

# Corruption, Transaction Costs and Seigniorage in a Two-Sector Endogenous Growth Model

Réda Marakbi, Patrick Villieu

*University of Orléans, Laboratoire d'Économie d'Orléans, UMR CNRS 7322, Rue de Blois BP 26039 45067 Orléans - Cedex 2 France. Emails: reda.marakbi@univ-orleans.fr ; patrick.villieu@univ-orleans.fr*

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## Abstract

In this paper, we reassess the link between corruption, economic growth and inflation. To this end, we build an endogenous-growth model with transaction costs in which a corruption sector allows households evading from taxation. Two main results emerge. *First*, the relation between corruption and inflation is U-shaped, contrasting with the positive relation obtained in Al-Marhubi (2000) and Blackburn *et al.* (2011). This nonlinear relationship between corruption and inflation is confirmed by empirical evidence. *Second*, from monetary policy perspective, corruption increases the growth-maximizing seigniorage rate, and, unlike Paldam (2002) and Braun and Di Tella (2004), our model produces a negative association between seigniorage and corruption.

*Keywords:* corruption, endogenous growth, monetary policy, seigniorage, inflation

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## 1. Introduction

In many countries, corruption<sup>1</sup> within the public administration remains an important cause of poor macroeconomic performance. In particular, corruption is often viewed as detrimental for economic growth (Mauro, 1995 ; Mo, 2001 ; Tanzi and Davoodi, 2002 ; Martinez-Vasquez *et al.*, 2005) by hampering domestic private investment (Mauro 1996 ; Brunetti *et al.*, 1998 ; Campos *et al.*, 1999 ; Akai *et al.* 2005) as well as foreign direct investment (Wei, 2000 ; Abed and Davoodi, 2002), and by lowering productivity (Lambdsorff, 2003) and reducing government expenditures in education and health (Mauro, 1998). In addition, many studies highlight a strong

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<sup>1</sup>Corruption is commonly defined as the misuse or the abuse of public office for private gain (Rose-Ackerman, 1997; Bardhan, 1997 ; Amundsen, 1999)

positive correlation between corruption and tax evasion (Ghura, 1998 ; Tanzi and Davoodi, 2000 ; Imam and Jacobs, 2014), the size of the shadow economy (Johnson *et al.*, 1997 ; Schneider *et al.*, 2010) and public debt accumulation (Cooray *et al.*, 2017).

In recent years, some studies have been interested in the relation between corruption, inflation and seigniorage. On the empirical ground, Al-Marhubi (2000) highlights, in a cross-sectional approach, a positive relation between corruption and inflation. Abed and Davoodi (2002) find similar results in panel data. Several attempts have been undertaken to rationalize these results in theoretical approaches. Blackburn and Powell (2011) analyze, in a simple cash-in-advance model, the relation between corruption, inflation and growth and show that corruption adversely affects growth through the channel of a higher inflation. In their model, corruption undermines the capacity of the government to collect taxes and therefore turns towards seigniorage to finance public spending. This increase in seigniorage rises inflation and lowers economic growth. However, in their model, corruption is not endogenously determined. More recently, Myles and Yousefi (2015) develop a rich and interesting overlapping generation model in which money is the only store of value. They model corruption in three different ways and highlight that increasing the seigniorage rate can be a rational strategy for a government which faces a reduction of resources because of corruption. Nevertheless, their analysis focuses on the causality running from corruption to seigniorage and inflation and does not explore the inverse causality while other works suggest that the causality may run from inflation and seigniorage to corruption as well (see Paldam, 2002 ; Braun and Di Tella, 2004 ; Akça *et al.*, 2012 among others).

In this paper, we aim at reassessing the relationship between corruption, economic growth and inflation in an endogenous growth model with transaction costs. In our model corruption is endogenous, so that, in equilibrium, the balanced growth path, inflation and corruption are jointly determined.

The main value of our approach is to build a framework that allows studying the reciprocal interactions between these variables and, in particular (i) the effect of seigniorage<sup>2</sup> on the level of corruption and (ii) the effects of corruption on seigniorage and inflation. Specifically, we develop a two-sector endogenous growth model with productive public spending, following Barro (1990), with a private sector and a “corruption sector”. The private sector describes households who seek to evade as much taxes as possible to increase their disposable income. The “corruption sector”

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<sup>2</sup>In our endogenous growth setup, seigniorage is not assimilable to inflation, contrary to ???. Effectively, inflation is the difference between seigniorage and economic growth.

is composed of corrupt bureaucrats who produce “bribery services” that households purchase to pay less taxes.<sup>3</sup> As a result, corruption positively affects the disposable income of households while decreasing the tax revenues collected by the government, with a detrimental effect on productive public expenditures. In addition, to motivate the demand for money, we assume that all transactions, including corruption expenditures, are subject to transaction costs. These costs can be reduced by using money, which provides liquidity services. Money demand then positively depends on income and corruption and negatively depends on the nominal interest rate. At equilibrium, economic growth, inflation and the aggregate level of corruption are jointly determined as functions of the seigniorage rate and other parameters of the model.

Our findings are the following. First, in contrast with the previous literature, we show that seigniorage can reduce the aggregate level of corruption in the economy. Indeed, since corruption is subject to transaction costs, seigniorage, by increasing the nominal interest rate, acts as a tax on corruption and lowers the inducement to buy corruption services. Second, our model exhibits a “Laffer curve” of seigniorage. Effectively, there is an inverted U-shaped relation between seigniorage and growth (and welfare). Specifically, we demonstrate that corruption increases the growth-maximizing (and the welfare-maximizing) seigniorage rate for a lower growth rate (and level of intertemporal welfare). Indeed, the income-tax rate and the seigniorage rate are two alternative instruments to finance productive public expenditures. In the presence of a corruption sector reducing tax revenues, the government is induced to further resort to seigniorage to finance productive public expenditures that sustain economic growth. Importantly, the originality of our framework is then that corruption is an autonomous channel to generate the non-superneutrality of money in the long-run. Finally, our model highlights a nonlinear relation in the corruption-inflation nexus. In our setup, the impact of corruption on inflation passes through the channel of economic growth. By lowering productive public spending and economic growth, high levels of corruption lead to an increase in the inflation rate (as in Al-Marhubi, 2000 ; Abed and Davoodi, 2002 ; Samimi *et al.* ; 2012 and Ben Ali and Sassi, 2016). However, by generating high taxation and low private investment and growth, low levels of corruption also are positively associated with inflation. Some empirical evidence confirm this theoretical prediction.

The remainder of the paper is organized as follows. Section 2 presents the model

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<sup>3</sup>Thus, in our model corruption can be assimilated to tax evasion. The empirical literature has highlighted a very strong correlation between these two variables. See, e.g., Ghura (1998), Tanzi and Davoodi (2000) and Imam and Jacobs (2014).

and computes the equilibrium. Section 3 focuses on the cash-in-advance special case of the model and analyze the effects of seigniorage on corruption as well as the impact of corruption on the growth-maximizing seigniorage rate. Section 4 extends these results to the general transaction cost technology and provides some comparative statics regarding, notably, the optimal policy-mix. Section 5 provides some new insights about the corruption-inflation nexus, and Section 6 concludes.

## 2. The model

We develop an endogenous growth model in continuous time describing a closed economy populated with a private sector, a corruption sector and monetary and fiscal authorities. All variables are per capita. For the sake of simplicity, population is normalized to unity.

### 2.1. The private sector

We consider a continuum of households indexed by  $i$  ( $i \in (0, 1)$ ) who maximize the present discounted sum of instantaneous utility functions based on consumption ( $c_{i,t} > 0$ )

$$\mathcal{U}(c_{i,t}) = \int_0^{\infty} \exp(-\rho t) u(c_{i,t}) dt, \quad (1)$$

where  $\mathcal{U}(c_{i,t})$  denotes intertemporal welfare and  $\rho$  the discount rate of the representative household. In order to generate an endogenous growth path in the long run, we assume the following constant-elasticity of substitution utility function

$$u(c_{i,t}) = \begin{cases} \frac{S}{S-1} [(c_{i,t})^{\frac{S-1}{S}} - 1] & \text{if } S \neq 1, \\ \log(c_{i,t}) & \text{if } S = 1, \end{cases} \quad (2)$$

with  $S$  the intertemporal elasticity of substitution.

In addition, for  $\mathcal{U}(c_{i,t})$  to be bounded, we have to ensure that  $(S - 1)\gamma_c < S\rho$  where  $\gamma_x$  denotes the growth rate of the variable  $x_t$ .<sup>4</sup>

The production function depends on private capital  $k_t$  and productive public expenditures  $g_t$ . Following Barro (1990) we assume productive public expenditures to be a flow variable

$$y_{i,t} \equiv f(k_{i,t}, g_t) = Ak_{i,t}^\alpha g_t^{1-\alpha}, \quad (3)$$

where  $A$  is a strictly positive scale parameter and  $\alpha$  is the elasticity of output with respect to private capital such that  $1/2 < \alpha < 1$  (similarly,  $1 - \alpha$  corresponds to the elasticity of output with respect to productive public expenditures). At equilibrium,  $g_t$  is endogenously determined,  $y_{i,t}$  has constant returns to scale and a balanced-growth path arises in the long run.

The disposable income of households is noted  $y_t^d$ . We assume that households strive to reduce a share of their income taxes by purchasing bribery services  $\theta_{i,t}$  at a (real) price  $p_{i,t}$ <sup>5</sup> from corrupt bureaucrats. Accordingly, the households' disposable income is

$$y_{i,t}^d = (1 - \tilde{\tau}_{i,t})f(k_{i,t}, g_t), \quad (4)$$

where  $\tilde{\tau}_{i,t}$  is the effective tax rate paid by household  $i$ . Without corruption, the effective tax rate would be equal to the tax rate  $\tau$  fixed by the government. In contrast,  $\tilde{\tau}_{i,t} < \tau$  in our model, since corruption allows households to realize tax savings, namely

$$\tilde{\tau}_{i,t} \equiv [1 - \zeta(\theta_{i,t})]\tau, \quad (5)$$

where  $\zeta(\theta_{i,t})$  describes the corruption technology, such that  $\zeta'(\theta_{i,t}) > 0$  and  $\zeta''(\theta_{i,t}) < 0$ .

To motivate a demand for real balances, we suppose that all transactions, including consumption ( $c_t$ ), investment ( $\dot{k}_{i,t} + \delta k_{i,t}$ ), public spending<sup>6</sup> ( $g_t$ ) and corruption

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<sup>4</sup>In equilibrium, this condition corresponds to a no-Ponzi game constraint where  $\gamma_c < r_t$ ,  $r_t$  being the real interest rate to be defined below.

<sup>5</sup>The price of bribery services depends on  $i$  since we assume the bribery market to be a monopolistic competitive market in which all bureaucrats are specialized (see the next subsection).

<sup>6</sup>For the sake of simplicity, public expenditures are assumed to be subject to the CIA constraint. This allows obtaining a simple money demand, without qualitative change in the model. See Minea and Villieu (2009) and Menuet et al. (2017).

$(p_{i,t}\theta_{i,t})$  are subject to a transaction cost and that money supplies liquidity services by lowering these costs

$$\Upsilon(.) = \frac{\xi}{\mu} \left[ \phi^y (c_{i,t} + z_{i,t} + g_t) + \phi^\theta p_{i,t}\theta_{i,t} \right]^{1+\mu} m_{i,t}^{-\mu}, \quad (6)$$

with  $\xi$  a strictly positive scale-parameter ensuring "small" transaction costs. Coefficients  $\phi^y > 0$  and  $\phi^\theta > 0$  reflect the efficiency of the transaction technology.  $m_t$  is stock of real balances and  $\mu$  (such as  $\mu \geq -1$ ) is a proxy for the elasticity of the real aggregate money demand with respect to the nominal interest rate ( $R_t$ , to be defined below). This specification of the transaction cost function is more general and more realistic than the usual cash-in-advance (hereafter CIA) model. Specifically, it allows to study different cases: the general transaction costs case when  $\mu < +\infty$  and the CIA special case when  $\mu \rightarrow +\infty$ <sup>7</sup>

To the best of our knowledge, there is no study that previously assumed corruption to be subject to a transaction costs or a cash-in-advance constraint. Yet, our specification's interest is to allow studying how monetary policy affects corruption when corruption is an endogenous variable. In addition, this is a quite realistic representation of households' behavior who usually have incentives to purchase "corruption services" by using cash in order to remain undetected. As a matter of fact, cash is one of the less traceable means of payment. More generally, this is why we can consider that any increase in illegal practices would lead to increase the demand for money.

Thus, the household  $i$ , who accumulates private capital  $k_{i,t}$  and real balances  $m_{i,t}$ , faces the following budget constraint in real variables is (we define  $\dot{x}_{i,t}$  as the dynamics of the variable  $x_{i,t}$  over time :  $\dot{x}_{i,t} \equiv \frac{\partial x_{i,t}}{\partial t} \forall x_{i,t}$ ) :

$$\dot{k}_{i,t} + \dot{m}_{i,t} = y_{i,t}^d - c_{i,t} - \delta k_{i,t} - \pi_t m_{i,t} - \Upsilon(.) - p_{i,t}\theta_{i,t} + T_{i,t}, \quad (7)$$

where  $\delta$  corresponds to the capital depreciation rate (with  $0 \leq \delta \leq 1$ ),  $\pi_t$  represents

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<sup>7</sup>From (6), we can write :  $m_{i,t} = \left( \frac{\xi [\phi^y (c_{i,t} + z_{i,t} + g_t) + \phi^\theta p_{i,t}\theta_{i,t}]^{1+\mu}}{\Upsilon(.)} \right)^{\frac{1}{\mu}}$ . Hence, we can determine :  $\lim_{\mu \rightarrow +\infty} \left( \frac{1}{\mu} \right)^{\frac{1}{\mu}} = \lim_{\mu \rightarrow +\infty} \left[ \exp \left( \left( \frac{1}{\mu} \right) \log \left( \frac{1}{\mu} \right) \right) \right] = 1$ . Therefore, when  $\mu \rightarrow +\infty$ , we have:  $m_t = \phi^y (c_{i,t} + z_{i,t} + g_t) + \phi^\theta p_{i,t}\theta_{i,t}$ . The specification of a transaction cost function also allows studying the no-money case when  $\xi = 0$ . However, this case is not relevant for the purpose of this paper.

the inflation rate and  $\pi_t m_{i,t}$  “the inflation tax”. Assuming the Fisher relation,  $\pi_t = R_t - r_t$  where  $R_t$  is the nominal interest rate.

Thus, the representative household uses his disposable income to consume, invest, purchase bribery services and hold money. Finally, to close the model and satisfy Walras’ Law, households receive a lump-sum transfer  $T_{i,t}$  (to be defined below).

The resolution of the households’ program is provided in Appendix A. We show that the inverse demand function for bribery services is obtained by equalizing the marginal cost of these services  $\left( \left( 1 + \phi^\theta h R_t^{\frac{\mu}{1+\mu}} \right) p_{i,t} \right)$  to their marginal return in terms of tax savings  $(\zeta'(\theta_{i,t}) \tau y_{i,t})$

$$\left( 1 + \phi^\theta h R_t^{\frac{\mu}{1+\mu}} \right) p_{i,t} = \zeta'(\theta_{i,t}) \tau y_{i,t}, \quad (8)$$

where  $h = \xi^{\frac{1}{1+\mu}} (1 + \mu) / \mu$ .

Notice that the marginal gain of the bribery services is a positive function of income, the tax rate and the aggregate level of corruption (since  $\zeta'(\theta_{i,t}) > 0$ ).

## 2.2. The corruption sector

We assume the existence of a corruption sector where households and bureaucrats are engaged in a “bribery market”. In this sector, households purchase “bribery services”  $\theta_{i,t}$  at a price  $p_{i,t}$  from corrupt bureaucrats. We model the corruption sector as a sector of monopolistic competition. Indeed, each bureaucrat provides specific services to each household and must therefore be specialized. This specificity allows bureaucrats to extract monopoly rents from their “business”. Assuming an isoelastic function, the production of bribery services is described by the following technology

$$\zeta(\theta_{i,t}) = \kappa \theta_{i,t}^\beta. \quad (9)$$

Therefore, the demand function for bribery services of the household  $i$  is given by

$$\theta_{i,t} = \left\{ \frac{\kappa \beta \tau y_{i,t}}{\left( 1 + \phi^\theta h R_t^{\frac{\mu}{1+\mu}} \right) p_{i,t}} \right\}^{\frac{1}{1-\beta}} \quad (10)$$

In this sector, each bureaucrat provides specific services to each household  $i$ . Indeed, we can suppose that each household has a specific tax position. Bureaucrats must therefore be specialized to provide relevant services to this specific position and to extract monopoly rents from their “bribery activity”. Formally speaking, this means that each bureaucrat maximizes its profit by taking the inverse demand function (8) as given. The supply of bribery services has a cost  $CT_{i,t}$  for bureaucrats, which we assume to be proportional to the intensity of the corruption activity. This cost corresponds to the risk related to corruption, namely the probability of detection (the higher the level of corruption, the higher the probability of detection). As we will show below, it crucially depends on the government’s effort in fighting corruption. Formally, the cost of corruption is defined as

$$CT_{i,t} = \eta y_t \theta_{i,t}. \quad (11)$$

Hence the following bureaucrat’s programme

$$\begin{cases} \max_{\{\theta_{i,t}\}} & \pi_t = p_{i,t} \theta_{i,t} - CT_{i,t}, \\ \text{s.t.} & \left(1 + \phi^\theta h R_t^{\frac{\mu}{1+\mu}}\right) p_{i,t} = \zeta'(\theta_{i,t}) \tau y_{i,t} \end{cases} \quad (12)$$

The resolution of this problem gives rise to the following expression of the aggregate level of corruption

$$\theta_{i,t} = \left\{ \frac{\kappa \beta \tau y_{i,t}}{\eta \left(1 + \phi^\theta h R_t^{\frac{\mu}{1+\mu}}\right) y_t} \right\}^{\frac{1}{1-\beta}}. \quad (13)$$

### 2.3. Monetary and fiscal authorities

The monetary authorities set a nominal stock of high-powered money  $M_t$ , assumed to be exogenous. Since we ignore the existence of banking and financial sectors, high-powered money is the unique form of money. It grows at a rate  $\frac{\dot{M}_t}{M_t} \equiv \omega$  that corresponds to the seigniorage rate. Thereafter, the monetary authorities transfer seigniorage revenues to the government who can use this resource in addition to effective tax collection to finance productive public expenditures.



In addition, the government uses a portion  $\eta$  of output to fight corruption and improve tax collection. Thus, the government budget constraint shares government's resources between productive and non (directly) productive expenditures, namely

$$g_t + \eta y_t = \int_0^1 \tilde{\tau}_{i,t} y_{i,t} di + \int_0^1 \omega m_{i,t} di. \quad (14)$$

This expression is an extension of the government budget constraint of Barro (1990) ( $g_t = \tau y_t$ ). In our model, productive public expenditures can either be higher or lower than the amount of taxes collected by the government, depending on the degree of corruption, the share of GDP invested to fight against corruption and seigniorage revenues.

#### 2.4. Symmetric equilibrium

In symmetric equilibrium, aggregate variables correspond to individual variables:  $y_{i,t} = y_t = \int_0^1 y_{i,t} di$ ,  $\theta_{i,t} = \theta_t = \int_0^1 \theta_{i,t} di$ ,  $p_{i,t} = p_t = \int_0^1 p_{i,t} di$ ,  $\tilde{\tau}_{i,t} = \tilde{\tau}_t = \int_0^1 \tilde{\tau}_{i,t} di$ ,  $m_{i,t} = m_t = \int_0^1 m_{i,t} di$  and  $i_t = k_t = \int_0^1 k_{i,t} di = k_t$ .

From the resolution of the model<sup>8</sup>, we get the following two relations

$$\gamma_c \equiv \frac{\dot{c}_t}{c_t} = S \left[ r_t - \rho - \frac{\phi^y \dot{R}_t}{1 + \phi^y R_t^{\frac{\mu}{1+\mu}}} \right], \quad (15)$$

$$\frac{\phi^y \dot{R}_t}{1 + \phi^y R_t^{\frac{\mu}{1+\mu}}} = r_t + \delta - \frac{(1 - \tilde{\tau}_t) \alpha A g_k^{1-\alpha}}{1 + \phi^y R_t^{\frac{\mu}{1+\mu}}}. \quad (16)$$

Equation (15) corresponds to the usual Keynes-Ramsey rule describing the optimal consumption path. In this relation, we can observe that the path of consumption is related to the path of the nominal interest rate provided in (16). This comes from the presence of transaction costs on consumption goods ( $\phi^y > 0$ ). If  $\phi^y = 0$ , we find the usual relation  $\gamma_c = S(r_t - \rho)$ . In addition, since transaction costs also affect in-

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<sup>8</sup>The resolution of the model is provided in Appendix A.

vestment, the real interest rate must be deflated by the financing cost  $\left(1 + \phi^y R_t^{\frac{\mu}{1+\mu}}\right)$  in a manner similar to the cash-in-advance model of Stockman (1981).

To solve the model, we define intensive variables by deflating all growing variables by the stock of private capital ( $x_k \equiv x_t/k_t$ ). Hence, we obtain the following relations

$$\frac{\dot{c}_k}{c_k} = S \left[ r_t - \rho - \frac{\phi^y \dot{R}_t}{1 + \phi^y R_t^{\frac{\mu}{1+\mu}}} \right] - \gamma_k, \quad (17)$$

where  $\gamma_k$  corresponds to the growth rate of capital which is obtained from the IS equilibrium

$$\gamma_k \equiv \frac{\dot{k}_t}{k_t} = A g_k^{1-\alpha} - g_k - c_k - \delta. \quad (18)$$

From the expression of the equilibrium nominal interest rate (see Appendix A), we obtain the demand for money

$$m_t = \xi^{\frac{1}{1+\mu}} (\phi^y y_t + \phi^\theta p_t \theta_t) R_t^{-\frac{1}{1+\mu}}, \quad (19)$$

where the aggregate level of corruption, in symmetric equilibrium, is expressed as

$$\theta_i = \left\{ \frac{\kappa \beta \tau}{\eta \left( 1 + \phi^\theta h R_t^{\frac{\mu}{1+\mu}} \right)} \right\}^{\frac{1}{1-\beta}}. \quad (20)$$

As in the Baumol-Tobin model, the demand for money positively depends on income and negatively on the interest rate. Nevertheless, the originality of our model comes from the fact that the demand for money now positively depends on the level of corruption.

From (14) and (19), we get the expression of the ratio of productive public expenditures to capital

$$g_k = \left\{ A \left[ \tilde{\tau}_t + \xi^{\frac{1}{1+\mu}} \omega \left( \phi^y + \phi^\theta \frac{\kappa \beta \theta_t^\beta \tau}{1 + \phi^\theta h R_t^{\frac{\mu}{1+\mu}}} \right) R_t^{-\frac{1}{1+\mu}} - \eta \right] \right\}^{\frac{1}{\alpha}}. \quad (21)$$

The money market equilibrium is such that

$$\frac{\dot{m}_k}{m_k} = \omega - \pi_t - \gamma_k = \omega + r_t - R_t - \gamma_k, \quad (22)$$

By differentiating the transaction costs function (6) and equalizing this differentiated relation to (22), we can extract the expression of the real interest rate

$$r_t = (1 - \alpha) \frac{\dot{g}_k}{g_k} + R_t + \gamma_k - \omega - \frac{1}{1 + \mu} \frac{\dot{R}_t}{R_t} - g(R) \dot{R}_t, \quad (23)$$

The system composed by equations (15) - (23) fully characterizes the equilibrium of the model.

### 2.5. The steady-state

We define the balanced growth path as the path where consumption, capital, productive public expenditures, money, output, corruption and the price of bribery services<sup>9</sup> grow at the same endogenous growth rate ( $\gamma^* = \dot{c}_t/c_t = \dot{k}_t/k_t = \dot{g}_t/g_t = \dot{m}_t/m_t = \dot{y}_t/y_t = \dot{\theta}_t/\theta_t = \dot{p}_t/p_t$ ). In addition, the real interest rate ( $r^*$ ) the nominal interest rate ( $R^*$ ) and then the inflation rate  $\pi^*$  are constant in the long run.

The steady-state growth rate is given by the following relation

$$\gamma^* = S(r^* - \rho), \quad (24)$$

where the real interest rate  $r^*$  is the marginal productivity of capital deflated by the financing cost of investment

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<sup>9</sup>For corruption services to be constant in the long run, the prices of corruption must grow at the same rate as GDP.

$$r^* = \frac{(1 - \tilde{\tau}^*)\alpha A g_k^{*1-\alpha}}{1 + \phi^y h R^{*\frac{\mu}{1+\mu}}} - \delta. \quad (25)$$

The productive public-expenditures to capital ratio in the long-run is such that

$$g_k^* = \left\{ A \left[ \tilde{\tau}^* + \xi^{\frac{1}{1+\mu}} \omega \left( \phi^y + \phi^\theta \frac{\kappa \beta \theta^{*\beta} \tau}{1 + \phi^\theta h R^{*\frac{\mu}{1+\mu}}} \right) R^{*-\frac{1}{1+\mu}} - \eta \right] \right\}^{\frac{1}{\alpha}}, \quad (26)$$

and the expression of the effective tax rate in the steady-state is such that  $\tilde{\tau}^* = (1 - \zeta(\theta^*))\tau$  where

$$\theta^* = \left[ \frac{\kappa \beta^2 \tau}{\eta \left( 1 + \phi^\theta h R^{*\frac{\mu}{1+\mu}} \right)} \right]^{\frac{1}{1-\beta}}. \quad (27)$$

Finally, the long-term nominal interest rate is the sum of the long-run inflation rate ( $\omega - \gamma^*$ ) and the real interest rate ( $r^*$ ), namely, from (23)

$$R^* = \omega + \rho - \varsigma(\gamma^*), \quad (28)$$

where  $\varsigma(\gamma^*) = (S - 1)/S$ . When  $S = 1$ , then  $\varsigma(\gamma^*) = 0$ .

**Proposition 1.** *(Uniqueness and stability of the steady-state) The model is characterized by a unique saddle-point-stable steady state.*

PROOF. See Appendix B.

As in Barro (1990), there is no transitional dynamics in this model. Therefore, all variables initially jump to their steady-state values and the description of short-term equilibrium by equations (23)-(27) is complete.

The following section derives some analytical findings in the cash-in-advance special case, before establishing numerical results for the general case in section 4.

### 3. The cash-in-advance special case

In the cash-in-advance special case,  $\mu \rightarrow +\infty$  and the steady-state solution can be summarized by the following three relations

$$\gamma^* = S \left[ \frac{(1 - \tilde{\tau}^*) \alpha A g_k^{*1-\alpha}}{1 + \phi^y R^*} - \delta - \rho \right], \quad (29)$$

$$g_k^* = \left\{ A \left[ \tilde{\tau}^* + \omega \left( \phi^y + \phi^\theta \frac{\kappa \beta \theta^{*\beta} \tau}{1 + \phi^\theta R^*} \right) - \eta \right] \right\}^{\frac{1}{\alpha}}, \quad (30)$$

$$\theta^* = \left[ \frac{\kappa \beta^2 \tau}{\eta (1 + \phi^\theta R^*)} \right]^{\frac{1}{1-\beta}}. \quad (31)$$

We first examine the impact of seigniorage on the aggregate level of corruption, in comparative statics. Second, we highlight the existence of a threshold effect in the seigniorage-growth and study how corruption affects this threshold. Third, we show that corruption is an autonomous channel of non-superneutrality of money.

### 3.1. The impact of seigniorage on corruption

Since corruption is endogenous, we can determine how monetary policy affects the degree of corruption in the economy. Indeed, the aggregate level of corruption depends on the money growth rate

$$\theta^* = \left\{ \left[ \frac{\kappa \beta^2 \tau}{\eta [1 + \phi^\theta (\rho + \omega - \varsigma(\gamma^*))]} \right] \right\}^{\frac{1}{1-\beta}}. \quad (32)$$

**Proposition 2.** *(The impact of seigniorage on the aggregate level of corruption) For  $\phi^\theta > 0$  :*

- (i) *any increase in the seigniorage rate reduces the aggregate level of corruption.*
- (ii) *the higher  $\phi^\theta$ , the stronger the negative link between seigniorage and the aggregate level of corruption.*

PROOF.

From (9) and (31), we can easily show that the first derivative of  $\zeta(\theta_t)$  around its steady-state value (in the neighborhood of  $S \rightarrow 1$ ) with respect to both the money growth rate  $\omega$  and the parameter describing the transaction cost related to corruption  $\phi^\theta$  are negative

$$\left. \frac{\partial \zeta(\theta_t)}{\partial \omega} \right|_{\theta^*} = - \left[ \frac{\kappa^2 \beta^3}{\eta(1-\beta)} \right] \left[ \frac{\phi^\theta \tau (\theta^*)^{2\beta-1}}{(1+\phi^\theta(\rho+\omega))^2} \right] < 0. \quad (33)$$

□

The negative impact of seigniorage on the level of corruption results from the transaction cost specification, in which seigniorage acts as a tax on corruption, especially as  $\phi^\theta$  is high. Thus, in our model, increasing the seigniorage rate can be considered as an useful tool to reduce the aggregate level of corruption. This would be particularly true in the developing countries where the level of financial development is rather low. Indeed, in such economies, the seigniorage revenues collected by the commercial banks are low while the seigniorage revenues retrieved by the government are high.

### 3.2. Corruption and the growth-maximizing seigniorage rate

The following proposition assesses the effect of seigniorage on economic growth.

**Proposition 3.** (*Seigniorage and growth*)

- (i) *There exists a threshold of seigniorage  $\hat{\omega}$  that maximizes economic growth.*
- (ii) *The threshold  $\hat{\omega}$  is higher in the presence of corruption.*

PROOF.

From the first-order condition for the maximization of (24), we can extract an implicit threshold of the seigniorage rate (noted  $\hat{\omega}$ ) for low values of  $\phi^\theta$  ( $\phi^\theta \rightarrow 0$ )

$$\hat{\omega} = \frac{1 + (1-\alpha)\phi^y \rho - \alpha[1 + (1-\zeta(\theta^*))\tau - \eta]}{\phi^y(2\alpha-1)}, \quad (34)$$

where  $\hat{\omega}$  is positive since  $\alpha > 1/2$ .<sup>10</sup>

We can observe that corruption increases the growth maximizing seigniorage compared to a situation with no corruption since  $\partial\zeta(\theta^*)/\partial\omega < 0$ . In the case of an economy without corruption,  $\kappa = \eta = 0$  and the growth-maximizing seigniorage rate (noted  $\hat{\omega}$ ) would be

$$\hat{\omega} = \frac{1 + (1 - \alpha)\phi^y\rho - \alpha(1 + \tau)}{\phi^y(2\alpha - 1)} < \hat{\omega}. \quad (35)$$

□

As established in proposition 3, there is an U-inverted relation between seigniorage and growth that can be interpreted as a “Laffer curve” of seigniorage. The intuition of the threshold effect in the seigniorage-growth nexus is the following. Seigniorage can be used to finance productive public expenditures (with beneficial effects on growth) but increases the nominal interest rate which, in turn, increases transaction costs (with detrimental effects on private investment). Furthermore, we have previously shown that seigniorage is an instrument which can be used to fight corruption and to improve the effectiveness of the tax collection. The higher the seigniorage rate, the lower the level of corruption in the economy and then the higher the taxes collected to finance productive public expenditures.

In addition, we show that corruption leads to an increase of the threshold of seigniorage that maximizes economic growth. Two arguments can be provided to justify this result. First, corruption undermines tax collection and leads to a flight of tax revenues. Consequently, the government has no choice but to resort to an other instrument to finance productive public expenditures. Since seigniorage and tax income are substitutes in terms of government finance, the government may have incentives to generate seigniorage, so as to collect the inflation tax. Second, corruption generates unproductive public expenditures for the government that must be financed; hence an additional inducement to resort to the inflation tax.

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<sup>10</sup>In addition, the second-order condition ensures the concavity of the function  $\gamma^*$  in  $\omega$  :

$$\left. \frac{\partial^2 \gamma^*}{\partial \omega^2} \right|_{\phi^\theta \rightarrow 0} = \frac{(\alpha - 1)\phi^{y2}[1 - (1 - \zeta(\theta^*))\tau][1 + \eta - (1 - \zeta(\theta^*))\tau + \phi^y\rho]}{[\eta - (1 - \zeta(\theta^*))\tau - \phi^y\omega]^2} < 0$$

### 3.3. Corruption and the non-superneutrality of money

From proposition 2 and proposition 3, we can deduce that corruption is an autonomous channel of non-superneutrality of money. Usually, investment (Stockman, 1981) and capital accumulation (Cooley and Hansen, 1989) are considered as the main channels through which the money growth rate affects the real variables. We reach a similar conclusion in our model. We can notice in (29) and (30) that the seigniorage rate actually affects economic growth ( $\gamma^* \equiv \gamma(\omega)$ ). In other words, money is not superneutral in the long run. Specifically, we can observe three “effects” causing non-superneutrality of money in the framework of our model. There is a “Stockman effect” linked to fact that investment is subject to the CIA constraint, a “seigniorage effect” resulting from the introduction of seigniorage as an instrument of public finance in the government budget constraint and a “corruption effect” through the parameter  $\phi^\theta$ .

To show that corruption is a channel of non-superneutrality of money, one should put  $\phi^y = 0$  and consider that corruption is the only transaction affected by the cash-in-advance constraint. We can easily show that  $\frac{\partial \gamma^*}{\partial \omega} \Big|_{\phi^y \rightarrow 0} \neq 0$ . Economically, the fact that corruption is a channel causing non-superneutrality of money can be explained as follows. The money growth rate negatively affects the level of corruption (proposition 2) and the aggregate level of corruption nonlinearly affects the economic growth rate. Therefore, the money growth rate affects the growth rate through the channel of corruption.

## 4. Corruption, growth and welfare with a general transaction cost function

This section extends the results of the previous section to a general transaction cost function. Additionally, we examine welfare implications of the model. In the general case, it is difficult to obtain results, so we resort to a numerical simulation.

Our calibration is based on reasonable values for parameters. Specifically, parameters are set in order for the economic growth rate and the inflation rate to coincide with realistic values (close to 3.5% in the data).

In the benchmark calibration, the intertemporal elasticity of substitution (the inverse of the risk-aversion coefficient) is fixed at  $S = 1$  and the discount rate at  $\rho = 0.02$  (Menuet *et al.*, 2017). The tax rate on income is set at  $\tau = 0.4$  (Trabandt and Uhlig, 2011 ; Gomes *et al.*, 2013) and the money-growth rate is fixed at  $\omega = 0.07$ . The latter corresponds to the the growth-maximizing seigniorage rate in an economy



<b>Private sector</b>		
$S$	1	Intertemporal elasticity of substitution
$\rho$	0.2	Discount rate
$\mu/(1 + \mu)$	1/2	Elasticity of the demand for money
$\phi^y$	1	Cash requirement for consumption and investment
$\phi^\theta$	1	Cash requirement for corruption
$\xi$	0.02	Transaction cost technology parameter
$A$	0.6	Total factor productivity
$\alpha$	0.7	Capital share in the production function
$\delta$	0.03	Capital depreciation rate
<b>Government</b>		
$\tau$	0.4	Income tax rate
$\omega$	0.07	Seigniorage rate
$\eta$	0.1	Share of GDP used to combat corruption
<b>Corruption sector</b>		
$\kappa$	0.25	Scale parameter of the bribery technology
$\beta$	0.6	Elasticity of corruption

Table 1: Baseline calibration

with no corruption. Concerning the total factor productivity, we set  $A = 0.6$  and the share of capital in the production function is  $\alpha = 0.7$  (as in Gomes *et al.*, 2013).

Regarding the transaction cost technology, we fix  $\xi = 0.02$  to ensure low transactions costs. Moreover, we consider  $\mu = 1$  to get an elasticity of the demand for money equal to 1/2. Finally, the coefficients describing the efficiency of the transaction technology are set at  $\phi^y = \phi^\theta = 1$ .

Finally, we fix the parameters related to the technology of corruption in order to reach our targets of inflation and economic growth rates. We set the elasticity of corruption at  $\beta = 0.6$ , the scale parameter related to the corruption technology at  $\kappa = 0.25$  and the share of the GDP used by the government to fight against corruption at  $\eta = 0.1$ .

This calibration allows studying the effects of seigniorage on economic growth and welfare. In our model, in contrast with Barro (1990), maximizing growth does not amount to maximizing welfare, because of tax evasion and the opportunity cost of holding money. In what follows, we only focus on “second-best” welfare strategies in which a benevolent government operating in a decentralized economy determines

the policy instruments maximizing households' welfare.<sup>11</sup>

Since there is no transitional dynamics in the model, the intertemporal welfare of the representative household can be expressed as follows

$$\mathcal{U}(c_t) = \begin{cases} \left( \frac{S}{S-1} \right) \left[ \frac{(c_0 k_0)^{\frac{S-1}{S}}}{\rho - \gamma^* \left( \frac{S-1}{S} \right)} - \frac{1}{\rho} \right] & \text{if } S \neq 1 \\ \frac{\log(c_0) + \log(k_0)}{\rho} + \frac{\gamma^*}{\rho^2} & \text{if } S = 1, \end{cases} \quad (36)$$

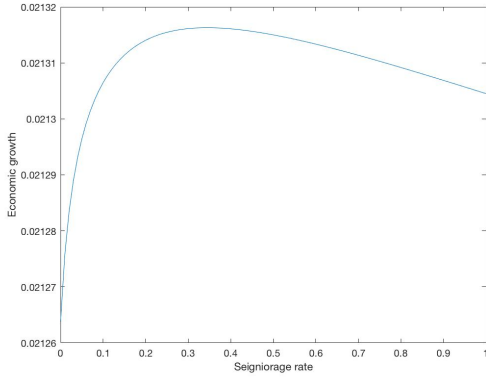
where initial consumption  $c_0$  is determined by the IS equilibrium such that  $c_0 = k_0 [Ag_{k_0}^{1-\alpha} - g_{k_0} - \gamma_0 - \delta]$ . The initial capital stock  $k_0$  is predetermined, and, for simplicity, normalized to one. Since there are no transitional dynamics in our model, we can write  $g_{k_0} = g_k^*$  and  $\gamma_0 = \gamma^*$ . However, it is quite difficult to find analytical expressions for the welfare-maximizing policy instruments (even in the CIA case). Consequently, we carry out numerical simulations.

Figure 1 reproduces the threshold between seigniorage and growth highlighted in the previous section and shows that corruption is a channel of nonsuperneutrality of money. Indeed, even if  $\phi^y = 0$ , the money growth rate affects the GDP growth rate and the effect remains nonlinear for the reasons mentioned above (see section 3.3). Additionally, can observe that a transaction cost function on all transactions leads to a lower growth-maximizing seigniorage rate and a lower economic growth rate than a transaction cost function on corruption only. This result is rather intuitive since transactions costs act as taxes on the monetary transactions.

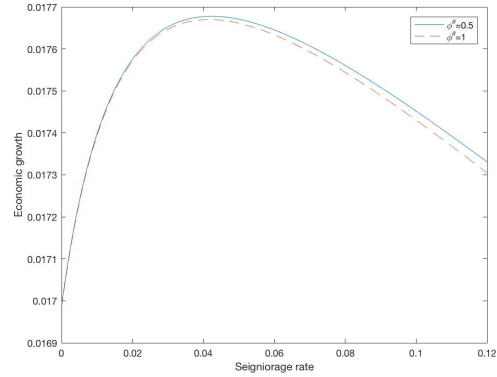
Figure 2 exhibits an inverted U-shaped relation between corruption and intertemporal welfare. Two remarks can be made. First, the welfare-maximizing seigniorage rate is clearly higher in an economy with corruption compared to an economy without corruption ( $\kappa = \eta = 0$ ). As in the growth-maximizing seigniorage rate case, this is explained by the fact that seigniorage allows reducing the degree of corruption in

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<sup>11</sup>Indeed, in our model, it is not possible for the government to reach the “first-best” solution. The “first-best” solution would require lump-sum taxation, zero corruption and no opportunity cost of holding money. In such a configuration, the “first-best” solution would correspond to that where a central planner chooses consumption, private investment and productive public expenditures by maximizing (1) under an aggregate constraint corresponding to the sum of the household budget constraint and the government budget constraint (7)+(14). Thus, the first order condition for the maximization of the program of the central planner would lead to the following “first-best” growth rate  $\gamma^{FB} = S \left[ \alpha A^{\frac{1}{\alpha}} (1 - \alpha)^{\frac{1-\alpha}{\alpha}} - \delta - \rho \right]$  where economic growth and intertemporal welfare are independent from the seigniorage rate and corruption.



(a)  $\phi^y = 0$  and  $\phi^\theta = 1$

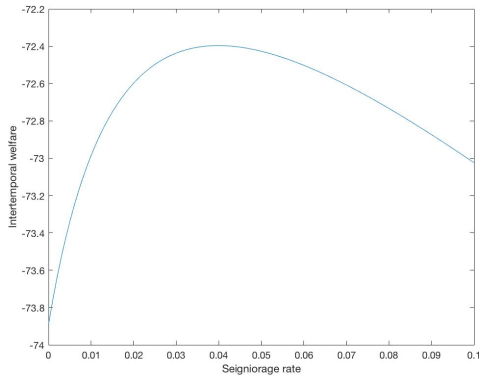


(b)  $\phi^y = 1$  and  $\phi^\theta > 0$

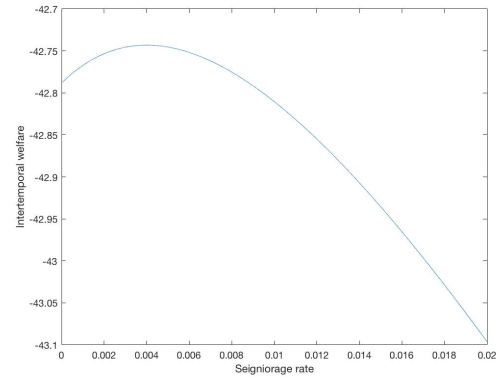
Figure 1: Seigniorage and growth

the economy and constitutes a substitute to the tax rate in terms of public finance.

Second, we can observe in figure 2 the welfare-maximizing seigniorage rate is slightly lower than the growth-maximizing seigniorage rate. In the case with corruption, the growth-maximizing seigniorage rate is equal to 4.15% while the welfare-maximizing seigniorage rate is equal to 4%.



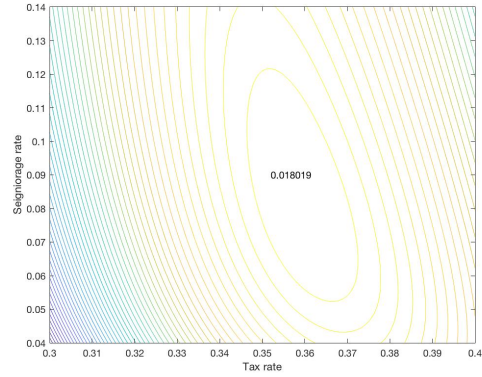
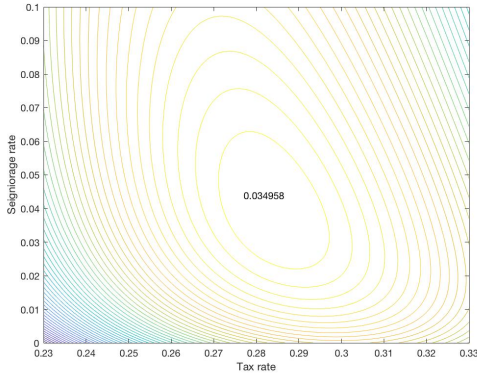
(a) With corruption ( $\phi^y = \phi^\theta = 1$ )



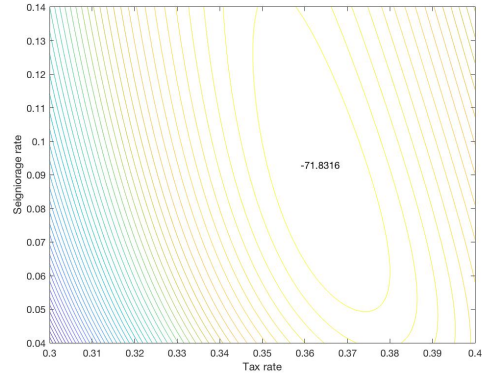
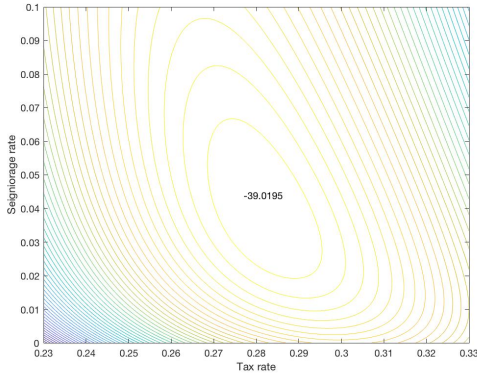
(b) Without corruption ( $\phi^y = \phi^\theta = 1$ )

Figure 2: Seigniorage and intertemporal welfare

Finally, figure 3 examines the growth-maximizing and the welfare-maximizing policy-mix. To determine the optimal policy-mix, the government simultaneously



(a) The growth-maximizing policy mix without corruption (b) The growth-maximizing policy mix with corruption



(c) The welfare-maximizing policy mix without corruption (d) The welfare-maximizing policy mix with corruption

Figure 3: The growth-maximizing and welfare-maximizing policy-mix

chooses the tax rate (fiscal policy instrument) and the seigniorage rate (monetary policy instrument) that maximize economic growth and intertemporal welfare. As it is well known, there is a “Laffer curve” of taxation in growth models based on the Barro (1990)’s archetype<sup>12</sup>. Therefore, the combination of this “Laffer curve” of taxation with the “Laffer curve” of seigniorage can give rise to interior solutions for

<sup>12</sup>In our model, we can easily obtain an implicit expression for the tax rate ceiling from the first order condition of (24) with respect to  $\tau$  (when  $\mu \rightarrow +\infty$ ):  $\hat{\tau} = \frac{(1-\alpha)-\alpha(\omega-\eta)}{1-\zeta(\theta^*)}$ .

the optimal policy-mix.

Figure 3 presents the contour lines of the growth-maximizing and the welfare-maximizing seigniorage rate for our baseline calibration. We can observe that corruption increases the optimal values of the policy instruments for both a growth-maximizing and a welfare-maximizing government. Nevertheless, we also observe that corruption dramatically lowers economic growth and intertemporal welfare. In other words, corruption leads to an increase in the optimal combination of the tax rate and the seigniorage rate but this optimal combination generates a lower growth rate (from 3.4859% to 1.8019%) and a lower intertemporal welfare (from -39.0195 to -71.8316).

## 5. Further results on corruption and inflation

In our model, the relationship between corruption and inflation goes through the channel of economic growth. Indeed, from money equilibrium, we get:  $\pi^* = \omega - \gamma^*$ . Inflation is then a positive function of seigniorage and a negative function of economic growth (as in De Gregorio, 1993 ; Barro, 1995 ; Andrés and Hernando, 1997 ; Adam and Bevan, 2005 ; Bose *et al.*, 2007). Thus, since growth depends on the aggregate level of corruption, we must analyze the mechanisms through which corruption affects growth in order to determine the relation between corruption and inflation. However, we should notice that both the inflation rate and the economic growth rate are endogenous variables and depend on the same policy parameters. Therefore, we need to resort to numerical simulations to determine the relation between the two variables.

**Proposition 4.** *(The relation between corruption and inflation) There is a U-shaped relation between corruption and inflation. At low levels, corruption reduces inflation. Conversely, high levels of corruption lead to an increase in the inflation rate.*

PROOF. Simulation-based proof

This proposition can be explained as follows. Corruption exerts a double on economic growth. On the one hand, it adversely affects growth by reducing tax revenues and limiting the capacity of the government to finance productive public expenditures. On the other hand, corruption can boost growth by increasing the

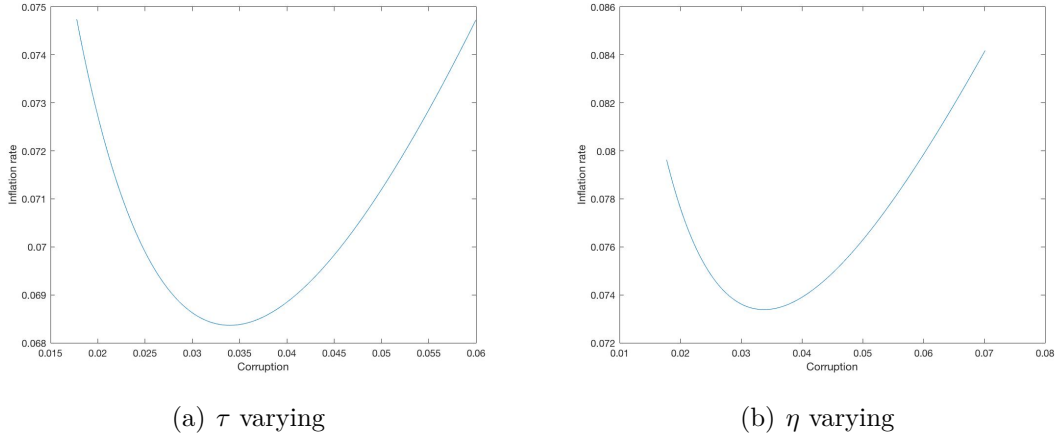


Figure 4: Corruption and inflation

disposable income of households and, consequently, capital accumulation. If the first effect dominates, we are on the decreasing part of the curve describing the relation between corruption and growth and conversely. This contrasts with the model of Blackburn and Powell (2011) which considers that corruption is exogenous and always negatively affects capital accumulation.

Since the seminal work of Al-Marhubi (2000), it is widely agreed in the literature that corruption increases inflation. Two main arguments sustain this view. First, higher seigniorage revenues are required to offset the losses caused by corruption. Second, corruption may increase public deficits, leading to inflationary pressures.

Our model reaches a similar conclusion, but for high levels of corruption only. Effectively, previous studies only focused on the effect of corruption on government finance, but neglected its beneficial impact on households' income. Since corruption rise households' disposable income, there can be a rise in private investment that overcomes the negative effect of tax evasion on productive public expenditures. This mechanism plays as long as corruption is low enough, hence the ceiling in the corruption-growth nexus, leading to a threshold effect on inflation.

To empirically assess this finding, we provide here some evidence about the relation between corruption and inflation. To test the potential existence of nonlinearities in the corruption-inflation nexus, we introduce a quadratic specification.<sup>13</sup>

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<sup>13</sup>To our knowledge, no empirical work has tested such a nonlinearity. See Ben Ali and Sassi (2016) for a review of the recent literature on the topic.

Regarding the data, we consider a panel of 85 developed and developing countries<sup>14</sup> over the period 1984-2012. The dependent variable (inflation) stems from the World Development Indicators database of the World Bank and is calculated as the annual increase in the Consumer Price Index (CPI). The corruption index is taken from the ICRG database. The control variables include usual determinants of inflation (see Al-Marhubi, 2000) : GDP per capita growth, openness, growth rate of broad money and central bank independence<sup>15</sup> (index of Cukierman *et al.*, 1992). All control variables stem from the the World Development Indicators database of the World Bank except the variable of central bank independence which is constructed by Garriga (2016). Since our model exhibits that corruption and inflation are endogenously related, we resort to a GMM approach to take this feature into account (Arellano and Bond, 1991 ; Arellano and Bover, 1998 and Blundell and Bond, 2001). Thus, the estimated equation is

$$\pi_{j,t} = \mu_j + \alpha_1\theta_{j,t} + \alpha_2\theta_{j,t}^2 + \alpha_3'X_{j,t} + \varepsilon_{j,t}, \quad (37)$$

where  $\mu_j$  denotes the individual fixed effects of the country  $j$ ,  $\pi_{j,t}$  corresponds to the inflation rate of the country  $j$  at time  $t$ ,  $\theta_{j,t}$  represents the level of corruption of the country  $j$  at time  $t$ ,  $X_{j,t}$  is a matrix of the other determinants of inflation and  $\varepsilon_{j,t}$  is the error term.

Thereafter, we highlight the relation between corruption and inflation by determining the marginal effect of corruption with respect to inflation

$$\frac{\partial \pi_{j,t}}{\partial \theta_{j,t}} = \alpha_1 + 2\alpha_2\theta_{j,t}, \quad (38)$$

and the threshold in the corruption-inflation nexus is obtained for  $\hat{\theta} = -\alpha_1/2\alpha_2$ .

Descriptive statistics are provided in Appendix 3. Table 2 presents the GMM estimates and figure 5 a graphic illustration of the marginal effect of corruption on inflation. Empirical results support the predictions of the theoretical model. Both corruption and squared corruption have the expected sign and are significant. Therefore, at low levels (below the threshold  $\hat{\theta}$ ), corruption and inflation are negatively associated, whereas at high levels (above  $\hat{\theta}$ ) they are positively associated. In addition, the AR(2) and Sargan tests allow not to reject the hypothesis of instruments

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<sup>14</sup>The list of countries is provided in Appendix C.

<sup>15</sup>High values of the CBI index denote low central bank independence.

validity.

<b>Dependent variable</b>	<b>Inflation</b>	
<b>Interest variables</b>	Coeff.	Std. Error
Corruption	-3.421***	1.184
Corruption <sup>2</sup>	0.954***	0.145
<b>Control variables</b>		
GDP per capita growth rate	-0.212***	0.011
Central Bank Independence	3.270***	0.981
Growth rate of broad money	-0.001	0.008
Openness	0.217***	0.006
AR(2) p-value	0.373	
Hansen test p-value	0.720	
Number of observations	1688	

Note: Standard errors in brackets. \*\*\* denotes significance at the 1% level.

Table 2: GMM estimates

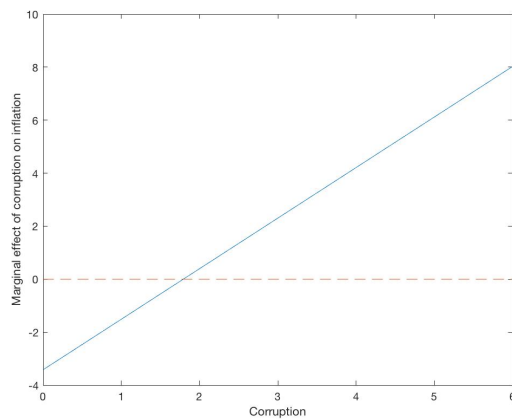


Figure 5: Marginal effect of corruption on inflation



## 6. Conclusion

In this paper, we have developed an endogenous growth model with transaction costs and endogenous corruption. Specifically, we have considered that households interact with corrupt bureaucrats in order to reduce the amount of taxes that they have to pay. We have also assumed that all the transactions, including corruption, are subject to a transaction cost function.

Our model provides several interesting results that contribute to the debate about the interactions between corruption, inflation and growth. First, seigniorage acts as a tax on corruption and therefore allows reducing the aggregate level of corruption in equilibrium. Second, corruption increases both the growth-maximizing and the welfare-maximizing seigniorage rate, in line with Blackburn and Powell (2011) and Myles and Yousefi (2015). Third, we have identified corruption as an autonomous channel of non-superneutrality of money. Fourth, our model exhibits a U-shaped relation between corruption and inflation. This confirms the positive effect of corruption on inflation, found by Al-Marhubi (2000) and Abed and Davoodi (2002) among others, for high levels of corruption. However, at low levels, corruption is negatively linked to inflation because of its positive effect on capital accumulation. On this last point, some empirical estimations are implemented and confirm the predictions of the theoretical model.

This paper can be extended in several directions. *First*, the conclusions of our model requires more investigations, especially with regard to the link between corruption, seigniorage and inflation, and should deepen at two levels. At the empirical level, we could resort to nonlinear models in panel data (like the PTR or the PSTR models) to examine the threshold effects between corruption and inflation on the one hand, and the impact of corruption on the values of the thresholds of the growth-maximizing seigniorage rate on the other. At the theoretical level, future research should also focus on (i) refining the microfoundations of corruption and (ii) introducing these microfoundations in other frameworks (in an OLG model for instance, as Myles and Yousefi, 2015). *Second*, the introduction of a financial sector affecting the seigniorage revenues retrieved by the government to finance productive public expenditures could be a potential subject for further research. Since the less financially developed countries resort more to seigniorage to finance public spending, the introduction of such a sector would allow nuancing the conclusions of our model, depending on the level of financial development.

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## Appendix A: Model solution

In equilibrium, the representative household maximizes intertemporal utility (1) subject to the constraints (2), (3), (4), (??) and (7),  $k_0$  given and a standard transversality condition

$$\lim_{t \rightarrow +\infty} \left( \exp \left( - \int_0^{+\infty} r_s ds \right) (k_{i,t} + m_{i,t}) \right) = 0 \quad (\text{A.1})$$

By using the definition of net investment:  $\dot{k}_{i,t} = z_{i,t} - \delta k_{i,t}$ , the current hamiltonian associated with the household's maximization program can be written

$$\mathcal{H}_c = u(c_{i,t}) + \lambda_{1,t} [(1 - \tilde{\tau}_{i,t}) y_{i,t} - c_t - \pi_t m_{i,t} - \Upsilon(\cdot) - z_t - p_{i,t} \theta_{i,t} + T_{i,t}] + \lambda_{2,t} [z_{i,t} - \delta k_{i,t}] \quad (\text{A.2})$$

where  $\lambda_{1,t}$  and  $\lambda_{2,t}$  are the co-state variables respectively associated with the two state variables  $m_t$  and  $k_t$ .

The first-order conditions are

$$/c_{i,t} \quad u'(c_{i,t}) = \lambda_{1,t} [1 + \phi^y \mathcal{Q}] \quad (\text{A.3})$$

$$/z_{i,t} \quad \lambda_{2,t} = \lambda_{1,t} [1 + \phi^y \mathcal{Q}] \quad (\text{A.4})$$

$$/\theta_{i,t} \quad \zeta'(\theta_{i,t}) \tau y_{i,t} = p_{i,t} [1 + \phi^\theta \mathcal{Q}] \quad (\text{A.5})$$

$$/m_{i,t} \quad \frac{\dot{\lambda}_{1,t}}{\lambda_{1,t}} = \rho + \pi_t - \xi \left( \frac{\phi^y y_{i,t} + \phi^\theta p_t \theta_{i,t}}{m_{i,t}} \right)^{1+\mu} \quad (\text{A.6})$$

$$/k_{i,t} \quad \frac{\dot{\lambda}_{2,t}}{\lambda_{2,t}} = \rho + \delta - (1 - \tilde{\tau}_{i,t}) \frac{\lambda_{1,t}}{\lambda_{2,t}} \alpha A k_{i,t}^{\alpha-1} g_{i,t}^{1-\alpha} \quad (\text{A.7})$$

where  $\mathcal{Q} = \xi \left( \frac{1+\mu}{\mu} \right) \left( \frac{\phi^y y_{i,t} + \phi^\theta p_{i,t} \theta_{i,t}}{m_{i,t}} \right)^\mu$

The first order conditions can be easily interpreted.  $\lambda_{1,t}$  represents the shadow price (i.e. the opportunity cost) of money while  $\lambda_{2,t}$  corresponds to the shadow price of capital. The shadow price of money  $\lambda_{1,t}$  differs from the shadow price of capital  $\lambda_{2,t}$  because investment expenditures are subject to a transaction cost ( $\lambda_{1,t} = \lambda_{2,t}$  if  $\phi^y = 0$  or if  $m_t \neq m(\dot{k}_t + \delta k_t)$ ). Indeed, in our specification, capital cannot be acquired without money. This is why the opportunity cost of capital is higher than the opportunity cost of money. Moreover, the dynamics of the shadow prices of money and capital are given in (A.6) and (A.7), respectively.

Hence, we obtain the expression of the nominal interest rate as

$$R_t = \xi \left( \frac{\phi^y y_t + \phi^\theta p_t \theta_t}{m_t} \right)^{1+\mu}, \quad (\text{A.8})$$

and

$$R_t = \left( \frac{\mu}{1 + \mu} \right) \left( \frac{\phi^y y_t + \phi^\theta p_t \theta_t}{m_t} \right) \mathcal{Q} \quad (\text{A.9})$$

and the demand function for money is

$$m_t = \xi^{\frac{1}{1+\mu}} (\phi^y y_t + \phi^\theta p_t \theta_t) R_t^{-\frac{1}{1+\mu}}. \quad (\text{A.10})$$

## Appendix B: Local stability of the steady-state

The reduced form of the model is given by (15) and (16)

$$\begin{cases} \dot{c}_k = S \left[ \frac{(1-\bar{\tau})\alpha A g_k^{1-\alpha}}{1+\phi^y R_t^{\frac{1}{1+\mu}}} - \delta - \rho \right] c_k - \gamma_k c_k \\ \dot{R}_t = \left( \frac{1+\phi^y R_t}{\phi^y} \right) \left[ r_t + \delta - \frac{(1-\bar{\tau})\alpha A g_k^{1-\alpha}}{1+\phi^y R_t^{\frac{1}{1+\mu}}} \right] \end{cases} \quad (\text{B.1})$$

where  $g_k \equiv g_k(R_t)$  and the growth rate of capital is obtained from the IS equilibrium

$$\gamma_k \equiv \frac{\dot{k}_t}{k_t} = A g_k^{1-\alpha} - g_k - c_k - \delta \quad (\text{B.2})$$

and

$$r_t = (1 - \alpha) \frac{\dot{g}_k}{g_k} + R_t + \gamma_k - \omega - \frac{1}{1 + \mu} \frac{\dot{R}_t}{R_t} - g(R) \dot{R}_t, \quad (\text{B.3})$$

where

$$\frac{\dot{g}_k}{g_k} = \frac{\beta\kappa\mu\tau\phi^\theta h\theta^{*\beta} \left[ R_t \left( 1 + \phi^\theta h R_t^{-\frac{1}{1+\mu}} \right) \right] - \xi^{\frac{1}{1+\mu}} \omega \left[ \phi^y (1-\beta) \left( 1 + \phi^\theta h R_t^{\frac{\mu}{1+\mu}} \right)^2 + \phi^\theta \beta\kappa\tau\theta^{*\beta} \left( 1 - \beta + h(1+\mu-\beta) R_t^{\frac{\mu}{1+\mu}} \right) \right] \frac{\dot{R}_t}{R_t}}{\alpha(1-\beta)(1+\mu) \left( 1 + \phi^\theta h R_t^{\frac{\mu}{1+\mu}} \right) \left[ \tilde{\tau}_t + \xi^{\frac{1}{1+\mu}} \omega \left( \phi^y + \phi^\theta \frac{\kappa\beta\theta_t^\beta \tau}{1+\phi^\theta h R_t^{\frac{\mu}{1+\mu}}} \right) R_t^{-\frac{1}{1+\mu}} - \eta \right]}, \quad (\text{B.4})$$

and

$$g(R) \equiv \frac{(\phi^\theta)^2 \mu h}{\beta(1-\beta)(1+\mu)} \frac{\theta_t R_t^{-\frac{1}{1+\mu}}}{\phi^y + \phi^\theta \phi^y h R_t^{\frac{\mu}{1+\mu}} + \beta\kappa\phi^\theta \tau (\theta_t)^\beta}. \quad (\text{B.5})$$

By linearizing of the model in the neighborhood of the steady state can, we obtain

$$\begin{pmatrix} \dot{c}_k \\ \dot{R}_t \end{pmatrix} = \mathbf{J} \begin{pmatrix} c_k - c_k^* \\ R_t - R^* \end{pmatrix} \quad (\text{B.6})$$

where  $\mathbf{J}$  is the Jacobian matrix, defined as (for  $\mu \rightarrow +\infty$  and  $\phi^\theta \rightarrow 0$ )

$$\mathbf{J} = \begin{pmatrix} c_k^* & -S\phi^y \left[ \frac{(1-\tilde{\tau})\alpha A g_k^{*1-\alpha}}{(1+\phi^y R^*)^2} \right] c_k^* \\ -\frac{1+\phi^y R^*}{\phi^y} & \left( \frac{1+\phi^y R^*}{\phi^y} \right) \left[ 1 + \frac{(1-\tilde{\tau})\alpha A g_k^{*1-\alpha}}{(1+\phi^y R^*)^2} \right] \end{pmatrix} \quad (\text{B.7})$$

Trivially, the trace of the Jacobian matrix is positive. In addition, the determinant is also positive for moderate values of the intertemporal elasticity of substitution (for  $S < \frac{1}{\phi^y} + \left( \frac{1+\phi^y R^*}{\phi^y} \right) \left[ \frac{(1+\phi^y R^*)^2}{(1-\tilde{\tau})\alpha A g_k^{*1-\alpha}} \right]$ ). Consequently, both eigenvalues are positive. Therefore, according to the Blanchard-Kahn conditions, there are no transitional dynamics in the model and all real variables jump from  $t = 0$  to their steady state values and grow at the same rate along the balanced growth path.

### Appendix C: Descriptive statistics

The 85 countries included in the panel are : Algeria, Albania, Australia, Bahrain, Belgium, Austria, Argentina, Bolivia, Botswana, Brazil, Burkina Faso, Cameroon, Chile, Colombia, China, Canada, Bulgaria, Cote d'Ivoire, Denmark, Costa Rica, Dominican Republic, Ecuador, Egypt Arab Rep., Finland, France, Gambia, Gabon,



Ghana, Greece, Guinea, Guyana, Hungary, India, Iran Islamic Rep., Ireland, Israel, Jamaica, Jordan, Kenya, Kuwait, Japan, Italy, Indonesia, Lebanon, Malawi, Malaysia, Mali, Morocco, Mexico, Mongolia, New Zealand, Niger, Norway, Pakistan, Namibia, Nicaragua, Nigeria, Oman, Poland, Romania, Saudi Arabia, Peru, Philippines, Paraguay, Portugal, Qatar, Senegal, Spain, Sri Lanka, Singapore, South Africa, Sweden, Tanzania, Tunisia, Uganda, Turkey, Trinidad and Tobago, Togo, Thailand, Switzerland, Uruguay, United States, United Kingdom, Venezuela and Vietnam.

<b>Variable</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min</b>	<b>Max</b>
<b>Inflation</b>	7.595	11.496	-27.632	11749.639
<b>Corruption</b>	3.164	1.203	0	6
<b>GDP per capita growth</b>	2.1642	3.8506	-42.623	35.718
<b>Openness</b>	78.461	47.575	12.346	439.657
<b>Growth rate of private credit</b>	56.036	47.651	0	218.088
<b>Central Bank Independence</b>	0.472	0.218	0	1

Table C.3: Descriptive statistics