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Corruption in Public Finances, and the Effects on Inflation, Taxation, and Growth

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Abstract
In this paper, we study the effects of bureaucratic corruption on inflation, taxation, and growth. Here corruption takes three forms: (i) it reduces the tax revenues that are raised from households, (ii) it inflates the volume of government spending, and (iii) it reduces the productivity of 'effective' government expenditure. Our policy experiments reveal that the effect of (i) is to increase both seigniorage and the income tax rate, and to decrease the steady-state growth rate. The effect of (ii) is to increase seigniorage, which leads to lower growth, although the effect on the income tax rate is ambiguous. The effect of (iii) is to increase seigniorage and decrease the income tax rate. The former yields a lower growth rate, while the latter has an ambiguous effect on growth. These findings, from our unified framework involving corruption in public finances, could rationalise the apparently conflicting evidence on the impact of corruption on economic growth provided in the literature, highlighting the presence of conditional corruption effects.

Keywords: Bureaucratic corruption, public finances, seigniorage, income tax, inflation, growth.

JEL classification: D73, E60, O42.

1. Introduction

The endogenous growth literature has demonstrated the importance of fiscal policy issues in relation to the long-run growth of nations. This paper attempts to bring together two strands in the literature on public finance and growth. The first refers to the way corruption affects public spending and revenues. The second relates to the modes of financing of public expenditures and their growth effects. Both aspects are rather important, but while each of these has been dealt with in the macro-growth literature, there has been insubstantial amount of research linking the two. This is precisely the objective of this paper.

Corruption, the abuse of public office for private gain, is a major problem afflicting mostly developing countries. There is a voluminous literature on the effects of bureaucratic corruption (see Bardhan (1997), Jain (2001), Aidt (2003), and Svensson (2005) for comprehensive reviews).[1] The negative aspects of corruption are well-documented. Shleifer and Vishny (1993), for instance, show that corruption may be costly because a weak central government could allow bureaucracies to impose independent bribes on private agents seeking permits from them; and also that the demands of secrecy can cause a shift in a country's public spending from socially desirable projects into potentially useless projects, where there is greater scope for inflating public expenditures and indulging in covert corruption. In most theories that link corruption to slow economic growth, the primary social losses of corruption come from propping up of inefficient firms, and the allocation of talent, technology and capital away from their socially most productive uses (Murphy, Shleifer and Vishny (1991), (1993)). Mauro (1995), who first studied the macroeconomic relationship between corruption and growth in a large cross-section of countries, finds robust evidence of a negative link between a broad measure of bureaucratic corruption on the one hand, and investment and growth on the other. The negative effect of corruption on growth is found also in Knack and Keefer (1995, 1997), Sachs and Warner (1997), Pellegrini and Gerlagh (2004), Meon and Sekkat (2005), among others.

[1] A point that ought to be made clear at the outset is that we are, in this paper, attempting to capture "petty" corruption rather than "grand" corruption. The former occurs when bureaucrats running the administration are corrupt, while the government is benevolent; with the latter, the government itself is corrupt. (See Rose-Ackerman (1999) for a distinction.)

But there are arguments in favour of corruption as well. We know that in a second-best world with pre-existing distortions, additional distortions could theoretically improve welfare. The argument for efficiency-improving corruption is a simple extension of this idea (see, for example, Leff (1964), Huntington (1968)). Another efficiency argument in favour of corruption is to view it as "speed money", i.e., that which circumvents other distortions that are induced by bureaucratic delays and red-tape. Thus, a system built on bribery in the allocation of licences may lead to an outcome where the highest bribes are paid by the most efficient firms (see Lui (1985)). However, as Myrdal (1968) has argued, corrupt officials may actually *cause* administrative delays in order to attract more bribes; so it is not clear that corruption actually does any good in effect.

In some recent papers, it has been argued that the relationship between corruption and growth is conditional upon particular country characteristics. These papers also demonstrate that there exist important links between political institutions/governance regimes on the one hand and economic growth on the other. Méon and Sekkat (2005) propose a test on whether corruption "greases" or "sands" the wheels of growth. Considering interactions between indicators of the quality of institutions and corruption, the authors report that corruption is most harmful to growth where governance is weak. Méndez and Sepúlveda (2006) argue that the negative impact of corruption on growth materializes only for the "free" countries.[2] Aidt *et al*. (2008), emphasizing the role of political institutions as a determinant of the governance regime, find a similar result: in countries with high quality institutions, corruption has a large, negative impact on growth and conversely that growth reduces corruption; in countries with low quality institutions, there is no impact on growth. In our paper, where we derive comparative-static effects of changes in corruption parameters on growth and inflation, we show that a connection can be made between our findings and the governance-growth results of the above papers.

In the context of public finances, corruption can clearly affect both the expenditure and revenue sides of the government's budget: corruption can distort the composition of expenditures by shifting resources towards items where the possibility of inflating spending and obtaining more "commissions" is higher, as alluded to by Shleifer

[2] The authors follow Ehrlich and Lui (1999) in distinguishing "free" and "non-free" countries via the Freedom House index of political rights and civil liberties.

and Vishny (1993), for example. Corruption can also alter the manner by which revenues are generated, e.g., by shifting from tax to seigniorage revenues when part of the tax proceeds do not accrue to the government and is usurped, as in Blackburn, Neanidis and Haque (2008) - henceforth, BNH - and as suggested by other empirical evidence. Also Ghura (1998), Imam and Jacobs (2007), and Tanzi and Davoodi (1997, 2000) conclude that corruption reduces total tax revenues by reducing the revenues from almost all taxable sources (including incomes, profits, property, capital gains, etc.). The implication is that, *ceteris paribus*, other means of raising income must be sought, and one of the most tempting of these is seigniorage. Significantly, it has been found that seigniorage is closely linked with inflation (see Cukierman *et al*. (1992)), and also that inflation is positively related to the incidence of corruption (e.g., Al-Marhubi 2000). Seigniorage, itself, has a negative effect on growth (e.g., Adam and Bevan (2005); Bose *et al*. (2007)). This paper, which seeks to analyse in detail how corruption influences the size and productivity of public spending, the composition of government revenues, and the implications of these for growth and development, is motivated by the above findings.

The literature on fiscal policy and growth has mostly concentrated on the effects of different types of expenditures on growth (see, for example, Barro (1990), Futagami *et al*. (1993), Devarajan *et al*. (1996), Turnovsky (1997), Turnovsky and Fisher (1995), etc.). In contrast, the literature on the effects on growth of the method of financing such expenditures is much sparser. De Gregorio (1993), Miller and Russek (1997), Palivos and Yip (1995), among others, deal with this issue. Although, in general, the two most common financing methods – income taxation and seigniorage – are both considered distortionary, there is no consensus on the relative merits of tax versus money financing of public spending. For example, Palivos and Yip (1995) consider income-tax financing to be worse than seigniorage financing, whereas De Gregorio (1993) generally argues the opposite. Bose *et al*. (2007) link the optimal mode of financing to the levels of development, i.e., they find that for low-income (high-income) countries, financing expenditures with revenue generated by income taxation (seigniorage) is less distortionary for growth. In a similar vein, Holman and Neanidis (2006), in a small open economy model, find that the adverse growth effects of seigniorage are more prominent than those of income taxes for economies that are less financially developed. Miller and

Russek (1997) find that a tax-financed increase in public spending in developing countries actually leads to higher growth, while that in developed countries lowers growth. None of these papers, however, attribute corruption as a factor that affects the relative efficiency of seigniorage as against income taxation. This is what we turn to in the following paragraphs.

In this paper, we identify some of the channels through which corruption in tax administration and/or corruption in public expenditures could lead to over-reliance on seigniorage, which could affect an economy's growth rate.[3] Here corruption features in three distinct ways. On the revenue side, corruption in tax administration implies that not all tax revenues come to the government coffers as some of it goes missing on account of corrupt bureaucrats involved in tax collection as in BNH, and Tanzi and Davoodi (2000). On the expenditure side, there are two types of effects: first, corrupt officials inflate the size of the public spending, not for increasing the size of the national cake, but for their own pecuniary gain; secondly, although the amount of public spending is higher than warranted, the productivity arising out of such spending is considerably lower than it would otherwise have been. Although some of these aspects have been captured in empirical models (see Mauro (1995, 1998), Tanzi and Davoodi (1997), and Haque and Kneller (2008), among others), explicit analytical conditions have not been derived in the literature on the effects of corruption in public finances.

Our theoretical analysis is based on an endogenous growth model in which capital accumulation is governed by the portfolio allocation decisions of financial intermediaries on behalf of agents. Following Diamond and Dybvig (1983) and Espinosa-Vega and Yip (1999, 2000), we consider a scenario in which individuals are subject to random relocation shocks that create a trade-off between investing in a productive, but illiquid, asset (capital) and a non-productive, but liquid, asset (money). Intermediaries, which receive deposits from individuals, optimise this trade-off by choosing a composition of portfolio that depends on the relative rates of return of the two assets. An increase in inflation, which reduces the return on money, causes a portfolio re-allocation away from

[3] The political model of tax reform by Cukierman *et al*. (1992) explains the prevalence of seigniorage relative to other sources of revenue in many countries in terms of the degree of political instability or polarization prevailing there, which may actually result in a more inefficient tax system to be preferred. The latter discourages public spending and forces the government to rely more on seigniorage and less on regular taxes.

capital investment (loans to firms) towards greater cash holdings in order to guarantee adequate provision of liquidity services for those agents who are forced to relocate. Against this background, we study the effects of corruption on growth and development. We model corruption as the embezzlement of public funds by bureaucrats who are appointed by the government to procure productive public goods and collect tax revenues from firms. An increase in corruption related with either of these implies (given the absence of borrowing), that the government must rely more on the revenue from printing money (i.e., seigniorage) in order to satisfy its budget constraint. The effect of this is to increase inflation with the consequences described above. Since capital investment is lower, so too is the accumulation of capital, and thereby the rate of growth. Higher corruption may also lead to a greater income tax rate, which may lower the rate of growth by influencing the net-of-tax investment in private capital. An increase in corruption leading to a lower productivity of public spending, on the other hand, will also have similar effects on seigniorage and the growth rate, while it leads to a lower income tax rate.

We perceive the value added of our paper in terms of the way we formally model the different types of corruption in government spending and revenue, based on the empirical literature in the area, and the comparative-statics effects of changes in the different corruption parameters on growth and inflation. In doing so, we establish a link between the literature on corruption in public revenues and expenditures, on the one hand, and studies focusing on the growth effects of different revenue-generating policies, on the other. To date we have not found any paper that jointly considers the effects of corruption through both sides of the government budget constraint, although empirical evidence has been provided in that direction.

The rest of the paper is organised as follows. Section 2 presents the theoretical model, and characterizes the balanced growth path of the economy. Section 3 contains the detailed comparative-static analysis, whereby we solve our model and analyse the effects of corruption on the key economic variables. Finally, Section 4 contains a few concluding remarks.

2. The analytical model

2.1. Bureaucrats

We begin by modelling the activities of bureaucrats or public officials, as the impact of their behaviour forms the backbone of our paper. The economy's agents are divided into households (μ) and public officials (1-μ).[4] Public officials are divided into those that work on revenue collection (v) and those that act in the procurement of the public good (1-v). This means that v(1-μ) bureaucrats collect revenues and (1-v)(1-μ) procure public goods.

The revenues collected by the bureaucrats are represented by a fixed proportional tax rate, $\tau \in (0,1)$, the government levies on firm's output, y_t. The public goods and services procured by the bureaucrats have a real value G_t and are thought to contribute to the efficiency of the firm's output production. We assume that the public outlays related to the provision of public goods are a fixed proportion, $\theta \in (0,1)$, of output, y_t.

From the v(1-μ) bureaucrats that collect revenues, we assume that (1-η) are corrupt. We also assume that a fraction χ of the officials that procure the public good are also corrupt.[5] This allows us to make a distinction as to the number of corrupt officials on the two sides of the constraint: $(1-\eta)\nu \neq \chi(1-\nu)$.

These imply that on the revenue side, which largely follows the analysis of BNH, each official collects taxes from $\frac{1}{\nu(1-\mu)}$ firms. This implies that total tax revenues collected by all bureaucrats are $\frac{\tau y_t}{\nu(1-\mu)}$. However, only the non-corrupt among the bureaucrats involved in revenue collection bring the tax proceeds to the government. Hence, total tax revenues provided to the government by the non-corrupt officials are described by $\eta\nu(1-\mu)\frac{\tau y_t}{\nu(1-\mu)} = \eta\tau y_t$. As a result, total tax revenues appropriated by corrupt officials are given by $(1-\eta)\tau y_t$.

[4] As in Blackburn *et al.* (2006) and Sarte (2000), we abstract from issues relating to occupational choice and assume that agents are differentiated at birth according to their abilities and skills.

[5] This distinction between corruptible and non-corruptible bureaucrats may reflect differences in proficiencies at being corrupt or differences in moral attitudes towards being corrupt (e.g., Acemoglou and Verdier (2000); Blackburn *et al*. (2006); Tirole (1996)).

On the spending side, each official is responsible for the procurement of $\frac{\theta}{(1-\nu)(1-\mu)} y_t$ public goods. However, while each non-corrupt official procures $\frac{\theta}{(1-\nu)(1-\mu)} y_t$, each corrupt official artificially inflates public spending to an amount equal to $\frac{\theta(1+\varepsilon)}{(1-\nu)(1-\mu)} y_t$, $\varepsilon > 0$. Here, ε represents the size by which spending is inflated due to corruption.

Therefore, total spending on public goods (g_t) is given by

$$\begin{aligned} g_t &= (1-\chi)(1-\nu)(1-\mu)\frac{\theta}{(1-\nu)(1-\mu)} y_t + \chi(1-\nu)(1-\mu)\frac{\theta(1+\varepsilon)}{(1-\nu)(1-\mu)} y_t \\ &= (1+\chi\varepsilon)\theta y_t. \end{aligned} \tag{1}$$

This means that the actual spending on public goods increases due to corrupt practices. However, as we will see below, only θy_t of total public spending is utilised in the firms' production function, so that the difference of $\chi\varepsilon\theta y_t$ represents the illegal income (i.e., embezzlement) of corrupt bureaucrats.

Note that the expression for public spending given above captures an aspect of corruption in public spending stressed by Mauro (1998), who in a cross-country empirical study, first conveyed the idea of the composition of public spending being determined largely by the capacity to generate bribes. Using corruption indices for the chosen countries, he shows that corruption reduces the spending on education, as it does not provide lucrative opportunities for government officials in a way that certain other components of spending do.[6] In terms of our analysis, higher corruption would be captured by a higher $\chi\varepsilon$ value (i.e., greater embezzlement), and the categories of spending that enable a large magnitude of $\chi\varepsilon$ to be generated would typically be preferred by bureaucrats. Considering broad categories of public expenditure, the study by Tanzi and Davoodi (1997) shows, using cross-country data, that high corruption is associated with high public capital expenditures, but low operations and maintenance expenditures. This is understandable, given that the scope for indulging in corrupt

[6] This is mainly because its provision typically does not require high technology inputs provided by oligopolistic suppliers.

practices is much higher for capital spending, given the discretionary nature of such spending.

It is important to note that corruption in our model also leads to a productivity loss, but only in the context of the procurement of public goods by corrupt bureaucrats. Each unit of the public good yields a productivity of ξ units when this is procured by (1-χ) non-corrupt bureaucrats, but only ξ(1-λ) units when this is procured by the χ corrupt bureaucrats. Therefore, the parameter $\lambda \in (0,1)$ captures the productivity loss of public spending due to corrupt practices.

So, incorporating this aspect on the spending side, we find that each non-corrupt official is responsible for procurement of public goods that yield a productivity of $\frac{\xi}{(1-\nu)(1-\mu)}$. Each corrupt official is responsible for procurement of public goods that yield a productivity of $\frac{\xi(1-\lambda)}{(1-\nu)(1-\mu)}$. Therefore, the total productivity generated from the public goods (by non-corrupt plus corrupt officials) is given by

$$(1-\chi)(1-\nu)(1-\mu)\frac{\xi}{(1-\nu)(1-\mu)}+\chi(1-\nu)(1-\mu)\frac{\xi(1-\lambda)}{(1-\nu)(1-\mu)}=\xi(1-\chi\lambda). \qquad (2)$$

It is clear that as λ is increasing in corruption, there is a lower productivity of public spending. The same outcome holds for a higher value of χ ($\chi \in (0,1)$), for a given value of λ.

The importance of (a high level of) productivity with which physical and human capital are used in contributing to output per worker has been stressed by Hall and Jones (1999). They contend that social infrastructure – which comprises of the institutions and government policies that make up the economic environment within which economic agents operate – contributes to the success on each of these fronts. Likewise, in our set-up, government procurement of public goods could be interpreted as contributing to social infrastructure, and the productivity of this is undermined in the presence of corruption.[7] So, $\xi(1-\chi\lambda)$ is the "effective" productivity of public spending, with $\chi\lambda$ being the amount by which corruption reduces efficiency. As much of the world's

[7] Hall and Jones (1999) mention thievery, expropriation and corruption among the sources of "diversion" of social infrastructure.

corruption comprises of public sector corruption, it is useful to characterise bureaucratic corruption in terms of the effective amount of resources that can be procured by the government.

The effect of corruption in reducing the effectiveness of public and private investment has been discussed by Bandeira *et al*. (2001). They contend that corruption affects not only the productivity of the factors but also their accumulation. The degree of institutional development can affect factor productivity in different ways: corruption diminishes the productivity of capital, the productivity of effective human capital, and the total factor productivity (TFP). We have adopted a similar notion in our bureaucratic corruption framework, where corruption reduces the productivity of effective public investment. In other words, the corruption 'institution' changes the productivity of this factor of production.[8]

2.2. <u>Other aspects of the model</u>

The benevolent government provides public services, g_t, that contribute to private productivity, as in Barro (1990). The government also pays bureaucrats' salaries, the latter earning the same salaries as that of households, w_t.[9] Therefore, the total real wage bill for the government is $(1-\mu)w_t$. The revenue side of the government's budget constraint comprises seigniorage and tax receipts. The first term on the left-hand-side of equation (3) denotes real money balances, while the second term gives the portion of tax receipts that are raised by tax-collectors (with a portion, $(1-\eta)\tau y_t$, of tax revenues going missing).

$$\frac{M_t - M_{t-1}}{P_t} + \eta\tau y_t = g_t + (1-\mu)w_t\,, \tag{3}$$

[8] Lambsdorff (2003) provides cross-sectional empirical evidence in support of the negative effect of corruption on physical capital productivity for a large number of countries (up to 79) in the year 2000. See also Dar and AmirKhalkhali (2002) on the link between TFP growth and government size: for a sample of OECD countries, they find a negative relationship between the two.

[9] This has a similar interpretation to the allocation of talent condition as in Acemoglu and Verdier (2000), whereby the government is able to induce potential bureaucrats to take up public office by paying them salaries that they would earn elsewhere. (See also BNH, Blackburn *et al*. (2005), and Haque and Kneller (2008) on this.)

where from (1) above, $g_t = (1+\chi\varepsilon)\theta y_t, \varepsilon > 0, (1+\chi\varepsilon)\theta < 1$. The latter condition places an upper limit to government spending as a fraction of output.

Households have identical preferences, with utility being given by

$$U_t = -\frac{c_{t+1}^{-\sigma}}{\sigma}, \sigma > 0, \tag{4}$$

where c_{t+1} denotes old-age consumption.

The production function of firms is given by

$$y_t = A l_t^{\alpha} k_t^{\beta} [\xi(1-\chi\lambda)G_t]^{1-\beta}, \tag{5}$$

where $A > 0$, $\alpha, \beta \in (0,1)$, and $G_t = \theta y_t$. As observed earlier, only a portion, θ, of public spending contributes to output via the production function, even though bureaucrats spend a bigger amount, $(1+\chi\varepsilon)\theta$, towards procurement (which they do for purposes of embezzlement). Also, the actual productivity of the public services is less than what would have been the case in the absence of corruption.[10]

Equilibrium in the labour market requires $l_t = \mu$, so that equation (5) can be written as:

$$y_t = bk_t, \tag{5'}$$

where $b \equiv \left(A\mu^{\alpha}[\xi(1-\chi\lambda)\theta]^{1-\beta}\right)^{\frac{1}{\beta}} > 0$.

Using (5'), the equilibrium factor prices are shown to be

$$w_t = \frac{(1-\tau)\alpha b}{\mu} k_t, \tag{6}$$

$$r_t = r = (1-\tau)\beta b, \tag{7}$$

where w_t and r_t are the competitively-determined wage and rental rates, respectively.

At this stage, we introduce some uncertainty – and thereby, a role for financial intermediaries – into the model, as in Espinosa-Vega and Yip (1999, 2000), by assuming that a typical agent is born at a point in time in one particular location, where he resides

[10] Clearly, in our set-up, only a portion of public spending is of use to the private sector. In a similar vein, in Del Monte and Papagni (2001), if g is defined as the amount of public goods production without any corruption, then the private sector can obtain a share, (1-θ), of it while corrupt agents usurp θ. See also Mauro (2004) for a similar specification.

in the first period of his life. In the second period, with probability q ($0 < q < 1$), this agent relocates to another location. These relocation shocks are assumed to be identically and independently distributed across the agents. This uncertainty regarding the location determines whether the agents would put their savings in the form of capital, an illiquid asset, or liquid money. Although the return on capital is higher than that of money, there nevertheless exists some demand for cash as the latter is 'mobile' because of its liquidity and is therefore demanded by agents who relocate. In this scenario, we introduce financial intermediaries who manage the savings of individuals and allocate their portfolios appropriately. These individuals take the help of financial intermediaries – who are viewed as being formed as cooperatives from young households, as in Diamond and Dybvig (1983) – as the latter are able to exploit the law of large numbers and thereby to eliminate individual risk.[11] Let δ ($0 < \delta < 1$) be the fraction of deposits lent to firms (i.e. held in the form of capital), which implies that a ($1-\delta$) fraction is held in the form of money. Also, let i_t (I_t) denote the gross real rate of return paid to depositors who move (do not move) location. Finally, the variable, $\pi_t (\equiv P_t / P_{t+1})$, which is the gross rate of deflation, denotes the real rate of return on money holdings, and is taken as given by the financial intermediaries.

It ought to be noted at this point that for households, as well as for non-corrupt bureaucrats, labour income (w_t) is the only source of earnings. However, for corrupt public officials involved in revenue collection, $(1-\eta)\tau y_t$ is the amount appropriated illegally, while for the corrupt bureaucrats involved in public procurement, $\chi \varepsilon \theta y_t$ represents the amount embezzled. We assume that these corrupt officials manage to escape punishment either because their actions are undetectable and/or governments find it difficult to implement punishment strategies due to resource constraints (which is true especially in developing countries). We also assume that whatever is embezzled by such officials is either readily consumed or saved via "non-standard" channels: in other words, the usual mode of saving via financial intermediaries described above only applies to the

[11] Instead of assuming that financial intermediaries operate as cooperatives drawn from households, one could consider such intermediaries as competing for the depositors, as in Bencivenga and Smith (1993). In that case, any (extra) economic profits that may accrue would be offered to depositors and therefore be competed away among the intermediaries, which in effect implies that competition leads to financial intermediaries acting in the best interests of depositors.

legal component of the income of corrupt officials (i.e., labour income), but not to the funds embezzled while undertaking revenue collection and public procurement. If that would have been the case, then the offenders would be exposed with certainty.

The optimisation problem facing financial intermediaries involves choosing δ_t, i_t and I_t, so as to maximise

$$\max_{\{\delta_t, i_t, I_t\}} V_t = -q\frac{(w_t i_t)^{-\sigma}}{\sigma} - (1-q)\frac{(w_t I_t)^{-\sigma}}{\sigma}, \qquad (8)$$

subject to

$$q i_t = (1-\delta_t)\pi_t, \qquad (9)$$

$$(1-q)I_t = \delta_t r. \qquad (10)$$

The financial intermediaries' portfolio problem is to maximise the expected welfare of a depositor who deposits his entire labour income with them; and this depositor faces a probability, q, of being relocated (thereby receiving i_t), and a probability, 1-q, of remaining in the same location (thereby receiving I_t). This is given by eq. (8) above. The resource constraint in (9) conveys the information that the financial intermediaries are able to meet the liquidity needs of the depositors who do relocate using their real money holdings, while (10) shows that the intermediaries are able to make the requisite payment (out of their lending to producers of capital) to the fraction of depositors who do not relocate.

The solution of this problem yields the optimal share of deposits invested in capital to be

$$\delta_t = \frac{\left(\frac{q}{1-q}\right)\left(\frac{\pi_t}{r}\right)^{\frac{\sigma}{1+\sigma}}}{1+\left(\frac{q}{1-q}\right)\left(\frac{\pi_t}{r}\right)^{\frac{\sigma}{1+\sigma}}} \equiv \Delta(\pi_t), \qquad (11)$$

where $\Delta^{'}(\pi_t) > 0$, implying that a decrease in π_t, the return on money, induces intermediaries to allocate a larger fraction of deposits towards cash holdings. This is because in the presence of higher inflation (i.e., lower π_t), intermediaries find difficult to provide sufficient liquidity for agents who relocate, unless they hold more money. This income effect of a change in inflation implies that more money needs to be held and a smaller proportion of deposits can be allocated to productive capital.

2.3. Balanced growth equilibrium

Along the balanced growth equilibrium, which is unique and stable, all variables grow at the same rate. The growth rate is determined from the capital market equilibrium condition where the total demand for capital by firms, k_{t+1}, equals the total supply of capital by financial intermediaries, $w_t\delta_t$ (which equals the investment in capital made by the intermediaries out of the deposits accruing from households plus bureaucrats).

From $k_{t+1} = w_t\delta_t$, we use equation (6) to obtain $\frac{k_{t+1}}{k_t} = \frac{(1-\tau)\alpha b}{\mu}\delta_t$, or

$$\gamma \equiv \frac{k_{t+1}}{k_t} = \frac{(1-\tau)\alpha b}{\mu}\Delta(\pi), \tag{12}$$

where γ is the economy's growth rate. From eq. (12), it is clear that γ responds positively to π_t. This is because a higher return on money (captured by higher π_t) eases the liquidity constraint for financial intermediaries, thereby enabling agents' savings to be channelled towards capital, which spurs growth.

Denoting $m_t \equiv M_t/P_t$ as the real value of money balances, we can express the money market clearing condition as $m_t = w_t(1-\delta_t)$, or using (6) and (11) obtain

$$m_t = \frac{(1-\tau)\alpha b}{\mu}[1-\Delta(\pi)]k_t. \tag{13}$$

An increase in π_t (lower inflation) implies that lower money holdings are required to satisfy the liquidity demands of households who relocate, and this is reflected in eq. (13).

Of course, in the steady-state, we have $\gamma \equiv \frac{k_{t+1}}{k_t} = \frac{m_{t+1}}{m_t} = \frac{y_{t+1}}{y_t}$. Using $m_t = \gamma m_{t-1}$, the government revenue from seigniorage can be expressed as $\frac{M_t - M_{t-1}}{P_t} = (\frac{\gamma-\pi}{\gamma})m_t$.

Then, combining equations (13) and (12) we obtain $\frac{M_t - M_{t-1}}{P_t} = (\gamma-\pi)\left[\frac{1-\Delta(\pi)}{\Delta(\pi)}\right]k_t$.

Next, using the above expression for seigniorage, along with equations (1), (5'), and (6), we can rewrite the government budget constraint equation, (3), as

$$\left(\frac{\gamma-\pi}{b}\right)\left[\frac{1-\Delta(\pi)}{\Delta(\pi)}\right]+\eta\tau=(1+\chi\varepsilon)\theta+\frac{(1-\mu)(1-\tau)\alpha}{\mu}. \qquad (14)$$

The first term on the left-hand-side of the above expression denotes the seigniorage revenue of the government. This seigniorage revenue is the product of the (productivity-adjusted) inflation tax rate and the (growth-adjusted) inflation tax base. The second term to the left of the equality is the tax revenue accruing to the government from the η-proportion of non-corrupt tax collectors. The first term to the right of the equality is the spending on procurement of public goods (which includes the inflating of public expenditures by corrupt bureaucrats), while the second term on the right-hand-side represents the salary payments made to bureaucrats, who comprise (1-μ)-proportion of the population.

As our task is to understand the effects of corruption (in its different forms) on economic growth, and given that growth and inflation are jointly determined through the government budget constraint, we need to consider the simultaneous system described by equations (12) and (14). Accordingly, we need to take the total derivatives of equations (12) and (14). Doing so, yields

$$d\gamma-\frac{(1-\tau)\alpha b}{\mu}\Delta' d\pi=-\frac{\alpha b}{\mu}\Delta d\tau+\frac{(1-\tau)\alpha\Delta}{\mu}\frac{\partial b}{\partial\chi}d\chi+\frac{(1-\tau)\alpha\Delta}{\mu}\frac{\partial b}{\partial\lambda}d\lambda. \qquad (12')$$

$$\begin{aligned}&\frac{1}{b}\frac{1-\Delta}{\Delta}d\gamma-\left[\frac{1-\Delta}{\Delta}+(\gamma-\pi)\frac{\Delta'}{\Delta^2}\right]\frac{1}{b}d\pi= \\ &-\frac{\eta\mu+(1-\mu)\alpha}{\mu}d\tau-\tau d\eta+\left[\theta\varepsilon+(\gamma-\pi)\frac{1-\Delta}{\Delta}\frac{1}{b^2}\frac{\partial b}{\partial\chi}\right]d\chi+(\gamma-\pi)\frac{1-\Delta}{\Delta}\frac{1}{b^2}\frac{\partial b}{\partial\lambda}d\lambda\end{aligned}. \qquad (14')$$

We will now use equations (12') and (14') to perform a number of comparative statics exercises, highlighting the role of the different aspects of corruption on the revenue and expenditure sides of the government's budget. These are described in the following section, and they enable us to obtain some interesting results discussed below.

3. Comparative statics results

In this section, we derive the impact of corruption on growth through the three channels we have described thus far: collection of tax revenue, procurement of public goods, and productivity of public goods. The transmission of corruption's impact depends heavily on the government's ability to adjust its revenue generating instruments as done in Espinosa-Vega and Yip (1999, 2000) and Bose *et al.* (2007). Following the same techniques, we will examine three distinct cases as to the further creation of public revenue when: (i) only seigniorage can vary, (ii) only the income tax rate can vary, (iii) both revenue sources are allowed to vary. To this end, we can use equations (12') and (14') to obtain our comparative statics results. Let us examine the three cases independently.

Although (i) is an extreme case, the reliance of many countries (developing countries in particular) on seigniorage often reflects an inefficient tax system, i.e., one with high costs of administering and collecting taxes. Seigniorage is a relatively inexpensive source of revenue in such countries (see Cukierman *et al*. (1992), De Gregorio (1993), Roubini and Sala-i-Martin (1995)). Cukierman *et al*. (1992) argue that the evolution of inefficient tax systems is a manifestation of a country's political structure, in particular, that this is more likely to happen in countries that are more unstable and polarised.

3.1. Seigniorage as the single source of variation in government revenue

This case amounts to setting changes in the rate of income tax equal to zero, $d\tau = 0$, in equation (14')**.** This, in turn, implies that changes in seigniorage are used to match any changes in public spending (level effect), and/or compensate for any changes in tax revenue for a given level of government outlays (revenue composition effect).

Appendix **A(I)** illustrates how equations (12') and (14') look in matrix form under the above condition. It also shows how the gross rate of deflation, π, and the rate of economic growth, γ, react to higher incidents of corruption as these materialise through the three different channels we consider. The results of these exercises take shape through the propositions below.

Proposition 1a: *Given a constant tax rate, an increase in corruption related with the collection of tax revenue (decrease in η) increases seigniorage (decreases π) and decreases the steady-state growth rate.*

This result reflects a negative effect of corruption on growth through changes in the *composition* of public revenue toward more seigniorage. This finding is consistent with the empirical evidence provided by BNH and the work of De Gregorio (1993). The former shows that a shift in the composition of public revenue toward more seigniorage at the expense of lower income taxes yields negative growth effects, while the latter highlights the role of an inefficient tax system which due to high tax collection costs produces high inflation rates and low economic growth. The incidence of tax collection costs across countries has been documented by Bird and Zolt (2005), who report that developed countries devote roughly one percent of tax revenues to cover the budgetary costs of tax collection. The costs of tax administration for developing countries, on the other hand, are substantially higher–almost three percent, according to Gallagher (2005). In our setup, the source of this inefficiency in tax administration arises out of corruption in the collection of public revenue.

Proposition 2a: *Given a constant tax rate, an increase in corruption related with the procurement of productive public goods (increase in χ) increases seigniorage and decreases the rate of steady-state growth.*

This result reflects a negative effect of corruption on growth through changes in the *level* of public revenue toward more seigniorage – for a given amount of revenue collected through taxation – due to an increase in public spending. At the same time, corruption diminishes the productivity of public spending which has a direct negative effect on growth. This result is in line with the empirical evidence provided by Adam and Bevan (2005) and Bose *et al*. (2007), who illustrate that greater reliance on seigniorage as a means of financing public expenditure generates distortionary effects on growth.

This case represents an example of a situation where a particular type of corruption that operates on the expenditure side of the government budget constraint (manifested through a higher value of χ), affects the growth rate not only via inflated public spending, but also via shifts in revenues toward more seigniorage. Even though in both Propositions 1a and 2a the outcome of higher corruption is lower economic growth, the difference is that in the former case the negative growth effect of a rise in seigniorage is a direct consequence of the fact that less tax revenues are generated (lower η). In the latter case, however, the growth effect (via higher χ) of higher seigniorage is indirect - strengthening the direct negative productivity effect on growth.

In addition, in both Propositions 1a and 2a, higher corruption induces higher inflation as the government relies more on seigniorage, a result empirically confirmed by Al-Marhubi (2000). Our contribution, therefore, lies in the fact that we identify two distinct channels through which corruption could lead to higher inflation: lower η (revenue side of the budget) or higher χ (expenditure side of the budget).

Proposition 3a: *Given a constant tax rate, an increase in corruption related with the productivity of public goods (increase in λ) increases seigniorage and decreases the steady-state growth rate.*

This result now reflects the direct negative effect of corruption on growth through a decline in the productivity of public goods, and an indirect negative effect through changes in the *composition* of public revenue toward more seigniorage causing inflation to rise (decline in π) and the growth rate to fall. As regards the direct productivity effect, an empirical study by Salinas-Jimenez and Salinas-Jimenez (2007) analyses whether corruption affects the economic performance of countries from a productivity-based perspective. By considering a sample of 22 OECD countries for the period 1980-2000, they show that corruption affects TFP growth, with economies that have lower levels of corruption recording, on average, faster growth rates.

Here, too, the change in an expenditure-side parameter has an indirect effect on growth via the revenue side of the government budget constraint. Note that the link between higher corruption, higher inflation and lower growth remains as before; here, due to lower effective public spending (due to higher λ) being financed by seigniorage.

3.2. Income tax as the single source of variation in government revenue

This case corresponds to setting changes in seigniorage revenue equal to zero in equation (14'). This, in turn, implies that any changes in spending and/or changes in tax revenue are matched by changes in the tax rate.

Although this too, is an extreme case, it is the limiting case of maintaining a very low rate of inflation. This is the experience of many developed countries, like the US and UK, and members of the European Union which have quite independent central banks with a commitment to maintain inflation within a specified target, as we know that there is a strong positive relation between inflation and seigniorage (see Cukierman *et al.* (1992)). Very low reliance on the inflation-tax as a source of revenue could be expected from governments abandoning a regime of financial repression of the sort described by Roubini and Sala-i-Martin (1995).[12]

Using the condition that changes in seigniorage are set to zero, the new matrix form expression for the set of equations (12') and (14') appears in Appendix **A(II)**. This Appendix also presents the comparative static exercises as to the effect of the three types of corruption on inflation and growth. Once again, we present the findings of these experiments in the form of the following Propositions.

Proposition 1b: *Given a constant revenue from seigniorage, an increase in corruption related with the collection of tax revenue (decrease in η) increases the income tax rate and decreases the steady-state growth rate.*

This is a sensible result stating that if corruption causes income tax revenue to drop, in the absence of an alternative method of raising revenue, the government has no other option but to increase the income tax rate to generate revenue that matches the revenue lost due to corruption.[13] As a result, the increase in the rate of income tax leads

[12] From a policy perspective, the importance of reducing permanently the need for seigniorage revenues has been stressed by the World Bank (see World Bank (1989)).

[13] De Gregorio (1993), in a model without corruption, shows that if the government is able to collect a smaller fraction of tax revenues (reflecting a more inefficient tax system), the tax rate has to increase when the rate of money creation is zero.

to a lower growth rate by diminishing the after tax income available for investment purposes.[14]

Proposition 2b: *Given a constant revenue from seigniorage, an increase in corruption related with the procurement of productive public goods (increase in χ) has an ambiguous effect on both the income tax rate and the steady-state growth rate.*

This result reflects an ambiguous effect of corruption on growth through changes in the *level* and the *productivity* of public spending. Intuitively, an increase in χ raises the size of government spending – see the government budget constraint equation (14). At the same time, however, it decreases the productivity of output, b, and therefore the tax base, which would have caused seigniorage revenue to rise (via a shift from income taxation). But given the constant revenue from seigniorage, if the tax rate has to fall to maintain the government budget constraint, then (given the fall in b), it is not clear how the growth rate would react. However, if the income tax rate has to rise in equilibrium, then (together with the fall in b), the growth rate falls.

An alternative way to view this ambiguity is as follows. Re-write equation (14) as:

$$\left(\gamma-\pi\right)\left[\frac{1-\Delta(\pi)}{\Delta(\pi)}\right]+\eta\tau b=(1+\chi\varepsilon)\theta b+\frac{(1-\mu)(1-\tau)\alpha b}{\mu}. \qquad (15)$$

An increase in χ decreases output productivity, b, so that the revenue side of equation (15) declines while the expenditure side may change in any direction. If expenditures rise, then for a balanced budget the tax rate needs to rise, so that the decrease in output productivity and the simultaneous increase in the tax rate inhibit the rate of growth. Similarly, the growth rate will decline if expenditures decrease (when the increase in χ dominates the decline in b) but by less than the decrease in revenues. If, however, spending goes down by more than revenue, then for a balanced budget the rate of taxation

[14] One could relate this correlation between higher tax rates and lower growth rates to the level of development along the lines of the analysis of Bose *et al*. (2007), where tax-financed increases in government spending thwart growth in richer nations. A more inefficient tax system (arising due to corruption in tax collection), a feature of many developing countries, would lead to lower tax revenues and reduce growth.

will decline. In this case, the decrease in both output productivity and the tax rate yield offsetting effects on growth. The relative size of the declines in b and τ will determine in which way economic growth will move. Overall, it is clear that corruption has an ambiguous effect on both the income tax rate and the rate of growth.

Proposition 3b: *Given a constant revenue from seigniorage, an increase in corruption related with the productivity of public goods (increase in λ) decreases the income tax rate and has an ambiguous effect on the steady-state growth rate.*

An increase in corruption associated with a lower output productivity of public goods, b, causes both the revenue and expenditure elements of the government budget to decline (see equation (15)). It is unclear, however, which element of the budget will decrease by a greater extent. If the decline in expenditure exceeds (falls below) the drop in revenue, then given a fixed revenue from seigniorage, this will induce a lower (higher) income tax rate to ensure a balanced budget. Our calculations show that the tax rate is actually lower as a result of the rise in λ, which implies, therefore, that the decline in spending is higher than the reduction in revenue. In the light of this finding, the ambiguity of the growth result seems fairly intuitive. It reflects the direct negative effect of corruption on growth through a decline in the productivity (b) of the public good, and a contrasting positive effect on growth through a lower income tax rate (τ).

3.3. Both seigniorage and income taxation as sources of variation in government revenue

As the above two classes of experiments, where governments are restricted in the use of a single revenue-generating mechanism, may lack realism, we now consider the effects of a joint use of both seigniorage and taxes as means of financing public outlays. This case simply amounts to the combination of the former two exercises. Combining Propositions 1a and 1b, one can state the following:

Proposition 1: *An increase in corruption related with the collection of tax revenue (decrease in η) increases both seigniorage and the income tax rate and decreases the steady-state growth rate.*

Comparing our results with studies linking tax systems with inflation and growth performance, we note that in De Gregorio (1993), a more inefficient tax system leads to a fall in the share of income tax revenues because the share of seigniorage increases, but the effect on the tax rate is ambiguous. The rate of growth of inflation increases, and the rate of growth of output falls unambiguously. Also, Roubini and Sala-i-Martin (1995) show that governments in countries with inefficient tax systems (high tax evasion) may optimally choose high rate of money growth leading to high inflation rates, high seigniorage and low economic growth. As these papers do not explicitly deal with corruption, our study identifies a specific channel through which such inflation and growth effects could materialise from inefficient tax systems.

Combining Propositions 2a and 2b, we obtain the following result

Proposition 2: *An increase in corruption related with the procurement of productive public goods (increase in χ) increases seigniorage and has an ambiguous effect on the income tax rate. Although an increase in seigniorage leads to a lower steady-state growth, a decrease in the income tax rate has an ambiguous effect on growth.*

Even though the impact of this type of corruption on the rates of income tax and economic growth is ambiguous, it is possible to derive an unambiguous effect by considering the original distribution of government revenue between seigniorage and taxes. The following Corollary illustrates this (see Appendix **A(III)** for details).

Corollary 2.1: *For a small amount of seigniorage revenue, an increase in corruption related with the procurement of productive public goods (increase in χ) increases the income tax rate and leads to a lower steady-state growth.*

The intuition of this corollary follows from equation (14). For a *small* initial size of seigniorage revenue, the rise in revenue from seigniorage due to a decline in output productivity, b, caused by an increase in χ, falls short of the rise in spending, so that the tax rate needs to be raised. In this case, the drop in b and the rise in τ jointly lead to a decline of the growth rate.

This corollary may rationalize the empirical findings of Mendez and Sepulveda (2006), who show that the negative effect of corruption on growth is confined mainly to "free" countries. The idea is that in countries with more political rights, it is possible that corruption promotes some public investment that is otherwise thwarted by bureaucratic delays (see Huntington (1968) and De Soto (1990)), and also that it is worth allowing a small amount of corruption in the economy as the resources required for combating it are quite large (see Klitgaard (1988), and Acemoglu and Verdier (1998)). So, a small but positive level of corruption may be optimal for the economy. Also, Aidt *et al*. (2008) find the effect of corruption on growth to be strong only in countries with a high quality of political institutions. Given that "free" countries and countries with a high quality of political institutions are typically developed nations, and given that seigniorage revenue is typically small for developed nations, we can draw a comparison between our findings and the governance-growth results of the above studies. We can claim that Corollary 2.1 supports the finding that the negative effect of corruption on growth clearly materializes for developed countries (that generate a small revenue through seigniorage) at higher levels of taxes. This allows us to tie our result with the recent empirical literature in this area.

This result can also be compared with the theoretical and empirical results obtained by Bose *et al*. (2007) that in developed countries (with efficient tax collection systems), government spending financed by taxes retards growth more than if financed by seigniorage. Although that paper is not about corruption, its introduction offers a clear link between the findings of our study and the results reported there.

Finally, combining Propositions 3a and 3b, one can make a general statement about the effects of productivity-related corruption when both seigniorage and taxation can be used to create revenue for the government.

Proposition 3: *An increase in corruption related with the productivity of public goods (increase in λ) increases seigniorage and decreases the income tax rate. The increase in* *seigniorage yields a lower steady-state growth rate, while the decline in the income tax rate has an ambiguous effect on steady-state growth.*

As in Proposition 2, the growth effects of corruption are not clear. Once again, however, we can draw unambiguous effects if we account for the original composition of public revenue (see Appendix **(AIII)**).

Corollary 3.1: *For a small amount of seigniorage revenue, an increase in corruption related with the productivity of public goods (increase in λ) leads to a lower steady-state growth.*

The intuition of this corollary is similar in spirit to Corollary 2.1. For a *small* initial size of seigniorage revenue, the rise in revenue from seigniorage due to the decline in output productivity, b, is relatively small. Given that spending remains unchanged, the marginal increase in seigniorage needs to be matched by a decline in tax revenue. This induces a decline in the tax rate, which along with the drop in b cause the rate of growth to decline, suggesting that the latter effect (drop in b) dominates in magnitude the former (drop in τ).

Overall, Propositions 1, 2, and 3 imply that seigniorage and the income tax rate may not change in the same direction due to corruption and that their subsequent effects on growth may differ depending on the type of corruption taking place. This also activates different channels through which the effect of corruption on growth is transmitted through. Thus, our unified framework by involving various forms of corruption could account for the existence of apparently conflicting results obtained in the growth literature as a function of the impact of different expenditure financing policies.[15]

[15] For example, Palivos and Yip (1995) find seigniorage financing to have a smaller negative effect on growth than income tax financing, while De Gregorio (1993) generally finds the opposite. See also Miller and Russek (1997), who find that tax-financed public expenditures result in *higher* growth in developing countries.

4. Conclusion

This paper studied, via an analytical model, the effects of corruption on an economy's growth rate, income tax rate, and inflation rate when bureaucratic corruption takes three forms: it reduces the tax revenues that are raised from households, inflates the volume of government spending, and reduces the productivity of effective government expenditure. Given the lowering of the tax base and the wastage of public expenditures (through higher spending but lower productivity), the outcome is a lower growth rate and higher seigniorage revenues. Specifically, the effects of our policy experiments are: (i) an increase in corruption related with the collection of tax revenue increases both seigniorage and the income tax rate, and decreases the steady-state growth rate, (ii) an increase in corruption related with the procurement of productive public goods increases seigniorage, and has an ambiguous effect on the income tax rate. Although an increase in seigniorage leads to a lower steady-state growth, an increase in the income tax rate has an ambiguous effect on growth, (iii) an increase in corruption related with the productivity of productive public goods increases seigniorage and decreases the income tax rate. The increase in seigniorage yields a lower steady-state growth rate, while the decrease in the income tax rate has an ambiguous effect on steady-state growth. The nature of these effects has not hitherto been explored in the literature. Moreover, in this paper, we attempted to combine the literature on corruption in public finances with that on the financing of public expenditures and growth, and established some interesting results that could rationalise some of the apparently contradictory findings of some of the earlier literature in the area.

Our research could be extended in different directions. One line of enquiry would be to estimate the effects of the different types of corruption in public expenditure on growth and inflation using panel data for a large group of countries. This would supplement the work of BNH on corruption on the revenue side of the government budget constraint. Another direction in which our research could be conducted is to study the case where bond financing (rather than money financing) of deficits – along with tax financing – is considered feasible. This would be an interesting exercise in the context of the Stability and Growth Pact, which assigns upper limits to deficits and debt for EMU members, and virtually rules out seigniorage. It would be interesting to relate our findings of this paper with those lines of research.

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Appendices

A(I).

Under the assumption of $d\tau = 0$, the matrix form expression of equations (12') and (14') is

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} d\gamma \\ d\pi \end{bmatrix} = \begin{bmatrix} a_{13} & a_{14} & a_{15} \\ a_{23} & a_{24} & a_{25} \end{bmatrix} \begin{bmatrix} d\eta \\ d\chi \\ d\lambda \end{bmatrix}, \tag{A1}$$

where $a_{11} = 1 > 0$, $a_{12} = -\frac{(1-\tau)\alpha b}{\mu}\Delta' < 0$, $a_{13} = 0$, $a_{14} = \frac{(1-\tau)\alpha\Delta}{\mu}\frac{\partial b}{\partial \chi} < 0$, $a_{15} = \frac{(1-\tau)\alpha\Delta}{\mu}\frac{\partial b}{\partial \lambda} < 0$, $a_{21} = \frac{1}{b}\frac{1-\Delta}{\Delta} > 0$, $a_{22} = -\left[\frac{1-\Delta}{\Delta} + (\gamma - \pi)\frac{\Delta'}{\Delta^2}\right]\frac{1}{b} < 0$, $a_{23} = -\tau < 0$, $a_{24} = \left(\theta\varepsilon + (\gamma - \pi)\frac{1-\Delta}{\Delta}\frac{1}{b^2}\frac{\partial b}{\partial \chi}\right)$, and $a_{25} = (\gamma - \pi)\frac{1-\Delta}{\Delta}\frac{1}{b^2}\frac{\partial b}{\partial \chi} < 0$.

In obtaining the signs of a_{14}, a_{15}, a_{24}, and a_{25}, we have used the expression of b from the output per capita equation (5'), from where it can be shown that $\frac{\partial b}{\partial \chi} < 0$ and $\frac{\partial b}{\partial \lambda} < 0$.

Using equation (A1), we can derive the inflation and growth effects of a change in corruption related with the collection of tax revenues; that is, of a higher η. These are

$$\frac{d\pi}{d\eta} = \frac{a_{11}a_{23} - a_{21}a_{13}}{Det}, \tag{A2}$$

$$\frac{d\gamma}{d\eta} = \frac{a_{13}a_{22} - a_{23}a_{12}}{Det}, \tag{A3}$$

where 'Det' is the determinant, for which the expression is provided after equation (A7) below.

Using equation (A1) again, we can derive the inflation and growth effects of a change in corruption related with the procurement of public goods; that is, of a higher χ. These are

$$\frac{d\pi}{d\chi} = \frac{a_{11}a_{24} - a_{21}a_{14}}{Det}, \tag{A4}$$

$$\frac{d\gamma}{d\chi} = \frac{a_{14}a_{22} - a_{24}a_{12}}{Det}, \tag{A5}$$

Using equation (A1) once again, we can derive the inflation and growth effects of a change in corruption related with the productivity of public goods; that is, of a higher λ, as

$$\frac{d\pi}{d\lambda} = \frac{a_{11}a_{25} - a_{21}a_{15}}{Det}, \tag{A6}$$

$$\frac{d\gamma}{d\lambda} = \frac{a_{15}a_{22} - a_{25}a_{12}}{Det}, \tag{A7}$$

In equations (A2)-(A7) the determinant is given by

$$Det = a_{11}a_{22} - a_{21}a_{12} = -\left[\frac{1-\Delta}{\Delta} + (\gamma - \pi)\frac{\Delta'}{\Delta^2} - \frac{1-\Delta}{\Delta}\frac{\Delta'}{\Delta}\gamma\right]\frac{1}{b}.$$

Using equation (11), we find

$$\Delta' = \frac{\Delta}{\pi}\frac{\sigma}{1+\sigma}\frac{1}{1+\left(\frac{q}{1-q}\right)\left(\frac{\pi}{r}\right)^{\frac{\sigma}{1+\sigma}}} > 0. \tag{A8}$$

So, the determinant becomes

$$Det = -\frac{1}{b}\frac{1}{\Delta}\frac{1}{1+\sigma}\frac{1+\sigma\Delta\frac{\gamma}{\pi}}{1+\left(\frac{q}{1-q}\right)\left(\frac{\pi}{r}\right)^{\frac{\sigma}{1+\sigma}}} < 0. \tag{A9}$$

Using equation (A9) along with the expressions for a_{ij} defined above into the pairs of equations (A2)-(A3), (A4)-(A5), and (A6)-(A7) respectively, we obtain that $\frac{d\pi}{d\eta} > 0$, $\frac{d\gamma}{d\eta} > 0$, $\frac{d\pi}{d\chi} < 0$, $\frac{d\gamma}{d\chi} < 0$, $\frac{d\pi}{d\lambda} < 0$, and $\frac{d\gamma}{d\lambda} < 0$, which form the basis for Propositions 1a-3a.

A(II).

Using the condition that changes in seigniorage are set to zero, the new matrix form expression for the set of equations (12') and (14') now is

$$\begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} \begin{bmatrix} d\gamma \\ d\tau \end{bmatrix} = \begin{bmatrix} b_{13} & b_{14} & b_{15} \\ b_{23} & b_{24} & b_{25} \end{bmatrix} \begin{bmatrix} d\eta \\ d\chi \\ d\lambda \end{bmatrix}, \tag{A10}$$

where $b_{ij} = a_{ij}$ except for $b_{12} = \frac{\alpha b}{\mu}\Delta > 0$, $b_{21} = 0$, and $b_{22} = \frac{\eta\mu + (1-\mu)\alpha}{\mu} > 0$.

Using equation (A10), we can derive the income tax rate and growth effects of a change in corruption related with the collection of tax revenues; that is, of a higher η. These are

$$\frac{d\tau}{d\eta} = \frac{b_{11}b_{23} - b_{21}b_{13}}{DET}, \tag{A11}$$

$$\frac{d\gamma}{d\eta} = \frac{b_{13}b_{22} - b_{23}b_{12}}{DET}, \tag{A12}$$

where 'DET' is the determinant, for which the expression is provided after equation (A16) below.

Using equation (A10) again, we can derive the income tax rate and growth effects of a change in corruption related with the procurement of public goods; that is, of a higher χ. These are

$$\frac{d\tau}{d\chi} = \frac{b_{11}b_{24} - b_{21}b_{14}}{DET}, \tag{A13}$$

$$\frac{d\gamma}{d\chi} = \frac{b_{14}b_{22} - b_{24}b_{12}}{DET}, \tag{A14}$$

Using equation (A10) once again, we can derive the income tax rate and growth effects of a change in corruption related with the productivity of public goods; that is, of a higher λ, as

$$\frac{d\tau}{d\lambda} = \frac{b_{11}b_{25} - b_{21}b_{15}}{DET}, \tag{A15}$$

$$\frac{d\gamma}{d\lambda} = \frac{b_{15}b_{22} - b_{25}b_{12}}{DET}, \tag{A16}$$

In equations (A11)-(A16) the determinant is given by

$$DET = b_{11}b_{22} - b_{21}b_{12} = b_{22} = \frac{\eta\mu + (1-\mu)\alpha}{\mu} > 0. \tag{A17}$$

Using equation (A17) along with the expressions for b_{ij} defined above into the pairs of equations (A11)-(A12), (A13)-(A14), and (A15)-(A16) respectively, we obtain that $\frac{d\tau}{d\eta}<0$, $\frac{d\gamma}{d\eta}>0$, $\frac{d\tau}{d\chi}=$ambiguous, $\frac{d\gamma}{d\chi}=$ ambiguous, $\frac{d\tau}{d\lambda}<0$, and $\frac{d\gamma}{d\lambda}=$ ambiguous, which form the basis for Propositions 1b-3b.

A(III).

Corollary 2.1: A necessary condition for $\frac{d\gamma}{d\chi}<0$ is $b_{14}b_{22}-b_{24}b_{12}<0$, which corresponds to

$$\frac{(1-\tau)\alpha\Delta}{\mu}\frac{\partial b}{\partial\chi}\frac{\eta\mu+(1-\mu)\alpha}{\mu}-\left(\theta\varepsilon+(\gamma-\pi)\frac{1-\Delta}{\Delta}\frac{1}{b^2}\frac{\partial b}{\partial\chi}\right)\frac{\alpha b}{\mu}\Delta<0. \tag{A18}$$

Simplifying equation (A18), yields

$$\frac{1}{b}\frac{\partial b}{\partial\chi}\frac{1}{\mu}\left(\gamma[\eta\mu+(1-\mu)\alpha]-(\gamma-\pi)(1-\Delta)\alpha\right)<\theta\varepsilon\frac{\alpha b}{\mu}\Delta. \tag{A19}$$

A sufficient condition for this inequality to hold is that

$$\frac{1}{b}\frac{\partial b}{\partial\chi}\frac{1}{\mu}\left(\gamma[\eta\mu+(1-\mu)\alpha]-(\gamma-\pi)(1-\Delta)\alpha\right)<0<\theta\varepsilon\frac{\alpha b}{\mu}\Delta, \tag{A20}$$

or simply, $\gamma[\eta\mu+(1-\mu)\alpha]>(\gamma-\pi)(1-\Delta)\alpha$, given that $\frac{\partial b}{\partial\chi}<0$.

Finally, this condition simplifies to

$$(\gamma-\pi)\frac{1-\Delta}{\Delta}<\frac{\gamma}{\Delta}\frac{\eta\mu+(1-\mu)\alpha}{\alpha}, \tag{A21}$$

where the left-hand side of the inequality represents revenue from seigniorage.

Corollary 3.1: A condition for $\frac{d\gamma}{d\lambda}<0$ is $b_{15}b_{22}-b_{25}b_{12}<0$, which implies

$$\frac{(1-\tau)\alpha\Delta}{\mu}\frac{\partial b}{\partial\lambda}\frac{\eta\mu+(1-\mu)\alpha}{\mu}-(\gamma-\pi)(1-\Delta)\frac{1}{b}\frac{\partial b}{\partial\lambda}\frac{\alpha}{\mu}<0, \tag{A22}$$

which, as before, simplifies to the condition (A21).