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a Unified Approach**

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Corruption, Fiscal Policy, and Growth: A Unified Approach

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Abstract

In this paper, we study the effects of bureaucratic corruption on fiscal policy and the subsequent impact on economic growth. Here corruption takes three forms: (i) it reduces the tax revenue raised from households, (ii) it inflates the volume of government spending, and (iii) it reduces the productivity of ‘effective’ government expenditure. The analysis distinguishes between the case where fiscal choices are determined exogenously to ensure a balanced budget and the case where the government optimally sets its policy instruments. Our policy experiments reveal the complexity of the channels through which corruption impacts upon growth, and the conditions under which the direction of the effect takes shape. The findings from our unified framework could rationalise the diverse (and sometimes, apparently conflicting) empirical evidence on the impact of corruption on economic growth offered in the literature.

Keywords: Corruption, public expenditure, public finances, seigniorage, income tax, growth.

JEL classification: D73, E60, O42.

1. Introduction

In the last two decades, a voluminous literature has emerged, which studies the causal factors of economic growth and development. Within this literature, an increasing number of studies have focused on the links between corruption and growth, on the one hand, and fiscal policy and growth, on the other. In other words, the two areas have often been examined independently of each other. Recent studies have, however, unveiled that corruption in the public sector impacts on both the level and the composition of public revenue and expenditure, thus influencing the conduct of fiscal policy-making. The natural next step, therefore, is to consider how corruption affects economic growth by fleshing out this fiscal policy transmission channel. This is how we identify the main objective of this paper.

Corruption, the abuse of public office for private gain, is a major problem afflicting developed and developing countries alike.¹ There is a voluminous literature on the effects of bureaucratic corruption (see Bardhan (1997), Jain (2001), Aidt (2003, 2009), and Svensson (2005) for comprehensive reviews). The relationship between corruption and growth, in particular, has been investigated in numerous studies with the direction of the effect being in dispute. Some of the literature has been in support of the so-called “speed money” hypothesis, according to which corruption can be beneficial to growth by helping to circumvent cumbersome regulations (red tape) in the bureaucratic process (e.g., Leff (1964), Huntington (1968), Lui (1985)). The bulk of the literature, however, overturns the “efficiency” argument of corruption and views corruption as being more than a price mechanism that leads to lower growth through a number of direct or indirect channels. Amongst these, corruption may cause a misallocation of talent and skills away from entrepreneurial activities towards rent-seeking activities (e.g., Murphy *et al.* (1991) and Acemoglu (1995)), it may create obstacles to doing business and impede innovation and technological transfer (e.g., Hall and Jones (1999)), and it may cause

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.)

firms to expand less rapidly, to adopt inefficient technologies and to shift their operations to the informal sector (e.g., Sarte (2000) and Svensson (2005)).

The literature on fiscal policy and growth has mostly concentrated on the effects of different types of expenditure on growth (see, among others, Barro (1990), Futagami *et al.* (1993), Devarajan *et al.* (1996), Turnovsky (1997), Turnovsky and Fisher (1995), and Agénor (2008)). In contrast, the literature on the effects on growth of the method of financing such expenditures is much sparser. De Gregorio (1993), Palivos and Yip (1995), Miller and Russek (1997), among others, deal with this issue. Although, in general, the two most common financing methods – income taxation and seigniorage – are both considered distortionary in terms of growth, 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.

In the context of public finances, corruption may impact independently on 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 and also where there is greater scope for indulging in covert corruption, as alluded to by Shleifer and Vishny (1993). 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 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, and capital gains). 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 that inflation is positively related to the incidence of corruption (e.g., Al-Marhubi 2000), while seigniorage, itself, has a negative effect on growth (e.g., Adam and Bevan (2005); Bose *et al.* (2007)). It is these observations that provide the motivation for this paper, which seeks to explore the influence of various forms of bureaucratic corruption on public spending and finance, and the implications of this for growth and development.

Here corruption features in three distinct ways: 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.² Although some of these aspects have been captured in previous empirical papers (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. On the revenue side, corruption in tax administration implies that not all tax revenues end up in government coffers, as some of it is embezzled by corrupt bureaucrats involved in tax collection.

Our 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, 2002), 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

² Olson et al. (2000) attribute the cross-country differences in growth of total factor productivity (TFP) to differences in governance, but do not show any explicit theoretical link between (various forms of) corruption and growth as we do.

inflation, which reduces the return on money, causes a portfolio re-allocation away from 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.

In this connection, we consider first the case of a benevolent government which passively adjusts its revenues/expenditures (to ensure a balanced budget) in response to corruption, and then that of a government which chooses its instruments optimally to maximize a social welfare function comprising of the lifetime utilities of all agents – both honest and corrupt – over generations.³ We show that while the workings of the model are different in the two cases, there are elements of ambiguity in the choice of appropriate policy instruments and the growth effects in both, which implies that the issue of whether a government takes a passive or an active stance is actually not that critical.⁴

Our results could provide a rationale for the empirical findings of some recent papers emphasizing the conditional (or non-monotonic) effects of corruption on growth via the political institutions/governance environment. Specifically, Méon and Sekkat (2005) considering interactions between indicators of the quality of institutions and corruption, report that corruption is most harmful to growth where governance is weak. In contrast, Méndez and Sepúlveda (2006) argue that the negative impact of corruption on growth materializes only at high levels of incidence in countries characterized by political freedom.⁵ Aidt *et al.* (2008) find a similar result: in countries with high quality institutions, corruption has a large, negative impact on growth. In our analysis, the comparative-static effects of corruption on growth show that a connection can be made with these papers. More specifically, we find that for countries that are able to generate insubstantial amounts through seigniorage (true generally for the developed nations), corruption that inflates public spending increases the tax rate and reduces growth. This result ties in with Bose *et al.* (2007), who find that tax-financed public spending retards growth in developed nations.

³ Note that corruption at an individual level is undetectable in our model, and hence, is exogenously given in the aggregate. An optimizing government consequently has to design a second-best fiscal policy, taking into account the welfare of all agents.

⁴ In the analysis, we have identified conditions under which a government could use its policy to mitigate the effects of corruption, so that steady state growth increases.

⁵ 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.

Clearly, the value added of our paper stems largely from the fact that to date we have not found any study that considers the effects of corruption through both sides of the government budget constraint, although empirical evidence has been provided in that direction. In addition, we capture these effects for a non-optimizing as well as an optimizing government.

The rest of the paper is organised as follows. Section 2 presents the analytical model, and characterizes the balanced growth path of the economy. Section 3 analyses the effects of corruption on the key economic variables when a government allows an exogenous adjustment of its fiscal instruments to ensure a balanced budget. Section 4 captures the effects of corruption under an optimizing government. Finally, Section 5 contains a few concluding remarks.

2. The analytical model

Consider an overlapping generations economy in which there is an infinite sequence of two-period-lived agents. Each generation of agents is comprised by private citizens (or households) and public officials (or bureaucrats). Households work for firms in the production of output, whilst bureaucrats work for the government in the administration of public policy. All agents work only when young and consume only when old. Consumption is financed from savings with financial intermediaries that make optimal portfolio choices on behalf of agents by allocating their deposits between liquid and illiquid assets. This role of intermediaries is created by the existence of idiosyncratic relocation shocks which also motivate a demand for liquidity. This financial friction provides a link between the monetary and the real side of the economy.

The government generates revenue by taxing labour income and by printing money (seigniorage), and undertakes expenditures on public goods and services. Corruption takes shape in three different ways. Firstly, some bureaucrats appropriate tax revenues for themselves; secondly, some bureaucrats inflate the cost of public services; and thirdly, corruption reduces the efficiency of the public good in the production process. Finally, firms, of which there is a unit mass, conduct all of their business in

perfectly competitive product and factor markets. The economy is described in more detail as follows.

2.1. Agents

There is a constant population (normalised to one) of two-period-lived agents belonging to overlapping generations of dynastic families. Agents are divided at birth into a fraction, μ , of households and a remaining fraction, $1-\mu$, of bureaucrats.⁶ Both households and bureaucrats work only when young and consume only when old, deriving lifetime utility according to

$$U_t = -\frac{c_{t+1}^{-\sigma}}{\sigma}, \sigma > 0, \quad (1)$$

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

All young agents are endowed with the same unit amount of labour which is supplied inelastically to a given occupation (private employment or public service) in return for the same labour income of w_t .⁷ This income is deposited as savings with financial intermediaries. As in Espinosa-Vega and Yip (1999, 2002), we introduce some uncertainty into the model by assuming that a typical agent is born at a point in time in one particular location, where he resides in the first period of his life. In the second period, with probability q ($0 < q < 1$), this agent relocates to another location. The uncertainty of individuals about their future location is important for determining the composition of savings which can take two forms - a liquid, but unproductive, asset (money) and an illiquid, but productive, asset (capital). 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. We assume that these shocks are identically and independently distributed across agents who prefer to save through intermediaries, rather than by themselves, because doing so allows them to exploit the law of large numbers in eliminating individual risk. We study this in detail in our subsequent analysis.

⁶ 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.

⁷ 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 Blackburn *et al.* (2005) and Haque and Kneller (2008).

2.2. Firms

Households work for firms in the production of output. There is a unit mass of firms, each of which combines l_t units of labour with k_t units of capital to produce y_t units of output according to

$$y_t = A l_t^\alpha k_t^\beta [\xi(1-\chi\lambda)G_t]^{1-\beta}, \quad (2)$$

($A > 0, \alpha, \beta \in (0,1)$), where G_t denotes productive public goods and services. We assume that expenditure on public goods and services is a fixed proportion of output, $G_t = \theta y_t$, ($\theta \in (0,1)$). The actual productivity of public goods and services, however, is less than what would have been in the absence of corruption. Specifically, as it is made clear in the next section, $\xi(1-\chi\lambda)$ is the “effective” productivity of public spending, with $\chi\lambda$ being the amount by which corruption reduces efficiency. This consideration is consistent with *Bandeira et al.* (2001) where corruption reduces the productivity of effective public investment.⁸

Given this, the firm maximises its profits by hiring labour at the real wage rate w_t and renting capital at the real interest rate r_t so as to satisfy the condition of perfect competition in factor markets. Observe that equilibrium in the labour market requires $l_t = \mu$, so that with the use of $G_t = \theta y_t$, equation (2) can be written as:

$$y_t = b k_t, \quad (2')$$

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

Using (2'), the equilibrium factor prices are shown to be

$$w_t = \frac{\alpha b}{\mu} k_t, \quad (3)$$

$$r_t = r = \beta b, \quad (4)$$

with equilibrium wages being proportional to the capital stock and the equilibrium interest rate being constant.

⁸ Corruption has also been found to diminish the productivity of private capital and total factor productivity. The former effect is illustrated by *Lambsdorff* (2003) while the latter by *Dar and AmirKhalkhali* (2002).

2.3. Bureaucrats

Bureaucrats work for the government in the administration of public policy. Specifically, public officials are divided into those that work on revenue collection (ν) and those that act in the procurement of the public good ($1-\nu$). This means that $\nu(1-\mu)$ bureaucrats collect revenues and $(1-\nu)(1-\mu)$ 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 wage earnings, w_t . The public goods and services procured by the bureaucrats have a real value G_t and, as described above, contribute to the efficiency of the firm's output production. From the $\nu(1-\mu)$ bureaucrats that collect revenues, we assume that $(1-\eta)$ are corrupt. We also assume that a fraction χ of the officials that procure the public good are also corrupt.⁹

The above imply that on the revenue side, each official collects taxes from $1/\nu(1-\mu)$ private sector employees so that collected tax revenues by each bureaucrat correspond to $\tau w_t / \nu(1-\mu)$. 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 all non-corrupt officials are described by $\eta \tau w_t$. As a result, tax revenues appropriated by corrupt officials are given by $(1-\eta)\tau w_t$. On the spending side, each official is responsible for the procurement of $\theta y_t / (1-\nu)(1-\mu)$ public goods, which corresponds to the amount each non-corrupt official procures. Each corrupt official, on the other hand, artificially inflates public spending to an amount equal to $\theta(1+\varepsilon)y_t / (1-\nu)(1-\mu)$, $\varepsilon > 0$. Here, ε represents the size by which spending is inflated due to corruption. Therefore, *total* spending on public goods (g_t) is given by

$$g_t = (1 + \chi\varepsilon)\theta y_t. \quad (5)$$

This means that actual spending on public goods increases due to corrupt practices as only θy_t of total public spending is utilised in the firms' production function. The

⁹ The 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., Acemoglu and Verdier (2000); Blackburn *et al.* (2006); Tirole (1996)). At a secondary level, we also make a distinction as to the number of corrupt officials on the two sides of the government budget constraint: $(1-\eta)\nu \neq \chi(1-\nu)$.

remaining amount of $\chi\epsilon\theta y_t$, represents the illegal income (i.e., embezzlement) of corrupt bureaucrats. Such practices have been stressed empirically by Tanzi and Davoodi (1997) who show that corruption inflates public capital expenditure, as the scope for indulging in corrupt practices is much higher for this type of spending.

As mentioned in the previous section, corruption in our model also leads to a productivity loss, but only in the context of the procurement of public goods by corrupt bureaucrats. Specifically, we assume that each unit of the public good yields a productivity of ξ units when procured by $(1-\chi)$ non-corrupt bureaucrats, but only $\xi(1-\lambda)$ 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. Incorporating this aspect, we find that each non-corrupt official is responsible for procurement of public goods that yield productivity of $\xi/(1-\nu)(1-\mu)$, while the respective productivity of each corrupt official is $\xi(1-\lambda)/(1-\nu)(1-\mu)$. Thus, total productivity generated from public goods is given by $\xi(1-\chi\lambda)$, as noted in the previous section. It is clear, therefore, that a higher value of λ , which represents more corruption, leads to lower productivity of public spending.

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.¹⁰

2.4. Government

A benevolent government provides public services, g_t , that (partially) contribute to private productivity, as in Barro (1990). The government also pays bureaucrats' salaries,

¹⁰ Hall and Jones (1999) mention thievery, expropriation and corruption among the sources of “diversion” of social infrastructure.

which, as already described, earn the same salaries as that of households, w_t . It follows then that 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 (6) denotes real revenue from money printing or seigniorage, while the second term gives the actual amount of tax revenue available to the government:

$$\frac{M_t - M_{t-1}}{P_t} + \eta \tau w_t = g_t + (1 - \mu)w_t, \quad (6)$$

where from (5) we need to assume that $(1 + \chi \varepsilon) \theta < 1$ so as to place an upper limit to government spending as a fraction of output.

In the analysis, we consider two different ways the government responds to corruption. First, we assume that the government allows for an exogenous adjustment of its fiscal instruments in order to ensure a balanced budget. We then consider the case where the government optimally chooses its instruments to maximize some social welfare function. The comparison between exogenous and endogenous fiscal policy adjustment gives us the opportunity to examine the extent by which the link between corruption and growth varies according to policy-making decisions.

2.5. Financial intermediaries

Financial intermediaries manage the savings of individuals and make portfolio allocation decisions in the interest of their depositors. The portfolio consists of money and capital, each of which has benefits and costs: money provides liquidity insurance for agents who are relocated, but does not pay any rate of interest; capital provides a rate of return for agents who do not relocate, but is unavailable to those who move. 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

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.

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, $R_t (\equiv P_t/P_{t+1})$, 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, $(1-\eta)\tau w_t$ is the amount appropriated illegally, while for the corrupt bureaucrats involved in public procurement, $\chi\epsilon\theta y_t$ 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 saved via “non-standard” channels: in other words, the usual mode of saving via financial intermediaries described above only applies to the 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 the expected utility of a representative depositor

$$V_t = -q \frac{[(1-\tau)w_t i_t]^{-\sigma}}{\sigma} - (1-q) \frac{[(1-\tau)w_t I_t]^{-\sigma}}{\sigma}, \quad (7)$$

subject to

$$q i_t = (1-\delta_t) R_t, \quad (8)$$

$$(1-q) I_t = \delta_t r. \quad (9)$$

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

equation (7) above. The resource constraint in (8) 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 (9) 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

$$\delta_t = \frac{\left(\frac{q}{1-q}\right)\left(\frac{R_t}{r}\right)^{\frac{\sigma}{1+\sigma}}}{1 + \left(\frac{q}{1-q}\right)\left(\frac{R_t}{r}\right)^{\frac{\sigma}{1+\sigma}}} \equiv \Delta(R_t), \quad (10)$$

where $\Delta'(R_t) > 0$, implying that a decrease in R_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 R_t), intermediaries find it 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.¹²

2.6. 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 all agents).

From $k_{t+1} = (1-\tau)w_t \delta_t$, we use equation (3) to obtain $k_{t+1}/k_t = (1-\tau)\alpha b \delta_t / \mu$, or

$$\gamma \equiv \frac{k_{t+1}}{k_t} = \frac{(1-\tau)\alpha b}{\mu} \Delta(R), \quad (11)$$

¹² This result is by now standard in studies that use this modeling framework. See Espinosa-Vega and Yip (1999, 2002).

where γ is the economy's equilibrium growth rate. From eq. (11), it is clear that γ responds positively to R_t . This is because a higher return on money (captured by higher R_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 $m_t = (1 - \tau)w_t(1 - \delta_t)$, or using (3) and (10) obtain

$$m_t = \frac{(1 - \tau)\alpha b}{\mu} [1 - \Delta(R)]k_t. \quad (12)$$

An increase in R_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. (12).

Of course, in the steady-state, we have $\gamma \equiv k_{t+1}/k_t = m_{t+1}/m_t = y_{t+1}/y_t$. Using $m_t = \gamma m_{t-1}$, the government revenue from seigniorage can be expressed as $(M_t - M_{t-1})/P_t = (\gamma - R)m_t/\gamma$. Then, combining equations (12) and (11) we obtain $(M_t - M_{t-1})/P_t = (\gamma - R)k_t[1 - \Delta(R)]/\Delta(R)$.

Next, using the above expression for seigniorage, along with equations (2'), (5), and (13), we can rewrite the government budget constraint equation, (6), as

$$\left(\frac{\gamma - R}{b}\right) \left[\frac{1 - \Delta(R)}{\Delta(R)} \right] + \eta \frac{\alpha}{\mu} \tau = (1 + \chi \varepsilon) \theta + \frac{(1 - \mu)\alpha}{\mu}. \quad (13)$$

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 $(1 - \mu)$ -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 fiscal instruments are jointly determined

through the government budget constraint, we need to consider the simultaneous system described by equations (11) and (13). Accordingly, we need to take the total derivatives of equations (11) and (13). Doing so, yields

$$d\gamma - \frac{(1-\tau)\alpha b}{\mu} \Delta' dR = -\frac{\alpha b}{\mu} \Delta d\tau + \frac{(1-\tau)\alpha\Delta}{\mu} \frac{\partial b}{\partial \chi} d\chi + \frac{(1-\tau)\alpha\Delta}{\mu} \frac{\partial b}{\partial \lambda} d\lambda. \quad (11')$$

$$\frac{1}{b} \frac{1-\Delta}{\Delta} d\gamma - \left[\frac{1-\Delta}{\Delta} + (\gamma-R) \frac{\Delta'}{\Delta^2} \right] \frac{1}{b} dR = -\frac{\eta\alpha}{\mu} d\tau - \frac{\alpha}{\mu} \tau d\eta + \left[\theta\varepsilon + (\gamma-R) \frac{1-\Delta}{\Delta} \frac{1}{b^2} \frac{\partial b}{\partial \chi} \right. \\ \left. + (\gamma-R) \frac{1-\Delta}{\Delta} \frac{1}{b^2} \frac{\partial b}{\partial \lambda} \right] d\lambda \quad (13')$$

We now use equations (11') and (13') 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, and eventually on growth. As already mentioned, the analysis distinguishes between the exogenous adjustment and the optimal choice of instruments by the government. These are described in the following sections, and enable us to obtain some interesting results.

3. Corruption and growth in the decentralized equilibrium

In this section, we examine the impact of the various forms of corruption (collection of tax revenue, procurement of public goods, and productivity of public goods) on growth by considering a passive stance by the government. That is, in response to corruption, the government is assumed to adjust its fiscal instruments to keep a balanced budget. To this effect, we examine independently the revenue generating and spending instruments. In particular, with regard to the creation of public revenue we examine three distinct cases: i) only seigniorage can vary, (ii) only the income tax rate can vary, (iii) both revenue sources are allowed to vary.

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

Even though this may reflect an extreme case, the reliance of many countries (developing countries in particular) on seigniorage is a reality, often due to an inefficient tax system, making seigniorage a relatively inexpensive source of revenue (see Cukierman *et al.* (1992), De Gregorio (1993), Roubini and Sala-i-Martin (1995)). In our model, this case

amounts to setting changes in the rate of income tax equal to zero, $d\tau = 0$, in equation (13'). This, in turn, implies that changes in seigniorage are used to match any changes in public spending (level effect), or compensate for any changes in tax revenue for a given level of government outlays (revenue composition effect).

Appendix A(I) illustrates how equations (11') and (13') look in matrix form under the above condition. It also shows how the gross rate of deflation, R , 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 path of public expenditure ($d\theta = 0$) and no fiscal consolidation ($d\tau = 0$), an increase in corruption related with the collection of tax revenue (decrease in η) increases seigniorage 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 Blackburn *et al.* (2010) 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 path of public expenditure ($d\theta = 0$) and no fiscal consolidation ($d\tau = 0$), 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 corresponds to 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 path of public expenditure ($d\theta = 0$) and no fiscal consolidation ($dx = 0$), 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 R) 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

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 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).¹³

Within our model, this case corresponds to setting changes in seigniorage revenue equal to zero in equation (13'). This, in turn, implies that any changes in spending or changes in tax revenue are matched by changes in the tax rate. Using this condition, the new matrix form expression for the set of equations (11') and (13') 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.

¹³ From a policy perspective, the World Bank (1989) has stressed the importance of reducing permanently the need for seigniorage revenues.

Proposition 1b: *Given a path of public expenditure ($d\theta = 0$) and 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 straightforward result states 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 in order to generate revenue to match the revenue lost due to corruption.¹⁴ As a result, the increase in the rate of income tax leads to a lower growth rate by diminishing the after tax income available for investment purposes.¹⁵

Proposition 2b: *Given a path of public expenditure ($d\theta = 0$) and 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. 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 to re-write equation (13) as:

¹⁴ 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.

¹⁵ 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.

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

An increase in χ decreases output productivity, b , so that the revenue side of equation (14) 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 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 path of public expenditure ($d\theta = 0$) and 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 (14)). 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: *Given a path of public expenditure ($d\theta = 0$), 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 a 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: *Given a path of public expenditure ($d\theta = 0$), 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: *Given a path of public expenditure ($d\theta = 0$), 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 (13). 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: *Given a path of public expenditure ($d\theta = 0$), 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: *Given a path of public expenditure ($d\theta = 0$), 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 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.¹⁶

3.4. Adjustments in public expenditure

We now examine the case where the government keeps its sources of revenue constant (both the tax rate and rate of inflation) and allows only exogenous adjustments in spending. Thus, the effects of corruption are now transmitted through the expenditure side of the government budget constraint. Appendix A(IV) illustrates how equations (11') and (13') look in matrix form under such a restriction. The impact of the different forms of corruption on the share of government expenditure (as fraction of GDP) and on economic growth, is summarized in the following proposition.

Proposition 4: *Given a constant income tax rate and rate of return on holding money, an increase in corruption of any form (collection of tax revenue, procurement and productivity of public goods), has an ambiguous effect on both the share of government expenditure and the steady-state growth rate.*

The intuition of these outcomes is best illustrated with the use of equation (14), and resembles the explanations given for propositions 2b and 3b. Specifically, a decrease in η decreases the revenue side in equation (14). The question now is: in which direction shall θ move to equilibrate the budget? Keeping in mind that output productivity, b , is positively influenced by changes in θ , we have a number of plausible outcomes. On the one hand, θ can increase, so that along with the increase in b , the expenditure side in equation (14) rises. But the rise in b will also increase the revenue side, so that if the rise in b exceeds the decline in η , a balanced budget is possible. Alternatively, θ can decline in response to a drop in η so that both sides of the budget will go down until a new

¹⁶ As described in the Introduction, 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.

equilibrium is achieved, assuming that the spending side will decrease by more. Moreover, the change in θ causes a change in the growth rate of output in the same direction through its impact on productivity. Thus, it is unclear in which way θ will adjust due to higher corruption on the collection of taxes, leading to ambiguous growth effects.

An increase in corruption related with the procurement of public goods, χ , leads to a decline in b so that the revenue side of equation (14) declines, while total expenditure may either fall or rise. If expenditures rise, then for a balanced budget, θ needs to drop, which will further reduce b . The double drop in b , due to the original increase in χ and the subsequent decreases in θ , diminishes the rate of growth. If, on the other hand, spending goes down by more than revenue, then for a balanced budget, θ will rise. This, in turn, will drive up both sides of the constraint. In this case, the offsetting effect of a higher χ and higher θ on productivity will have an ambiguous effect on growth. As before, this type of corruption also has unclear implications for the share of government spending and output growth.

Finally, an increase in λ , by decreasing output productivity, causes both sides of the budget to decline. But it is not identifiable which of the sides will decrease by more. If spending declines by more (less), then θ needs to rise (decline) to rebalance the budget. Once again, therefore, the impact of corruption is generally ambiguous. However, the general ambiguity of the effect of *all* types of corruption on both government spending and long-run growth can be identified as being related to a single variable: the size of public expenditure relative to the size of the economy, g/y . The following corollary illustrates this.

Corollary 4.1: *Given a constant income tax rate and rate of return on holding money, if the share of government expenditure as a fraction of total economic activity is relatively large (small), an increase in corruption of any form, decreases (raises) both the share of government expenditure and the steady-state growth rate.*

The exact expression of the threshold value of government spending-to-output appears at the end of Appendix **A(IV)**. If g/y , or $(1 + \chi\varepsilon)\theta$, is relatively large, a decrease in η which decreases the revenue side in equation (14), calls for a decline in θ so that both

sides of the constraint decrease. Given that g/y is large, the expenditure side will decrease by a greater amount to catch up with the initial decline in revenue due to corruption, and, thus, equilibrate the budget. The drop in θ leads to a lower steady-state growth rate of output. If instead θ were to increase, then both revenues and expenditures would rise but the latter would do so by more so that the budget would not have been balanced.

In a similar way, with a large government size, increases in χ and λ require a decline in θ for a balanced budget to be retained, followed by lower output growth. The increase in χ decreases the revenue side of equation (14), while the large and increasing size of $(1 + \chi\varepsilon)\theta$ leads to greater expenses, even with a lower b . To restore budget equilibrium, a downward adjustment of θ is needed. Finally, an increase in λ , even though causes both sides of the budget to decline, with a large government size, revenue declines by more. This, in turn, calls for lower θ .

The corollary supports the presence of non-linear effects of corruption on growth with the sign of the impact being contingent on the size of the government: corruption in an environment with a small government improves growth, while in a large government impedes growth. Even though the mechanism of transmission of these effects focuses purely on public spending considerations, other studies have unveiled conditional effects of corruption on growth by focusing on political institutional quality (Mendez and Sepulveda (2006), Meon and Sekkat (2005), and Aidt *et al.* (2008)). Studying interaction effects between corruption and government size in growth regressions could, therefore, be a worthwhile task.

4. Corruption and growth with optimal (second-best) economic policy

In the previous analysis, the role of the government has been “passive” in response to corruption, in the sense that its fiscal choices were determined by adjusting either the revenue or the expenditure side to ensure a balanced budget. This means that the government has not been choosing its instruments optimally in a way as to maximize some social welfare function. In this section, we examine whether the results obtained thus far as to the links among the key fiscal variables, corruption and growth are robust to an approach that allows for the government to be “active” in its choices of fiscal instruments.

In this section, we endogenize economic policy as this is reflected by the three fiscal instruments τ , θ , and R . We assume a benevolent government that plays a Stackelberg leader vis-à-vis the private sector. This corresponds to the situation where agents make consumption-investment decisions by taking fiscal policy variables as given and then the government chooses fiscal instruments taking the response functions of agents as given.¹⁷ That is, the government maximizes the utility of the agents taking the market allocation as a constraint, the latter being summarized by the growth rate equation (11). We assume commitment technologies on behalf of the government, so that decisions cannot be altered.¹⁸

To characterize the second-best equilibrium we use as objective of the benevolent government the sum of lifetime utilities of all agents over generations discounted by a factor ρ , $\rho \in (0,1)$, reflecting social time preference expressed as¹⁹

$$\Omega \equiv \sum_{t=0}^{\infty} \rho^t U_t, \quad (15)$$

where U_t is the utility function given in equation (1). To ensure boundedness of Ω , we follow Barro (1990) in assuming $\rho < \gamma^\sigma$. Appendix B shows that the welfare criterion Ω corresponds to

$$\Omega = -\frac{(bk_{-1})^{-\sigma}}{\sigma(\gamma^\sigma - \rho)} \left\{ \left[(1-\tau) \frac{\alpha}{\mu} \right]^{-\sigma} Y(R) + \left[(1-\mu)[(1-\eta) \frac{\alpha}{\mu} \tau + \chi \varepsilon \theta] \right]^{-\sigma} \right\}, \quad (15')$$

where²⁰

¹⁷ An alternative approach would be to solve for the first-best (command-optimum) equilibrium where the benevolent government chooses the fiscal policy variables and consumption-investment decision rules at the same time. Aside from the fact that this approach is less realistic (since a government is unlikely to have control over private investment and consumption decisions), it should also be noted that the key feature of our model is the existence of three different forms of corruption, which are exogenously given. Given that corruption is undetectable in our framework, a benevolent government has to choose its instruments appropriately while acknowledging that corruption does and will exist in equilibrium. In this context, the concept of an omniscient social planner that ‘internalizes’ corruption is difficult to fathom, and we therefore abstract from considerations of how a decentralized economy could replicate the social optimum (as, for example, could be studied when the services from public goods are affected by congestion), and focus on the government’s second-best policy, which is termed the ‘optimal’ policy.

¹⁸ Recent applications of this problem can be found in Park and Philippopoulos (2002), Espinosa-Vega and Yip (1999, 2002), and Chen (2005).

¹⁹ We follow the conventional practice of ignoring the initial old’s utility in the evaluation of social welfare.

²⁰ Espinosa-Vega and Yip (1999) illustrate that $Y'(R) \equiv -\sigma q^{1+\sigma} / [1 - \Delta(R)]^\sigma R^{1+\sigma} < 0$.

$$Y(R) \equiv q^{1+\sigma} [R[1 - \Delta(R)]]^{-\sigma} + (1 - q)^{1+\sigma} [\beta b \Delta(R)]^{-\sigma} > 0.$$

The first term in the brackets of equation (15') represents the agents' income associated with legal practices, while the second part denotes the income obtained through corrupt activities.²¹ Welfare, therefore, depends on both the legal and the illegal income of agents. The reason for including illegal income in the government's welfare function is that in our set-up, corruption is not detectable (which means that even though the government may know the distribution of agents indulging in corrupt practices, it does not know a particular agent's type). If corruption were actually detectable, the optimal corruption rate would have been zero, and if punishment strategies were not costly, the appropriate choice of fiscal instruments would have brought corruption down to zero. However, in circumstances such as these, the government has to choose instruments while acknowledging the distortions imposed by the presence of corrupt practices (and hence, illegal income) to attain the second-best. In other words, given that corruption influences both types of income, legal income being affected through the marginal product of private capital, b , any changes in corruption induce the government to optimally adjust its fiscal policy variables to ensure an undistorted level of welfare.

Total differentiation of equation (15') and use of the growth rate equation (11), yield the results of the comparative statics in Propositions 5-7, the proofs of which appear in Appendix B.

Proposition 5: *The optimal response of the government to an increase in corruption related with the collection of tax revenue (decrease in η) is to decrease both the share of government expenditure and the rate of return on holding money. It also raises the income tax rate, providing the effect of taxes on legal income dominates that on illegal income. The combined effect of all these is a fall in the steady-state growth rate.*

Starting from an initial equilibrium, a decrease in η implies that a higher proportion of tax revenues is appropriated by corrupt bureaucrats, which increases the illegal income component in the government's objective function. This will increase overall

²¹ As described earlier, only legal income is intermediated through financial corporations.

consumption and utility, and in the circumstances, the government should make use of its fiscal instruments to reduce the growth rate and, therefore, utility. To this effect, it should bring about a decrease in the optimal share of public expenditure and/or a decline in the optimal rate of return on holding money, both of which will lead to a decrease in the growth rate and, thereby, utility. The government can also additionally use its tax rate instrument. A rise in the tax rate can reduce the post-tax marginal product of capital and reduce the growth rate via the legal income channel, while it will raise consumption via the illegal income channel (as the possibility of embezzlement out of corrupt income rises). If the latter effect is small, then a tax increase would be the optimal response from the government.

To establish the steady-state growth effects of the above actions, note from equation (11) that $\gamma'(\tau) < 0$, $\gamma'(\theta) > 0$, and $\gamma'(R) > 0$. Since both θ and R are optimally reduced, while the tax rate can go in any way, in response to a decrease in η , the total effect on growth is ambiguous. An unambiguously negative growth effect is obtained only when the optimal income tax rate rises.

Proposition 6: *The optimal response of the government to an increase in corruption related with the procurement of productive public goods (increase in χ) is in general ambiguous. However, if corruption has a greater effect on legal income, the government optimally increases both its share of expenditure and the rate of return on holding money, while it lowers the income tax rate. The combined effect of all these is a rise in the steady-state growth rate.*

An increase in χ implies a lower marginal product of capital (as far as legal income is concerned), lower growth and lower steady state utility. In order to increase utility, higher future consumption via an increase in the growth rate is called for, which can be achieved through an increase in θ and/or R . However, a rise in χ implies more illegal income and consumption, for which the government is called for to do the opposite (i.e., decrease θ and/or R). If the former effect dominates, then the government's optimal response is to bring about an increase in the share of public expenditure and/or a rise in the rate of return on holding money. Which way the tax rate instrument will be adjusted depends on

the considerations discussed in the previous case (where a change in η was considered). In sum, a reduction in the tax rate would be called for to increase long-run growth and welfare, if the proportion of legal income earned by bureaucrats is higher than that of illegal income.

Proposition 7: *The optimal response of the government to an increase in corruption related with the productivity of public goods (increase in λ) is to increase both the share of government expenditure and the rate of return on holding money. It also reduces the income tax rate, providing the effect of taxes on legal income dominates that on illegal income. The combined effect of all these is a rise in the steady-state growth rate.*

An increase in λ implies a lower marginal product of capital (as far as legal income is concerned), lower growth and lower steady state utility. In order to achieve higher future consumption and utility, an increase in the growth rate is called for, which can be achieved through an increase in θ and/or R . The way the government will adjust the tax rate depends on the following considerations: A reduction in the tax rate will raise the after-tax marginal product of capital, the growth rate and consumption via the legal income channel, while it will reduce consumption via the illegal income channel (as the possibility of embezzlement out of corrupt income falls). If the latter effect is small, then a tax decrease would be the optimal response of the government, which – together with an increase in θ and/or R (noted earlier) – would lead to higher growth and welfare.

Propositions 5-7 illustrate that the optimal choice of fiscal variables by the government in response to the various types of corrupt practices could, in general, give rise to an ambiguous effect on growth. These findings are consistent with the results obtained in Propositions 2-4, under exogenous adjustment of fiscal variables, where corruption has also been found to have in general an ambiguous growth effect. But as to the effects of corruption on all fiscal instruments and growth, one can also identify similarities between the governments' passive and active policy-making decisions under more specific conditions, as these have been presented in the various corollaries and Propositions. For instance, Propositions 1 and 5 along with Corollary 4.1 state that higher corruption in the form of tax revenue appropriation leads jointly to a lower rate of return

on holding money (and thus higher seigniorage revenue), higher tax rate, lower public spending, and following these, lower output growth. These hold, however, only when the government is large and the effect of taxes on legal income dominates that on illegal income. The same results are also obtained under higher embezzlement in the procurement of productive public goods, as described in Propositions 2, 6 and Corollary 4.1. The required conditions now though are a large government size and the effect of corruption being greater on illegal income. It is only under the third type of corruption (related with the productivity of public goods) that the exogenous and endogenous adjustments of fiscal variables, and hence growth, do not match each other.

In general, a government that acts in such a way as to optimally choose its fiscal instruments in the presence of corruption leads to growth outcomes that are in line with those under a government that adjusts its fiscal choices to run a balanced budget. Therefore, in connection with the growth and welfare effects of corruption, our findings show that it may not be critical whether the government takes a passive or an active stance in setting its fiscal variables, although one can identify the channels through which a benevolent government could attempt to mitigate the negative effects of corruption on economic growth.

5. Conclusion

This paper studied, via a unified analytical framework, the effects of corruption on an economy's growth rate, and on the policy instruments (income tax rate, inflation rate, and size of government spending) that are employed 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. Moreover, our analysis has distinguished between the case where fiscal choices are effectively determined exogenously through the balanced budget constraint, and the case where the government sets its instruments in an optimal manner to achieve the second-best policy outcome.

The effects of corruption on fiscal policy variables as well as growth are, in general, ambiguous. But once specific conditions are taken into account (as identified in the paper), the transmission effects become clear. The conditions that critically guide the

direction of the effects, under both a passive and an active stance by the government, amount to the size of the government, the original distribution of government revenue between seigniorage and taxes, and the relative effect of taxes on legal and illegal income. The nature of these effects has not hitherto been explored in the literature. Moreover, our analysis - by combining the literature on corruption in public spending and finances with that on fiscal policy and growth - has established some results that could rationalise some of the findings in 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 and revenue on growth using panel data for a large group of countries. This would supplement the work of Blackburn *et al.* (2010) 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.

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Appendices

A(I).

Under the assumptions of $d\theta = 0$ and $d\tau = 0$, the matrix form expression of equations (11') and (13') is

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} d\gamma \\ dR \end{bmatrix} = \begin{bmatrix} a_{13} & a_{14} & a_{15} \\ a_{23} & a_{24} & a_{25} \end{bmatrix} \begin{bmatrix} d\eta \\ d\chi \\ d\lambda \end{bmatrix}, \quad (\text{A1})$$

where $a_{11} = 1 > 0$, $a_{12} = -\frac{(1-\tau)\alpha b}{\mu} \Delta' < 0$, $a_{13} = 0$, $a_{14} = \frac{(1-\tau)\alpha \Delta}{\mu} \frac{\partial b}{\partial \chi} < 0$,

$a_{15} = \frac{(1-\tau)\alpha \Delta}{\mu} \frac{\partial b}{\partial \lambda} < 0$, $a_{21} = \frac{1-\Delta}{b} \frac{1}{\Delta} > 0$, $a_{22} = -\left[\frac{1-\Delta}{\Delta} + (\gamma-\pi) \frac{\Delta}{\Delta^2} \right] \frac{1}{b} < 0$,

$a_{23} = -\frac{\alpha}{\mu} \tau < 0$, $a_{24} = \left(\theta \varepsilon + (\gamma-R) \frac{1-\Delta}{\Delta} \frac{1}{b^2} \frac{\partial b}{\partial \chi} \right)$, and $a_{25} = (\gamma-R) \frac{1-\Delta}{\Delta} \frac{1}{b^2} \frac{\partial b}{\partial \lambda} < 0$.

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 (2'), from where it can be shown that $\partial b / \partial \chi < 0$ and $\partial b / \partial \lambda < 0$.

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 lower η . These are

$$\frac{dR}{d\eta} = \frac{a_{11}a_{23} - a_{21}a_{13}}{Det}, \quad (A2)$$

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

where 'Det' is the determinant, for which the expression is provided in equation (A9) 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

$$\frac{dR}{d\chi} = \frac{a_{11}a_{24} - a_{21}a_{14}}{Det}, \quad (A4)$$

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

Finally, using equation (A1) 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

$$\frac{dR}{d\lambda} = \frac{a_{11}a_{25} - a_{21}a_{15}}{Det}, \quad (A6)$$

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

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

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

Using equation (10), we find

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

So, the determinant becomes

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

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 $dR/d\eta > 0$, $d\gamma/d\eta > 0$, $dR/d\chi < 0$, $d\gamma/d\chi < 0$, $dR/d\lambda < 0$, and $d\gamma/d\lambda < 0$, 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 (11') and (13') now is

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

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

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 lower η . These are

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

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

where 'DET' is the determinant, for which the expression is provided in equation (A17) 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

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

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

Finally, using equation (A10) 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

$$\frac{d\tau}{d\lambda} = \frac{b_{11}b_{25} - b_{21}b_{15}}{DET}, \quad (\text{A15})$$

$$\frac{d\gamma}{d\lambda} = \frac{b_{15}b_{22} - b_{25}b_{12}}{DET}, \quad (\text{A16})$$

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

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

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 $d\tau/d\eta < 0$, $d\gamma/d\eta > 0$, $d\tau/d\chi = \text{ambiguous}$, $d\gamma/d\chi = \text{ambiguous}$, $d\tau/d\lambda < 0$, and $d\gamma/d\lambda = \text{ambiguous}$, which form the basis for Propositions 1b-3b.

A(III).

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

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

Simplifying equation (A18), yields

$$\frac{1}{\mu} \frac{\partial b}{\partial \chi} \frac{1}{b} (\gamma\eta\alpha - (\gamma - R)(1-\Delta)\alpha) < \theta\varepsilon \frac{\alpha b}{\mu} \Delta. \quad (\text{A19})$$

A sufficient condition for this inequality to hold is that

$$\frac{1}{\mu} \frac{\partial b}{\partial \chi} \frac{1}{b} (\gamma\eta\alpha - (\gamma - R)(1-\Delta)\alpha) < 0 < \theta\varepsilon \frac{\alpha b}{\mu} \Delta, \quad (\text{A20})$$

or simply, $\gamma\eta\alpha > (\gamma - R)(1-\Delta)\alpha$, given that $db/d\chi < 0$.

Finally, this condition simplifies to

$$(\gamma - R) \frac{1-\Delta}{\Delta} < \frac{\gamma\eta}{\Delta}, \quad (\text{A21})$$

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

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

$$\frac{(1-\tau)\alpha\Delta}{\mu} \frac{\partial b}{\partial \lambda} \frac{\eta\alpha}{\mu} - (\gamma-R)(1-\Delta) \frac{1}{b} \frac{\partial b}{\partial \lambda} \frac{\alpha}{\mu} < 0, \quad (\text{A22})$$

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

A(IV).

Using the restriction that changes in total government revenue are set to zero, the new matrix form expression for the set of equations (11') and (13') now is

$$\begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} d\gamma \\ d\theta \end{bmatrix} = \begin{bmatrix} c_{13} & c_{14} & c_{15} \\ c_{23} & c_{24} & c_{25} \end{bmatrix} \begin{bmatrix} d\eta \\ d\chi \\ d\lambda \end{bmatrix}, \quad (\text{A23})$$

where $c_{ij} = a_{ij}$ except for $c_{12} = -\frac{(1-\tau)\alpha\Delta}{\mu} \frac{\partial b}{\partial \theta} < 0$ and

$$c_{22} = -\left((\gamma-R) \frac{1-\Delta}{\Delta} \frac{1}{b^2} \frac{\partial b}{\partial \theta} + 1 + \chi\varepsilon \right) < 0.$$

Using equation (A23), we can derive the effects of a change in corruption associated with the collection of tax revenues (a lower η) on government expenditure and growth. These are

$$\frac{d\theta}{d\eta} = \frac{c_{11}c_{23} - c_{21}c_{13}}{Det'}, \quad (\text{A24})$$

$$\frac{d\gamma}{d\eta} = \frac{c_{13}c_{22} - c_{23}c_{12}}{Det'}, \quad (\text{A25})$$

where 'Det'' is the determinant, for which the expression is provided in equation (A30) below.

Using equation (A23) again, we can derive the effects of a change in corruption associated with the procurement of public goods (a higher χ) on government expenditure and growth. These are

$$\frac{d\theta}{d\chi} = \frac{c_{11}c_{24} - c_{21}c_{14}}{Det'}, \quad (\text{A26})$$

$$\frac{d\gamma}{d\chi} = \frac{c_{14}c_{22} - c_{24}c_{12}}{Det'}, \quad (\text{A27})$$

Finally, using equation (A23) we can derive the effects of a change in corruption associated with the productivity of public goods (a higher λ) on government expenditure and growth. These are

$$\frac{d\theta}{d\lambda} = \frac{c_{11}c_{25} - c_{21}c_{15}}{Det'}, \quad (A28)$$

$$\frac{d\gamma}{d\lambda} = \frac{c_{15}c_{22} - c_{25}c_{12}}{Det'}, \quad (A29)$$

In equations (A24)-(A29) the determinant is given by

$$Det' = c_{11}c_{22} - c_{21}c_{12} = R \frac{1-\Delta}{\Delta} \frac{1}{b^2} \frac{\partial b}{\partial \theta} - (1 + \chi\epsilon). \quad (A30)$$

Multiplying and dividing through equation (A30) by θ , and using equations (2') and (5), yields

$$Det' = \frac{1}{\theta} \left[\frac{R}{b} \frac{1-\Delta}{\Delta} \frac{1-\beta}{\beta} - \frac{g}{y} \right], \quad (A31)$$

the sign of which is in general ambiguous. The sign depends on the relative size of total spending on public goods and services (as a fraction of GDP). If this ratio is large, then $Det' < 0$ and the effects captured by equations (A24)-(A29) can be assigned the following signs: $d\theta/d\eta > 0$, $d\gamma/d\eta > 0$, $d\theta/d\chi < 0$, $d\gamma/d\chi < 0$, $d\theta/d\lambda < 0$, and $d\gamma/d\lambda < 0$. If g/y is relatively small, the opposite effects take shape. These findings form the basis for Corollary 4.1.

B.

Our economy is populated by two types of agents, households and bureaucrats, of which bureaucrats are divided into those that oversee the collection of tax revenue and the procurement of the public good. In these two classes of bureaucrats, there are in place both honest and corrupt public officials. This description of the structure of our economy shows that there is no such thing as one representative agent. Therefore, when the benevolent government is deriving the welfare criterion, \mathcal{Q} in equation (15), it takes into account the discounted lifetime utility of *all* agents. Given that utility is solely based on consumption during the second period of the agents' lives, the appropriate measure of welfare is a function of the total level of consumption in the economy during the agents' lifetime.

The income of households and the legal income of bureaucrats are saved with the financial intermediaries, while the illegal income of bureaucrats is saved "under the mattress." This means that only the income saved through banks is subject to an uncertain rate of return conditional on the probability of the agent's relocation. The illegal income, on the other hand, carries no rate of return. This latter income is represented by the total amount appropriated by corrupt bureaucrats: $(1 - \mu)[(1 - \eta)\tau w_t + \chi\epsilon\theta_t]$.

From equations (15), (1), and (7), the benevolent government maximizes

$$\Omega \equiv \sum_{t=0}^{\infty} \rho^t U_t, \quad (\text{B1})$$

where

$$U_t = -q \frac{[(1-\tau)w_t i_t]^{-\sigma}}{\sigma} - (1-q) \frac{[(1-\tau)w_t I_t]^{-\sigma}}{\sigma} - \frac{\{(1-\mu)[(1-\eta)\tau w_t + \chi \varepsilon \theta_t]\}^{-\sigma}}{\sigma}, \quad (\text{B2})$$

subject to the economic growth rate equation (11), which we re-write here for convenience

$$\gamma = \frac{(1-\tau)\alpha b}{\mu} \Delta(R). \quad (\text{B3})$$

Using equations (2'), (3), (4), (8), and (9) into equation (B2), the latter becomes

$$U_t = -\frac{1}{\sigma} \left\{ q \left[(1-\tau) \frac{\alpha R}{\mu q} [1-\Delta(R)] \right]^{-\sigma} + (1-q) \left[(1-\tau) \frac{\alpha \beta b}{\mu (1-q)} \Delta(R) \right]^{-\sigma} + \left\{ (1-\mu) \left[(1-\eta) \tau \frac{\alpha}{\mu} + \chi \varepsilon \theta \right] \right\}^{-\sigma} \right\} (bk_t)^{-\sigma},$$

or

$$U_t = -\frac{1}{\sigma} \left\{ \left[(1-\tau) \frac{\alpha}{\mu} \right]^{-\sigma} Y(R) + \left\{ (1-\mu) \left[(1-\eta) \tau \frac{\alpha}{\mu} + \chi \varepsilon \theta \right] \right\}^{-\sigma} \right\} (bk_t)^{-\sigma}, \quad (\text{B2}')$$

where

$$Y(R) \equiv q^{1+\sigma} [R[1-\Delta(R)]]^{-\sigma} + (1-q)^{1+\sigma} [\beta b \Delta(R)]^{-\sigma} > 0.$$

Using equation (B2') and the growth rate equation (B3), some algebra reveals that equation (B1) becomes equation (15'), or

$$\Omega = -\frac{(bk_{-1})^{-\sigma}}{\sigma(\gamma^{\sigma} - \rho)} \left\{ \left[(1-\tau) \frac{\alpha}{\mu} \right]^{-\sigma} Y(R) + \left[(1-\mu) \left[(1-\eta) \frac{\alpha}{\mu} \tau + \chi \varepsilon \theta \right] \right]^{-\sigma} \right\}. \quad (\text{B4})$$

If we totally differentiate equation (B4) with respect to θ , R , τ , η , χ , and λ , we obtain the comparative static results in Propositions 5-7. In particular, for Proposition 5

$$\frac{d\theta}{d\eta} > 0, \quad \frac{dR}{d\eta} > 0, \quad \frac{d\tau}{d\eta} \quad \text{and} \quad \frac{d\gamma}{d\eta} \quad \text{are ambiguous}, \quad (\text{B5})$$

while

$$\frac{d\tau}{d\eta} < 0, \frac{d\gamma}{d\eta} > 0 \text{ if } \frac{(1-\tau)(\gamma^\sigma - \rho)}{\gamma^\sigma} < \frac{(1-\eta)\frac{\alpha}{\mu}\tau + \chi\varepsilon\theta}{(1-\eta)\frac{\alpha}{\mu}}.$$

For Proposition 6,

$$\frac{d\theta}{d\chi}, \frac{dR}{d\chi}, \frac{d\tau}{d\chi}, \text{ and } \frac{d\gamma}{d\chi} \text{ are all ambiguous.} \quad (\text{B6})$$

Finally, for Proposition 7,

$$\frac{d\theta}{d\lambda} > 0, \frac{dR}{d\lambda} > 0, \frac{d\tau}{d\lambda} \text{ and } \frac{d\gamma}{d\lambda} \text{ are ambiguous,} \quad (\text{B7})$$

while

$$\frac{d\tau}{d\lambda} < 0, \frac{d\gamma}{d\lambda} > 0 \text{ if } \frac{(1-\tau)(\gamma^\sigma - \rho)}{\gamma^\sigma} < \frac{(1-\eta)\frac{\alpha}{\mu}\tau + \chi\varepsilon\theta}{(1-\eta)\frac{\alpha}{\mu}}.$$