Hence, considering the endogenous horizontal R&D-growth literature, we propose a theoretical model modified to consider the intermediate goods used by the aggregate final good as a

[2] Following d'Agostino and Scarlato (2016, 2019), we restrict the analysis to a sub-set of 15 EU countries for which fully comparable data on corruption and control of corruption are available: Austria (AUT), Belgium (BEL), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Ireland (IRL), Italy (ITA), Luxemburg (LUX), the Netherlands (NLD), Portugal (PRT), Spain (ESP), Sweden (SWE), and the United Kingdom (GBR); we can state that the exclusion of more recent EU member countries is due to their different institutional background on corruption, which could bias the data comparability, as well as to data limitations.

Figure 1

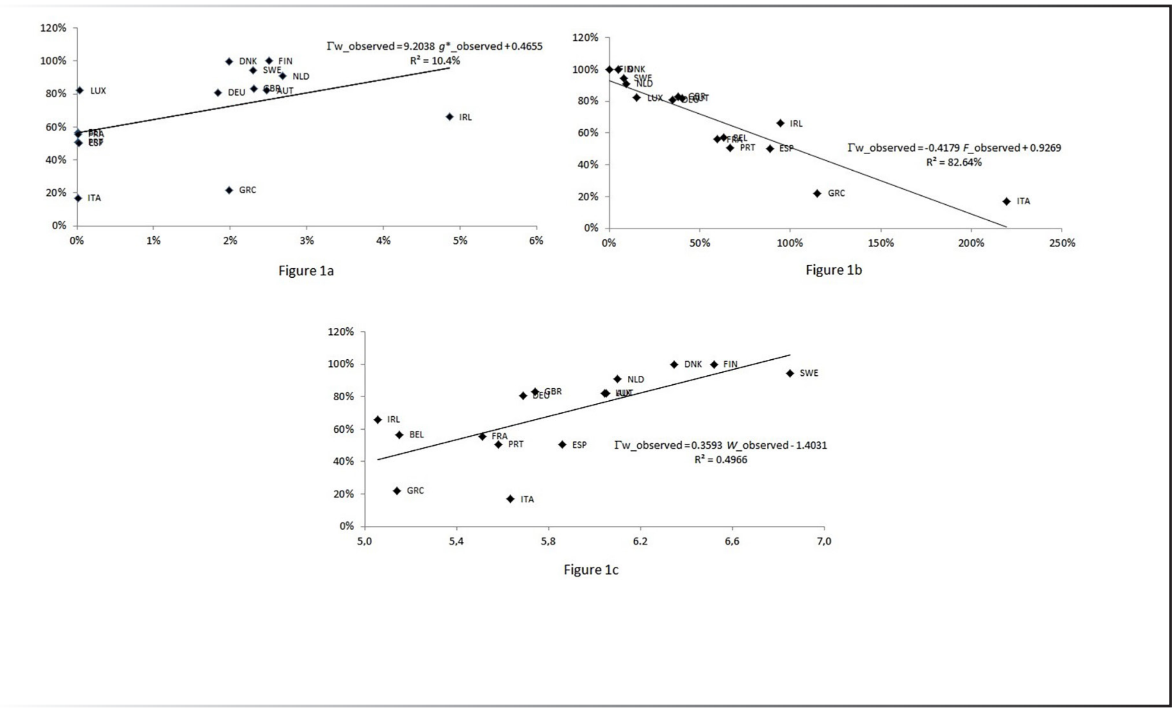

Figure 1: Observed penalty of corruption, Γw_observed, economic growth rate, g∗_observed, welfare, W_observed, and corruption level, F_observed, in 15 EU countries in the time period 1990-2010. The top-left Figure (1a) depicts the relationship between the penalty of corruption (Γw_observed in the Y-axis) and the economic growth rate (g∗_observed in the X-axis); the top-right Figure (1b) illustrates the relationship between the penalty of corruption (Γw_observed in the Y-axis) and the level of corruption (F_observed in the X-axis); the bottom Figure (Figure 1c) shows the relationship between the penalty of corruption (Γw_observed in the Y-axis) and the welfare level (W_observed in the X-axis). The straight lines in 1a, 1b and 1c are OLS regression lines. As detailed in the Appendix, the countries considered are Austria (AUT), Belgium (BEL), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Ireland (IRL), Italy (ITA), Luxemburg (LUX), the Netherlands (NLD), Portugal (PRT), Spain (ESP), Sweden (SWE), and the United Kingdom (GBR) e.g., d'Agostino and Scarlato (2016, 2019). Also in the Appendix is detailed the precise meaning of the observed variables Γw_observed, g∗_observed, F_observed and W_observed, and the precise primary source of the data.

source of business-corruption. Therefore, the aggregate level of corruption relies on the intermediate-goods production and on a corruption-technology index, which is negatively connected to the number of intermediate goods that emerge from the R&D sector; thus, the corruption intensity is determined endogenously. In addition, we consider that corruption a ects negatively the household's utility and we propose a more general utility function than the one proposed in the baseline horizontal R&D-growth model (e.g., Romer 1990; Grossman and Helpman 1991; Barro and Sala-i-Martin 2004, Ch. 6), which permits us to analyze the effect of corruption on the marginal utility.

We show that a greater punishing tax reduces final-good production and intermediate-goods demand; therefore, it penalizes the profits of intermediate good producers. Nevertheless, it also penalizes the price elasticity of intermediate-goods demand, and increases its rate of mark-up. Furthermore, the labor reallocation from the intermediate-goods sector to the R&D sector improves innovative activity isto é, the generation of new varieties of intermediate goods and, thus, the economic-growth rate, matching the data in Figure 1a. We also find that a greater punishing tax reduces the level of corruption in line with data in Figure 1b and as expected, and increases the welfare as also occurs in Figure 1c.

The paper is structured as follows. Section 2 presents the setup of the R&D-growth model. Section 3 analyses the dynamic general equilibrium of the model and the implications of a higher punishing tax. Finally, section 4 concludes.

>> THEORETICAL SETUP

Overview

This Section describes the economic setup, emphasizing the interactions among economic agents. Our starting point is the baseline endogenous R&D-growth model, which relies on horizontal innovations; isto é, on the development of new product varieties.[3] We adjust the setup of the baseline horizontal R&D-growth model proposed by Romer (1990), Jones (1995) and Barro and Sala-i-Martin (2004, Ch. 6), to consider that: (i) aggregate final-good producer uses intermediate goods as single production factor and that the aggregate final good is consumed; (ii) intermediate-goods producers use labor as single production factor and the technological-knowledge needed to produce intermediate goods isto é, designs obtained from successful R&D activities; (iii) R&D producers use only labor to create new intermediate goods more specifically, more designs that allow the materialization of the new intermediate goods , such that each successful innovator becomes a monopolist in the respective intermediate good. Finally, we assume that an infinitely lived representative household inelastically supply labor, determines the respective consumption by maximizing an intertemporal utility function, and invests in the firm's equity. Moreover, we extend the baseline setup by considering corruption as a by-product of intermediate goods that negatively affects the utility of the representative household.

Production and prices

In the final-good sector, the aggregate final good, Z, is produced under perfect competition through the production function

$$Z(t) = \frac{1}{1-\alpha}\int_0^{A(t)} q(j,t)^{1-\alpha} dj, \tag{1}$$

where $0 < 1 - \alpha < 1$ represents the intermediate-goods share in production, A(t) is the number of available intermediate goods measuring the technological knowledge at time t, and q(j,t) is the quantity of the intermediate good j used at time t. In (1), we also consider $1 - \alpha$ in the denominator and normalize the price of the final good at each time t to one.

To include the corruption in model we need to consider the nature, the source and the effects of the corruption (Pelizzo et al. 2017). Concerning the nature, we take the corruption as a flow, meaning that it relies only on the level created in the period. Regarding the source, we assume that the

[3] Using a model with vertical innovations in which the quality of existing products is improved would not change the results.

flow of corruption is related to an externality, and thus we consider that the aggregate level of corruption F(t) relies on the intermediate-goods production q(j,t) and on a corruption-technology index $f(t) \in [0,1]$

$$F(t) = \int_0^{A(t)} f(t) \cdot q(j,t) dj. \tag{2}$$

Hence, we take into account the intensity of corruption by considering that it relies negatively on the number of available intermediate goods; isto é. Finally, as shown later on, we also model the effects of corruption on the household's utility. We consider that the government should charge a punitive tax on corrupts as a way to discourage corruption. We assume that this tax should be levied on the final-goods sector, bearing in mind the corruption level. The profit flow at time t of the final-good producer in face of the punishing tax is

$$\pi_Z(t) = \frac{1}{1-\alpha} \int_0^{A(t)} q(j,t)^{1-\alpha} dj - \int_0^{A(t)} p(j,t) \cdot q(j,t) dj - \tau(t) \int_0^{A(t)} \frac{q(j,t)}{A(t)} dj.$$

(3)

where p(j,t) is the price of the intermediate good j and $\tau(t) \in (0,1)$ is the punishing tax. The first-order condition gives us the inverse demand of the intermediate good j by the representative final-good producer

$$p(j,t) = q(j,t)^{-\alpha} - \frac{\tau(t)}{A(t)}. \tag{4}$$

In turn, in the intermediate-goods sector, labor is the only input used and $\psi(t)$ units of labor are required to produce one unit of an intermediate good at time t. Hence, the profit of the intermediate-good producer of j at t is

$$\pi(j,t) = q(j,t)^{1-\alpha} - \frac{\tau(t)}{A(t)} q(j,t) - \psi(t) \cdot w(t) \cdot q(j,t), \tag{5}$$

where w(t) is the wage rate per unit of labor at t. At this stage, we consider that $\psi(t)$ is inversely connected to the number of available intermediate goods. We also consider that the government can control the punishing tax through the indicator Γw that represents the ratio between the punishing tax and the wage per unit of labor, which, in equilibrium, is stable over time. Hence, equation (5) should be written in the for

$$\pi(j,t) = q(j,t)^{1-\alpha} - \left(\frac{1+\Gamma_w}{A(t)}\right) \cdot w(t) \cdot q(j,t). \tag{6}$$

From the first order condition we reach the demand function, which bearing in mind (4) gives us the equilibrium price of the intermediate good j is $p(j,t) = q(\mu) - \alpha - \Gamma w \cdot \mu$.

$$p(j,t) = q(\mu)^{-\alpha} - \Gamma_w \cdot \mu. \tag{7}$$

The equilibrium profit of each firm is

$$\pi(j,t) = \left(\frac{\alpha}{1-\alpha}\right) \cdot (1+\Gamma_w) \cdot \mu \cdot \widetilde{q}(\mu) \tag{8}$$

Hence, the profit of the producer of each intermediate good is determined by two opposite effects. The former, called profitability effect, represents the positive effect of punishing tax on profit. Indeed, a raise in the punishing tax raises the mark-up rate and, therefore, the profit. The latter, which is negative and o sets the former, is the traditional effect, which reduces the profit by depressing the labor demand. The sum of these two effects gives us what we can designate the short-run loss of the punishing policy.

The R&D sector

As is usual in the R&D-growth literature (e.g., Barro and Sala-i-Martin 2004, Chs. 6 and 7), to produce an intermediate good a rm needs a design, which, in our case, is produced through horizontal R&D activities and which is granted a patent. Thus, a successful innovator retains exclusive rights over the use of his/her good and since there is perfect competition among entrants and free-entry in the R&D business, each successful R&D leads to the setup of a new firm in a new industry j.

We consider the following production function in the R&D sector:

$$A(t) = \eta \cdot A(t) \cdot L_N(t). \tag{9}$$

where: $\eta > 0$ is a constant fixed (flow) cost, and can be interpreted as a productivity of labor in R&D activities and also as a measure of barriers to entry; A(t) (isto é, the number of available intermediate goods) denotes the spillover effects since designs are non-rival goods, isto é, the positive externalities from the available technological knowledge; $L_N(t)$ is the labor-level employed in the R&D sector at t. As standard, the Hamilton-Bellman-Jacobi equation is $r(t)V(j,t) - V^{\cdot}(j,t) = \pi(j,t)$, where V(j,t) is the net present discounted value of the design required to produce j at t, and r(t) is the interest rate at t. The R&D free-entry condition is

$$\eta \cdot V(j,t) = w(t), \tag{10}$$

where $\eta \cdot V(j,t)$ and $w(t)$ represent, respectively, the return and the flow cost of hiring one unit of labor for R&D.

Consumers and the government

The representative household maximizes the utility given by

$$U(t) = \int_0^\infty \left\{ \frac{\left[C(t) \cdot F(t)^{-\delta}\right]^{1-\theta} - 1}{1-\theta} \right\} e^{-\rho t} dt, \tag{11}$$

where: $C(t)$ is the consumption of the household at time t; θ represents the inverse of the elasticity of intertemporal substitution; $\rho > 0$ is the time preference rate to ensure that U is bounded away from infinity if C is constant over time; $\delta > 1-\alpha$ is a parameter that allows us to have the household's preference toward an economy without corruption. In the problem of maximization the household takes the flow of corruption as exogenously given; isto é. the effects of corruption are modeled by considering the household's preferences negatively dependent on the flow of corruption, F. Therefore, through $F(t)-\delta$ we include corruption directly in the utility function, which provokes dis-utility. Moreover, the household de nes the consumption plan that maximizes the present value stream of utility taking into account the initial assets, $K(0) = K0$, and the income; isto é, the maximization problem is subject to the intertemporal budget constraint: $\dot{K}(t) = r(t) \cdot K(t) + w(t) + T(t) - C(t)$, where $T(t)$ is the transfers of the fiscal revenue to the household, and, remember, $K(t)$, $r(t)$ and $w(t)$ are, respectively, the assets, the interest rate, and the wage at t. The consumption plan satisfies a standard Euler equation

$$g_C \equiv \frac{\dot{C}(t)}{C(t)} = \frac{\eta \cdot (1-\theta)\frac{\dot{F}(t)}{F(t)} + r(t) - \rho}{\theta} = \frac{r(t)-\rho}{\theta}, \tag{12}$$

since corruption is constant over time, and satisfies the transversality condition $\lim_{t\to\infty} [\vartheta(t) \cdot K(t) \cdot e^{-\rho t}] = 0$, where $\vartheta(t)$ is the Hamiltonian multiplier; isto é, the shadow price in the present-value Hamiltonian since the current value Hamiltonian is

$$H = \left\{ \frac{\left[C(t) \cdot F(t)^{-\delta}\right]^{1-\theta} - 1}{1-\theta} \right\} + \vartheta(t) \left[r(t) \cdot K(t) + w(t) + T(t) - C(t)\right] \tag{13}$$

In turn, the government uses the punishing tax $\tau(t)$ to regulate the economy and transfers this fiscal revenue to the household in the form of $T(t)$; isto é, $\tau(t) \cdot F(t) = T(t)$.

>> THE BALANCED GROWTH PATH

This section analyses the dynamic general equilibrium of the model such that consumers and firms solve their problems, there is free entry and absence of arbitrage opportunities in R&D, and markets clear.

Steady-state equilibrium

To analyze the dynamics of the economy, we start by noticing that the aggregate resource constraint at time t is C(t) ≤ Z(t). In the labor market, labor is employed either in intermediate-goods production or in the production of designs; isto é, in the intermediate-goods sector or in the R&D sector:

$$L(t) = L_x(t) + L_N(t), \tag{14}$$

where L(t), Lx(t), and $L_N(t)$ are, respectively, the labor-level total, employed in intermediate-goods production, and employed in R&D. In steady state, $\dot{V}(t) = 0$ since the interest rate in (12) and the profit of the j intermediate-good producer (8) are stable, implying the following net present discounted value of the firm

$$r^*(t)\cdot V^*(j,t) = \pi(j,t) \Rightarrow V^* = \frac{\left(\frac{\alpha}{1-\alpha}\right)\cdot(1+\Gamma_w)\cdot\mu\cdot\widetilde{q}(\mu)}{r^*} \tag{15}$$

Hence, from (10), the balanced-growth path (BGP) constant interest rate is

$r^* = \eta\cdot\left(\frac{\alpha}{1-\alpha}\right)\cdot(1+\Gamma_w)\cdot L_x^*$ and, thus, using the Euler equation (12), the consumption-growth rate is

$$g^* \equiv g_C^* \equiv \left(\frac{\dot{C}}{C}\right)^* = \frac{\eta\cdot\left(\frac{\alpha}{1-\alpha}\right)\cdot(1+\Gamma_w)\cdot L_x^* - \rho}{\theta}. \tag{16}$$

To complete the characterization of the BGP equilibrium, the BGP labor-level employed needs to be determined.

From the R&D production function (10), in BGP, we obtain $\frac{\dot{A}}{A} = \eta\cdot L_N^* = \eta\cdot(L - L_x^*)$. Moreover, by definition, the BGP consumption growth rate, $\frac{\dot{C}}{C}$, is equal to the technological-knowledge progress, $\frac{\dot{A}}{A}$; isto é,

$g^* = \frac{\dot{C}}{C} = \frac{\dot{A}}{A}$. Bearing in mind (15), this implies that the BGP labor-level employed in intermediate-goods production is $L_x^* = \frac{\eta \cdot \theta \cdot L + \rho}{\eta \cdot \left(\frac{\alpha}{1-\alpha}\right) \cdot (1+\Gamma_w) + \eta \cdot \theta}$, which, as expected, is stable. Finally, the expression for the BGP equilibrium interest rate is

$$r^* = \frac{\left(\frac{\alpha}{1-\alpha}\right) \cdot (1+\Gamma_w) \cdot (\eta \cdot \theta \cdot L + \rho)}{\left(\frac{\alpha}{1-\alpha}\right) \cdot (1+\Gamma_w) + \theta} \qquad (17)$$

and the BGP economic-growth rate is

$$g^* = \frac{\eta \cdot \left(\frac{\alpha}{1-\alpha}\right) \cdot (1+\Gamma_w) \cdot L - \rho}{\left(\frac{\alpha}{1-\alpha}\right) \cdot (1+\Gamma_w) + \theta}. \qquad (18)$$

We consider that $\eta \cdot \left(\frac{\alpha}{1-\alpha}\right) \cdot (1+\Gamma_w) \cdot L > \rho$, which ensures a positive BGP economic-growth rate, and $\rho > \frac{\alpha \cdot (1-\theta) \cdot (1+\Gamma_w) \cdot \eta \cdot L}{1+\alpha \cdot \Gamma_w}$, which guarantees a finite household's utility and the verification of the transversality condition.

Steady-state effects of a stricter punishing tax

In this Subsection, we analyze the steady-state effects of a stricter anti-corruption taxation.

Proposition 1. A greater punishing tax raises the economic-growth rate.
Proof.

$$\frac{\partial g^*}{\partial \Gamma_w} = \frac{\frac{\alpha}{1-\alpha} \cdot (\eta \cdot L \cdot \theta + \rho)}{\left[\left(\frac{\alpha}{1-\alpha}\right) \cdot (1+\Gamma_w) + \theta\right]^2} > 0.$$

Proposition 1 reveals the positive effect of the punishing tax on economic growth. A greater tax on corruption depresses the intermediate-goods profits since depresses the aggregate final output and the intermediate-goods demand. This negative effect can be understood as the short-run loss provoked by the punishing tax profitability effect. However, this effect is softened by the raise in the price elasticity of demand, though the global effect on the profit of intermediate-good producers stays negative. In turn, the punishing tax has an indirect effect on the labor market the labor-reallocation effect. Indeed, since this tax reduces final-good production, it also reduces the intermediate-goods production and, thus, encourages the labor reallocation from the intermediate-goods sector to the R&D sector. The labor-reallocation effect offsets the profitability effect and, therefore, in line with the dominate literature on the subject (e.g., Li 2016; Chang and Hao 2017; Neanidis et al. 2017), a greater tax on corruption enhances R&D activity and economic growth.

Proposition 2. A greater punishing tax reduces the level of corruption.

Proof. The derivative of $F(t) \equiv \widetilde{q}(\mu) = \left(\frac{1-\alpha}{(1+\Gamma_w)\cdot\mu}\right)^{\frac{1}{\alpha}}$, with respect to Γw is negative:

$$\frac{\partial F^*}{\partial \Gamma_w} = \left(-\frac{1}{\alpha}\right) \cdot \left(\frac{1-\alpha}{\mu}\right)^{\frac{1}{\alpha}} \cdot (1+\Gamma_w)^{-\frac{(1+\alpha)}{\alpha}} < 0\,.$$

Proposition 2 reveals the negative effect of the punishing policy on the corruption level. As already stated, a greater tax on corruption decreases the level of intermediate-goods production and, thus, the level of corruption.

Finally, we also analyze the effect of the punishing policy on the welfare. From (11), in BGP the welfare is:

$$W(t) = \int_0^\infty \left\{ \frac{\left[C(t)\cdot F(t)^{-\delta}\right]^{1-\theta} - 1}{1-\theta} \right\} e^{-\rho t} dt; \tag{19}$$

and taking into account (13), the level of welfare is

$$W(t) = \left(\frac{1}{1-\theta}\right) \cdot \left\{ \left[Z(0)\cdot F(0)^{-\delta}\right]^{1-\theta} \cdot \left(\frac{1}{\rho - g^*(1-\theta)}\right) - \frac{1}{\rho} \right\}, \tag{20}$$

where Z(0) is the aggregate final good at time 0, while F(0) is the level of corruption at time 0. To emphasize the effect of the punishing tax on the welfare, we compute the first derivative W in (19) with respect to the punishing tax Γw

$$\begin{aligned} \frac{dW}{d\Gamma_w} &= \left[\frac{\partial Z(0)}{\partial \Gamma_w} F(0)^{-\delta}\right] \left[Z(0)\cdot F(0)^{-\delta}\right]^{-\theta} \left(\frac{1}{\rho - g^*(1-\theta)}\right) - \\ &- \left[\delta \cdot Z(0)\cdot F(0)^{-\delta-1} \frac{\partial F(0)}{\partial \Gamma_w}\right] \left[Z(0)\cdot F(0)^{-\delta}\right]^{-\theta} \left(\frac{1}{\rho - g^*(1-\theta)}\right) \cdot \\ &+ \left(\frac{\frac{\partial g^*}{\partial \Gamma_w}}{[\rho - g^*(1-\theta)]^2}\right) \left[Z(0)\cdot F(0)^{-\delta}\right]^{1-\theta}. \end{aligned} \tag{21}$$

The first term on the right side of (21) describes the effect of the punishing tax on the welfare through its effect on the aggregate final-good production; it tell us that a raise of the punishing tax reduces the demand of intermediate goods and, consequently, reduces aggregate final-good production, indicating that the production effect is negative. The second term on the right side of (22) describes the effect of the punishing tax on the welfare through its effect on corruption level. Since the level of corruption depends on the intermediate-goods production, a raise in the punishing tax decreases the latter and, consequently, decreases the level of corruption; as the decrease in the level of corruption affects positively the welfare, this corruption effect is positive. The third term on the right side of (22) is the effect of the punishing tax on the welfare by its effect on the economic-growth rate; as a greater punishing tax enhances the economic-growth rate, this economic-growth effect is positive. In brief, the punishing tax influences the welfare by three effects, and the two positive corruption and economic-growth effects o set the negative production effect Proposition 3.

Proposition 3. A greater punishing tax increases welfare if the household's preference toward an environment without corruption is large enough.

Proof. As the economic-growth effect is positive, we need to prove that the negative production effect is more than compensated by the positive corruption effect. Since $\left[Z(0)\cdot F(0)^{-\delta}\right]^{-\theta}$ and $\left[Z(0)\cdot F(0)^{-\delta}\right]^{-\theta}$ are both positive, this condition can be rewritten as $-\delta\cdot Z(0)\cdot F(0)^{-\delta-1}\cdot \frac{\partial F(0)}{\partial \Gamma_w} > \frac{\partial Z(0)}{\partial \Gamma_w}\cdot F(0)^{-\delta}$.

Rearranging this inequality, we get $\delta > \frac{\frac{\partial Z(0)}{\partial \Gamma_w}}{\frac{\partial F(0)}{\partial \Gamma_w}}\cdot \frac{F(0)}{Z(0)}$. From (1), (7) and (13) we find the initial aggregate-production level $Z(0) = \left(\frac{1}{1-\alpha}\right)\cdot \widetilde{q}(\mu)^{1-\alpha}\cdot N(0)$,

and from (2) and (7) we find the initial corruption level, F(0) = q( ). Rearranging again the inequality, we reach the condition $\delta > 1 - \alpha$, which, by definition, is observed.

>> CONCLUDING REMARKS

We have analyzed the steady-state effect of a punishing tax on economic growth, corruption, and welfare. To that end, we have included corruption in the baseline endogenous R&D-growth model, which we consider emerging with the production of intermediate goods and by assuming that there is a negative externality of corruption on consumer's utility.

The analysis reveals that a greater punishing tax depresses the aggregate final-good production and the demand for intermediate goods. Hence, a greater punishing tax reduces the profits of intermediate-goods producers. However, a greater punishing tax also softens this effect since reduces the price elasticity of intermediate-goods demand and increases its rate of mark-up. In addition, the labor reallocation from the intermediate-goods sector to the R&D sector enhances innovative-R&D activity and, thus, the economic-growth rate. Therefore, we find that a greater punishing tax increases the economic-growth rate and reduces the corruption level.

On the other hand, a greater punishing tax affects the welfare via three effects. The production effect reduces welfare since decreases the demand for intermediate goods. The corruption effect raises welfare since also reduces the demand for intermediate goods (and thus corruption). The economic-growth effect induced by a greater punishing tax is positive for welfare. To sum up, the overall effect of a greater punishing tax on welfare is positive.

Interestingly, the results are in line with the data observed for 15 EU countries.

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>> APPENDIX

The countries considered are those in Figure 1 and in Section 4 are those in d'Agostino and Scarlato (2016, 2019). Thus, we have restricted the analysis to a sub-set of 15 EU countries for which fully comparable data on corruption and control of corruption are available: Austria (AUT), Belgium (BEL), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Ireland (IRL), Italy (ITA), Luxemburg (LUX), the Netherlands (NLD), Portugal (PRT), Spain (ESP), Sweden (SWE), and the United Kingdom (GBR). In particular, we can state that the exclusion of more recent EU member countries is due to their different institutional backgrounds on corruption, which could bias the data comparability, as well as to data limitations.

Figure 1. The precise meaning of variables and source of data.

For the observed economic growth rate, g∗_observed, we take the average in the period 1990-2010 of the annual percentage growth rate of GDP at market prices based on constant local currency in which aggregates are based on constant 2010 US dollars source: World Development Indicators; column g∗_observed in Table 1.

From d'Agostino and Scarlato (2019, Table 1) we take data covering the period 1985-2010 for the indicator corruption , which is an assessment of corruption that is a threat to innovation for several reasons: it distorts the economic and financial environment; it reduces the efficiency of government and business by enabling people to assume positions of power through patronage rather than ability (...). The most common form of corruption met directly by the business is due to demands for special payments and bribes (...) (d'Agostino and Scarlato 2019, p. 89). In Table 1 we take into account the data provided by d'Agostino and Scarlato (2019, p. 89), column F_observed 1985-2010 in Table 1, and then F_observed is computed to represent the additional percentage of corruption compared to Finland, which has the lowest level of corruption, column F_observed Face to FIN in Table 1.

In turn, as a proxy for the observed penalty of corruption, Γw_observed, we proceed as follows. From d'Agostino and Scarlato (2016, Appendix B) [and the World Bank], we take data covering the period 1990-2010 for the indicator control of corruption Index , which is an index constructed by the World Bank to capture the control of corruption in the country. According to the link https://www.mcc.gov/who-we-fund/indicator/control-of-corruption-indicator it measures the strength and e effectiveness of a country's policy and institutional framework to prevent and combat corruption. Its scale varies between -2.5 and +2.5, where the higher the index the higher the control; column Γw_observed 1990-2010 in Table 1. Then, to nd Γw_observed in 1a, 1b and 1c we divide the value of each country by the value of the country that most penalizes corruption, which is Finland, thus obtaining the percentage of control of corruption in face of Finland's protection, Γw_observed Face to FIN in Table 1.

Finally, concerning the variable welfare , W_observed, we take as a proxy values from the Sustainable Society Index produced by the Sustainable Society Foundation available in the link http://www.ss ndex.com/data-allcountries/ in which is stated that the Sustainable Society Index integrates Human Well-being and Environmental Well-being that is the proper way to look at development to a sustainable world. Human and Environmental Well-being are the goals we are aiming at. Human Well-being without Environmental Well-being is a dead-end, Environmental Well-being without Human Well-being makes no sense, at least not for human beings. Economic Well-being is not a goal in itself. It is integrated as a condition to achieve Human and Environmental Well-being. It can be considered as a safeguard to well-being. In particular, for each country, we consider the three periods available until 2010 (2006, 2008 and 2010) and compute the average in these periods in the three components of the index (Human Well-being, Environmental Well-being, and Economic Well-being); column W_observed 2006, 2008,2010 .

Variables are measured over the time span 1990-2010 for the variables Γw, g$*$ and F, and over the time span 1985-2010 for variable F. The initial year was imposed by the availability of data and the last one aims to end the analysis before the implementation of foreign aid plans in some countries following the financial-economic crisis. It would be desirable to consider, at least in a time-series perspective, a wider time frame. However, the lack of data in some variables has led us to consider, for each variable, the average of the period as corresponding to the steady state. Since each one of the 15 OECD countries has its own singularities in Table 1 we divide the countries according to the different welfare or social models (e.g., World Bank, 1999; Blanchard, 2004; Afonso 2016): (i) the Nordic model in which F is less significant; (ii) the Continental-European model where F is also insignificant; (iii) the Anglo-Saxon model where F already has worrying values; (iv) the Mediterranean model where F is worrying.

Table 1: Data of the variables g∗_observed, F_observed and Γw_observed.

Countries		g∗_observed	F_observed		g∗_observed		ΓW_observed
		1990-2010 %	1985-2010	Face to FIN %	1990-2010	Face to FIN %	2006, 2008, 2010
Continental Europe Countries	Austria	2.48	0.713	40	1.99	82	6.1
	Belgium	2.00	0.613	63	1.37	57	5.2
	France	1.75	0.626	60	1.35	56	5.5
	Germany	1.85	0.741	35	1.96	81	5.7
	Luxembourg	3.93	0.867	15	1.99	82	6.0
	The Netherlands	2.69	0.915	9	2.20	91	6.1
Anglo-saxons countries	Ireland	4.87	0.514	95	1.60	6	5.1
	The UK	2.31	0.723	38	2.02	83	5.7
Mediterranean countries	Greece	1.99	0.465	115	0.53	22	5.1
	Italy	1.04	0.313	219	0.41	17	5.6
	Portugal	1.93	0.600	67	1.23	51	5.6
	Spain	2.58	0.530	89	1.22	50	5.9
Nordic Countries	Denmark	1.99	0.953	5	2.42	100	6.3
	Finland	2.51	1.000	0	2.42	100	6.5
	Sweden	2.30	0.925	8	2.29	94	6.9