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Corruption and growth: The role of governance, public spending, and economic development☆

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ABSTRACT

This paper analyses how the quality of governance, the size of public spending, and economic development affect the relationship between bureaucratic corruption and economic growth. The analysis shows that the interaction between corruption and governance shapes the efficiency of public spending, which in turn, determines the growth effects of corruption. Specifically, corruption improves economic efficiency only when the actual government size is above the optimal level. It implies that a growth-maximising level of corruption is possible. This paper also finds that the incidence of corruption declines with economic development. This is because with economic development the wage rate rises and makes private rent seeking costs higher, thereby, discouraging corruption. The main policy implication is that targeting tax evaders instead of bureaucrats is more effective in terms of both reducing corruption and improving the growth potential of an economy.

1. Introduction

When the public and private sectors interact, bureaucrats may abuse their public position for private gains by accepting bribes or even actively extorting them. This behaviour is defined as an act of bureaucratic corruption. Examining the effects of bureaucratic corruption on economic growth and more importantly, how this relationship is influenced by the quality of governance, the size of public spending, and economic development is the primary focus of this paper.

Notably, the extant literature finds that corruption either may facilitate growth by helping firms circumvent the burden of the public sector or may retard it by increasing this burden and reducing the efficiency of public spending that contributes to productivity.[1] The literature highlights that whether the positive or negative effect dominates depends on the quality of governance, the size of the public sector, and the level of economic development; as these factors play a significant role in corruption outcomes. However, there are some inconsistencies and gaps in the literature in explaining the dependence of the corruption-growth nexus on these factors, which merit a further investigation.

First, the literature is not clear about how the quality and structure of underlying institutions influence the relationship between corruption and economic performance. One line of reasoning in this literature is based on the idea that corruption is driven by the institutional setting.[2] According to this rationale, the institutional structure determines the degree of organisation of corruption, which then impacts on the income uncertainty faced by the private agents and thus on the economic performance (Blackburn and Forgues-Puccio, 2009; Shleifer and Vishny, 1993). On the contrary, the other line of reasoning assumes that corruption alters the effects of institutions on the economy, such as the burden imposed or the productivity input provided by the public sector, thereby, impacts on economic growth (for example, see (Acemoglu and Verdier, 2000; Aidt, 2009; de Vaal and Ebben, 2011; Keefer and Knack, 1997; Knack and Keefer, 1995; Rajkumar and Swaroop, 2008).

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[1] For example, see *inter alia* Leff (1964), Huntington (1968), Liu (1985, 1996), Fisman and Svensson (2007), Pellegrini and Gerlagh (2004), Ali and Isse (2003), Tanzi and Davoodi (2000), Tanzi and Davoodi (1998), Bardhan (1997), Mauro (1995), Aidt (2003), Abed and Gupta (2002).

[2] Aidt (2003), Andvig and Moene (1990), Bardhan (1997), Blackburn et al. (2006), Ryvkin and Serra (2012), Celentani and Ganuza (2002) argue that the governance structure indeed drives the incidence of corruption, either by impacting the uncertainty of corruption outcomes or by altering the incentives for corruption.

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Although offering useful insights, the analysis in the aforementioned literature provides us with a limited understanding of the issue, as it focuses on narrowly defined transmission mechanisms of the effects of corruption. The lack of a systematic explanation of the role of governance in the corruption-growth nexus is evident also from the existing inconclusive empirical findings. For example, Méon and Weill (2010) and, Aidt et al. (2008) find that corruption is less detrimental to efficiency and growth in countries where institutions are weak. Méon and Sekkat (2005) contradict the above-mentioned authors, and report that corruption is most harmful to growth where governance is weak. In the same vein, Méndez and Sepúlveda (2006), and Aidt (2009) demonstrate empirically that in countries with high political freedom and low level of corruption, the beneficial effects of corruption outweigh the detrimental effects, and vice versa.[3]

Second, there is another inconsistency in the literature with respect to the relationship between government size and corruption. In particular, if government size is related to the degree of government intervention and the inefficiencies induced by it, then, an increase in government size creates more room for rent-seeking and corruption (for example, see Alesina and Angeletos, 2005; Goel and Nelson, 1998; Rose-Ackerman, 1999). However, if the government size reflects its control of corruption and accountability, an increase in government size should curb corruption. La Porta et al. (1999) and Billger and Goel (2009) find evidence supporting the latter hypothesis for Scandinavian countries. Intuitively, the inconsistency in this case stems from ignoring the interaction of the quality of governance with both corruption and government size.

Third, there is strong evidence indicating that the incidence of corruption is related to the level of economic development. For example, studies by Mauro (1995), Knack and Keefer (1995), Keefer and Knack (1997), Fisman and Gatti (2002), Rauch and Evans (2000), Blackburn and Forgues-Puccio (2007) find that there is a significant negative relationship between the level of corruption and the level of economic development of countries. Blackburn et al. (2006, 2010) and Haque and Kneller (2009) explain this link between development and corruption by suggesting that the expected losses of corrupt bureaucrats increase with income levels. Intuitively, one can also relate the cost of corrupt rent seeking to the cost stemming from concealment of illicit income gained from corruption. In fact, analysing tax evasion Cowell (1990), Chen (2003), and Hillman (2009) explain that rent seeking costs arise because tax evaders have to hire experts and lawyers to conceal their illegally obtained income. The relevance of this rationale to corrupt activities has also been emphasised by Barreto (2000) and Blackburn et al. (2006), who link the cost of corrupt behaviour to the incidence of corruption.[4] Despite being highlighted as an important channel, the possible implications of the link between rent seeking costs and the wage rate driven by the level of economic development on corruption outcomes, have not been thoroughly examined in the literature.

To summarise, the existing literature lacks a more general approach for interpreting the role of governance, the size of government, and the level of development in the relationship between corruption and growth. This paper attempts to address this issue. A formal analysis of how these factors affect the relationship between corruption and growth in a more general framework is important for a number of reasons. First, by gaining insights into this issue one will be better capable in interpreting the above controversial empirical results. Second, this is important because by ascertaining how these factors alter the corruption-growth nexus will help one to assess the growth effects of corruption more accurately. Moreover, a good understanding of how corruption impacts economic performance is essential for formulating and implementing effective development policies.

This paper attempts to shed a new light on the issues raised above by considering the link between governance, the size of the public sector, and corruption from a broader perspective. Specifically, the analytical framework employed in this study integrates the aforementioned approaches, thereby making it more general.[5] First, following Andvig and Moene (1990), Ryvkin and Serra (2012), Haque and Kneller (2009), and Blackburn et al. (2006), the framework incorporates the idea that the ability of the government to contain corruption is driven by the quality of governance. The statistical evidence by Butkiewicz and Yanikkaya (2006) supports this tenet by demonstrating that the correlation between corruption and different measures of the quality of governance is consistently negative. In the model, this aspect of governance is captured by the parameters that affect compliance and bribery. Second, the quality of institutions also drives the efficiency of the public sector, and hence it determines the optimal size of public spending.[6] Another key element in the workings of the corruption-growth nexus is that corruption distorts both the burden of the public sector driven by the quality of institutions and the productive inputs generated by the government.[7] This implies that corruption affects economic performance also through the (in)efficiency of public spending, driving a disparity between actual and optimal government sizes. Thus, the relationship between corruption and growth depends directly on governance as this drives the level of corruption; and indirectly through the interactions between the efficiency of government spending and the distortions caused by corruption in the cost–benefit balance of the public sector.

Another distinctive feature of the analysis in this paper is that it emphasizes that the cost of rent seeking is an important factor driving the incidence of corruption. Explaining this link helps to establish a new channel through which the level of development affects the incidence of corruption. In this respect, by adopting a different view to the current literature, this paper postulates that the negative relationship between the incidence of corruption and the level of development is driven by rent-seeking costs which rise with the wage rate. This is because this cost depends on the effort to conceal the illegally obtained income; and hence, this effort should be costlier as the wage rate increases, which in turn increases with the level of economic development. Thus, by accounting for the rent seeking costs, this paper addresses another aspect of corruption that has not been thoroughly examined in the corruption literature.

It is worthwhile to note that the analysis conducted in this paper differs from the closely related papers in several aspects. In particular, Blackburn and Forgues-Puccio (2009) and Shleifer and Vishny (1993) focus on how the structure of governance drives corruption, but do not consider how corruption affects public productive inputs and tax evasion. Keefer and Knack (1997); Rajkumar and Swaroop (2008); Knack and Keefer (1995), and Aidt (2009) only empirically examine the effect of governance on the relationship between corruption and the efficiency of public spending. Unlike the paper of de Vaal and Ebben (2011),

[3] Nevertheless, Aidt (2009) argues that these results may not be robust because they depend on the choice of the dummy variables; and also intuitively it is hard to accept that in countries with strong institutions, at low levels, corruption may be beneficial.

[4] There are some papers that focus on the relationship between relative public–private wages and corruption, rather than the average wage rate of the economy. For example, Van Rijckeghem and Weder (2008) and Panizza (2001) find evidence of a statistically and economically significant relationship between relative civil-service pay and corruption in regressions based on cross-country averages. However, Sosa (2004), based on the empirical studies done on the wage-corruption trade-off, finds no conclusive support for the effectiveness of increasing wages as an anti-corruption measure.

[5] However, it should be admitted that, due to this generalisation in the model, some trivial but clear relations mentioned in the literature and theory may not be captured by the model.

[6] To account fully for the economic effect of the public sector it is essential to consider the benefits provided by the public sector along with the burden imposed by it (Barro, 1990; Cowell and Gordon, 1988). Barro (1990) has explained that the optimal size of the government is determined by the trade-off between the marginal cost and benefit of public goods.

[7] For example, Mauro (1998), Delavallade (2006), Kagundu (2006), Devarajan et al. (1996), Keefer and Knack (2002), Gupta et al. (2001), Rajkumar and Swaroop (2008), and de la Croix and Delavallade (2009) have shown that corruption distorts the effectiveness of public spending. Whereas, Blackburn et al. (2006), Dreher et al. (in press), Dreher and Gassebner (2007), Guriev (2004), Svensson (2003), and Kaufmann and Wei (1999) corruption imposes a significant burden on private agents.

Blackburn et al. (2010), and Haque and Kneller (2009), where they model corruption as embezzlement of public funds by corrupt bureaucrats, this paper considers corruption strategies between private agents and bureaucrats. This approach allows us to underpin behavioural patterns of both private agents and bureaucrats, thereby allowing to gain useful insights for policy formulation. Finally, de Vaal and Ebben (2011) assume a 'reduced form' approach by treating the quality of institutions as a factor directly augmenting productivity. Unlike them, in this study, it is rather a factor that affects the economic performance through its effect on corruption outcomes and the public sector burden and benefit.

The analysis along these lines yields the following results: (i) the effect of corruption on the economy depends on the trade-off between the burden of regulations and the efficiency of productive public inputs; (ii) if the gain through decreased public sector burden is greater than the loss in public productive inputs, collusive corruption might have positive growth effects; (iii) the cost of corruption increases with the wage rate, thus, development and corruption are negatively correlated; (iv), this paper gains some insights into the effectiveness of anti-corruption policies in terms of reducing the incidence of corruption and enhancing growth simultaneously. Namely, it is found that targeting tax evaders instead of bureaucrats is more effective in terms of both reducing corruption and improving the growth potential of the economy. A calibration of the model and a simulation analysis yields numerical patterns supportive of the theoretical conjectures stemming from the model.

The rest of the paper is structured as follows: Section 2 presents the model and its solution, whereas Section 3 discusses growth implications of corruption. Section 4 discusses the results and concludes the analysis.

2. The model

The model developed in this section draws on the endogenous growth model developed in Barro (1990). In general, the public sector interacts with the private sector in two broad fields: taxation and public goods provision. Barro (1990) generalizes this idea by expressing the burden of regulations as an average tax rate, τ, and the benefit of public goods as the productive input per worker, $g(t)$. With imperfect monitoring, private agents have an incentive not to comply to taxation and to increase their disposable income by defying tax compliance. To deal with this issue, governments hire bureaucrats to monitor private agents' compliance, and allow them to punish the non-complying private agents. However, when private agents are detected for non-compliance they may collude with the self-serving bureaucrats.[8] In this case, private agents are not punished for the non-compliance, instead they pay bribes to corrupt bureaucrats, which are usually less than the statutory penalty. This gain comes at a cost in terms of the amount of productive inputs because tax evasion induced by corruption reduces tax revenue. Indeed, it has been observed that corrupt governments often tend to collect less tax revenue while utilizing the scarce public funds inefficiently.[9] However, it should be noted that efficiency in tax collections may be attributable to other factors that also drive corruption. Thus, perhaps, it would be safer to see this relationship between corruption and revenue collection as correlation rather than causation.

There is no reason to believe that corruption always occurs in the form of collusion between private and public agents. In fact, corruption can often result from situations where bureaucrats extort bribes from honest citizens, by abusing their authority of discretion when enforcing regulations.[10] Addressing this issue, the model described below incorporates the effects of distortions created by corruption in both fields of private–public interactions.

2.1. The set-up

Following Blackburn et al. (2006), it is assumed that the economy is populated with two-types of agents: one type is involved in private production, the other type is involved in public good production. Hence, there is no social mobility in this model. This assumption seems reasonable for economies with robust corruption in public ranks.[11] The difference between the two agents lies in their occupation, not in their preferences. The preferences of both types of agents are identical and they maximize their utility given by $U = \int_0^\infty u[c(t)]dt$. The population is assumed to be static and the number of people is normalized at unity; a fraction of the population equal to $1 - \lambda$ are workers, and the rest, λ, are bureaucrats.

2.1.1. Bureaucrat households

The members of the bureaucrat families work for the public sector and produce public inputs. A bureaucrat's objective is to maximize the inter-temporal utility given by $U = \int_0^\infty u[c(t)]dt$, subject to their budget constraint. The bureaucrats generate their income by working for the government and by holding assets, $a_1(t)$, which are claims on the physical capital used by the firms. It is assumed that the bureaucrats are endowed with both monitoring and licencing functions.[12] Therefore, the bureaucrats are able to engage in both types of corruption, and can generate additional income by collecting bribes from firms, which is discussed in more detail below.

2.1.2. Worker households

The worker households supply labour and capital to firms and seek to maximize the inter-temporal utility given by the function of the same form as that for the bureaucrat agent. For simplicity, it is assumed that there is one member in each household endowed with one unit of labour, supplied inelastically. The households generate income by working for firms, and, just like the bureaucrat agents, by holding assets, $a_2(t)$. λ_t.

2.1.3. Firms

There are N identical firms that use the technology given by the constant returns to scale production function, $y = Af(k(t), g(t))$, where $k(t)$ is the instantaneous capital input per worker, $g(t)$ is the public sector input per worker, and A is the coefficient of technology. Output of the firms is taxed at a flat rate, τ. The production function is increasing in k and g at a decreasing rate; thus, $f_k, f_g > 0$ and $f_{kk}, f_{gg} < 0$. The firms maximize after-tax profit, hence, the profit maximisation involves not only choosing the production factors, but also the rate of tax compliance. If detected for non-compliance, the firm pays either fines or bribes depending on whether the detecting bureaucrat chooses to be corrupt or not.

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8 See e.g. Shleifer and Vishny (1993).

9 See Abed and Gupta (2002) for an excellent collection of papers that study the implications of corruption on public finance. Mauro (1998) finds evidence for the argument that relatively corrupt governments tend to favour capital spending projects. Delavallade (2006) on the other hand finds that corruption distorts public spending by reducing expenditure on health and social protection while increasing expenditure on defence. Gupta et al. (2001), provide empirical results, on the positive and significant correlation between corruption and military spending as a share of GDP. Devarajan et al. (1996) using data for 43 developing countries find that an increase in the share of current expenditure has positive effects on economic growth, while an increase in the share of capital expenditure denotes negative effects. Corroborating the above studies, Keefer and Knack, (2002), Gupta et al. (2001), Rajkumar and Swaroop (2008), de la Croix and Delavallade (2009) and Tanzi and Davoodi (1998) have shown that corruption distorts the effectiveness of public spending in promoting economic development and growth.

10 See e.g. (Hindriks et al., 1999; Kaufmann, 1997; Polinsky and Shavell, 2001; Shleifer and Vishny, 1993; Sjaifudian, 1997).

11 The role of elites in determining institutions is discussed in Acemoglu and Robinson (2008). These authors also model two distinct groups of agents: the elite and the citizens.

12 In this model, there is no hierarchy in bureaucracy. See Hillman and Katz (1987) and Kahana and Qijun (2010) for the role of hierarchy in rent-seeking and the persistence of corruption.

2.1.4. Government

The (central) government hires and monitors bureaucrats. The government's budget constraint is:

$$T(t) + F(t) = M(t) + G(t), \tag{1}$$

where $T(t)$ is the effective tax revenue, $F(t)$ is the amount of fines collected from penalties for non-compliance, $M(t)$ is the cost of monitoring, and $G(t)$ is the total productive public input for private production. It is assumed that the government budget is always balanced. The government sets the tax rate, τ, the penalty rate for tax evasion, θ, the penalty rate for corruption, ξ, and chooses the monitoring effort, $p_a(t)$. Since in the model there is no social mobility, the wage rate of the bureaucrat is determined by the government based on the budget constraint and the number of bureaucrat agents. However, in this set-up, the wage rate of the bureaucrat, w_B, is not a driving factor, thus it is simply defined to satisfy the government budget constraint: $w_B \leq \frac{G(t)}{\lambda}$.

2.1.5. The quality of governance

The quality of governance is manifested through exogenous cost parameters faced by the agents for corruption, tax evasion, and monitoring. Notably, Álvarez-Díaz and Caballero (2008) find that the parametric perspective about institutional quality can be treated as accurate. Intuitively, a better quality of institutions leads to higher costs imposed on illicit behaviour. In addition, the quality of public institutions drives the marginal contribution of public inputs into private productivity. This implies that for economies with more efficient governments, the optimal size of public spending is larger than for economies with less efficient governments.

2.2. Bureaucracy and corruption

The bureaucrat is involved in the production of public inputs, licencing and monitoring of the firms. When the bureaucrat is imperfectly monitored by the government, he or she can abuse their public position and rent seek by being corrupt. This corruption can be of two forms as classified by Shleifer and Vishny (1993): *with theft* or collusive corruption, and *without theft* or non-collusive corruption. Collusive corruption involves collusion with a private agent where concealment of a non-compliance to regulations by the private agent is exchanged for a bribe. The best example of this type of corruption is tax evasion under corrupt tax inspectors. In the case of non-collusive corruption, a bureaucrat behaves like a monopolist and provides a public good or service with a mark-up. Generally, it means that the private agent over-pays for the public good or service. In this situation, the bureaucrat, by abusing his public position forces private agents to pay bribes. As a result of his corrupt behaviour whilst in a public position, the bureaucrat increases his income by adding to his salary, $w_B(t)$, illegal income collected in the form of bribes, $B(t)$.

2.2.1. Bribes and cost of corruption

As mentioned above, the bribes are of two types: the bribes collected through collusive corruption, B_1, and the bribes collected through extortion (or non-collusive corruption), B_2 (for simplicity, where it is not essential, the time variable is omitted). The subsequent section presents how bribes for each type of corruption are determined.

2.2.1.1. Collusive corruption. The amount of bribes generated through collusive corruption, B_1, depends on several factors: i) the probability of non-compliance by a firm, p_n; ii) the degree of compliance (the rate of income declaration), $\varepsilon \in [0,1]$; iii) the probability of detecting the act of non-compliance, p; iv) the rate of penalty applied to the infringement, $\theta > 1$; v) the probability of the bureaucrat being corrupt, p_b; vi) and the bribe rate, $0 < \beta_1 < 1$. That is, the corruption outcome is determined jointly by the private agent (p_n, and ε), the bureaucrat (β_1, p_b), and the governance structure (p, θ). Within the representative framework the first factor is not relevant, as the representative agent will choose not to comply with the regulations as long as the expected pay-off is positive. Therefore, it can be assumed that $p_n = 1$.

The degree of non-compliance by a firm is determined as an optimal reaction to the enforcement strategy of the government, the probability of the bureaucrat being corrupt, and his bargaining power. Let us denote the taxable per worker income by x. Taxable income is found as $x = y - \delta k$, where y is the gross per worker output, and δ is the depreciation rate. Therefore, the firm saves $(1 - \varepsilon)\tau x$ by not complying fully to the regulations (e.g. evading taxes), and when caught it incurs a loss due to the penalty imposed, which is equal to $\theta(1 - \varepsilon)\tau x$. It is also assumed that the bribe is proportional to the penalty that has to be paid for non-compliance, $\beta_1\theta(1 - \varepsilon)\tau x$. Given the bribe is paid only if non-compliance is detected by a corrupt bureaucrat, the joint probability of bribery is exogenously given by $p_1 = p \cdot p_b$. This gives us the expected bribe amount in per worker terms: $p_1\beta_1\theta(1 - \varepsilon)\tau x$. The total amount of bribes collected by a bureaucrat is found as the product of the bribe rate in per worker terms, multiplied by the number of workers per bureaucrat, $n = \frac{1-\lambda}{\lambda}$, where λ is the share of bureaucrats in the total population. Thus, if the degree of non-compliance is known, then given the other variables, the amount of the bribes collected is determined by:

$$B_1 = p_1\beta_1\theta(1-\varepsilon)\tau x n. \tag{2}$$

Recall that taxable income and the evasion rate depend on the private agent's decisions, while the penalty rate is set by the government and the detection probability depends on the amount of resources available for tax auditing. The bureaucrat takes the tax rate, τ, taxable income of the taxpayer, x, the evasion rate, $(1 - \varepsilon)$, the penalty rate, θ, and the probability of detection, p, as given. The bribe rate, β_1, depends on the bargaining power of both the private agent and the bureaucrat involved in the corrupt deal. The bribe rate cannot exceed unity as the private agent will then choose to pay the official penalty instead of the bribe. For simplicity, it is assumed that as a result of the bargaining process among taxpayers and bureaucrats, the equilibrium bribe rate, β_1 is attained and is well known to both parties.[13] This reduces the problem of the bureaucrat to choosing the probability of being corrupt, given the costs and benefits. Therefore, we can simplify the bureaucrats decision problem to choosing the expected bribe rate, $\overline{\beta}_1 = p_1\beta_1$. Hence the bribes collected can be expressed as,

$$B_1 = \overline{\beta}_1\theta(1-\varepsilon)\tau x n. \tag{3}$$

However, as it will be clear further on, the initiation of a bribe by the bureaucrat, who chooses to be corrupt, is not a simple choice. The bureaucrat's choice may stem from a number of endogenous factors such as the productive externality of government spending and the cost of corruption, which, consequently, depends both on the incidence of corruption and the income levels in the particular economy.

Now, let us focus on the cost borne by the corrupt bureaucrats. The costs of being corrupt may come in different forms. For example, Blackburn et al. (2006) argue that these costs stem from hiding illegal income, investing it differently than legal income, or changing the pattern of expenditure. In addition, a part of illegal income may be spent on higher level bureaucrats in hierarchical corruption, as described by Hillman and Katz (1987), and Kahana and Qijun (2010). These costs may include hiring experts and lawyers to conceal illegal income, for example, such as the transaction costs involved in tax evasion, as explained by Cowell (1990), Chen (2003), and Hillman (2009).

In general, these costs increase with both the degree of corruption and the income level. For example, Barreto (2000) explains this link intuitively that as the size of illegal income rises, it becomes increasingly difficult to conceal it. Analogously, Blackburn et al. (2006) model this cost as a convex function of bribe income and the number of corrupt

[13] In reality, the bribe rate, β, is more likely given by a distribution. The agents still can use the expected value of this distribution in their decision making, which technically implies the same approach as the above assumption.

bureaucrats, whereas Chen (2003) captures the costs of concealing illegal income by a function that depends on the squared tax evasion rate. Moreover, with the income level, the cost of labour rises, so that the cost of any activities related to the concealment of corruption also increases.

Based on this discussion, the cost of being corrupt is postulated as a convex function that depends on the degree of corruption, the monitoring effort by the government, p_a, and the wage rate for workers, w.[14] Further, the expected bribe rate, $\overline{\beta}_1$, is utilized as a measure of the degree of corruption; as, for any given non-compliance of the private agent, an increase in the expected bribe rate increases illegal income of the bureaucrat. and thus the expected cost incurred by the corrupt bureaucrat it is related to it. Therefore, the concealment cost is formulated as:

$$\psi p_a w \overline{\beta}_1^2,$$

where, the term ψ is a cost parameter that depends on the quality of institutions.

Along with the concealment costs, the total cost of being corrupt includes also the penalties paid by the bureaucrat if detected for their corrupt behaviour. Assuming that the penalty is proportional to the bribe amount, the expected penalties are expressed by

$$p_a \xi \theta \tau (1-\varepsilon) x \overline{\beta}_1,$$

where, ξ is the penalty rate, and p_a is the probability of detecting an act of corruption, and $\tau(1-\varepsilon)x\overline{\beta}_1$ is the expected amount of bribes extracted from a taxpayer.

Therefore, the cost function for a corrupt activity is conveniently formulated as:

$$c_{b1} = p_a \xi \theta \tau (1-\varepsilon) x \overline{\beta}_1 + \psi p_a w \overline{\beta}_1^2. \quad (4)$$

Now, by accounting for the related costs and the number of private agents dealing with the bureaucrat, we can write the net expected bribes collected by a bureaucrat through collusive corruption as:

$$\overline{B}_1 = n \overline{\beta}_1 x \tau \theta (1-\varepsilon)(1-\xi p_a) - \psi p_a w \overline{\beta}_1^2. \quad (5)$$

The first term captures the bribes less the expected cost of penalties for corruption, while the second term captures the cost related to the concealment of the illicit behaviour.

2.2.1.2. Non-collusive corruption. Most economic activities within the economy are regulated and are therefore subject to some sort of licencing which is implemented by the bureaucrats. The second type of bribe can generally be seen as being generated by the bureaucrat by abusing the discretionary power he or she has in licencing and monitoring. For example, Blackburn and Forgues-Puccio (2009) and Dreher et al. (2009) model corruption as bribe extortions from firms in the process of obtaining licences and permits. Moreover, extortion is possible even in the tax collection process. For example, Hindriks et al. (1999), and Polinsky and Shavell (2001) have discussed about such interactions between taxpayers and tax inspectors.

Following Blackburn and Forgues-Puccio (2009), it is assumed that there is no legal cost involved for the private agent in order to get the licence, except for the cost of meeting the licence requirements, which is normalized at zero. However, as the bureaucrat possesses monopolistic power, the bureaucrat sells the permit with a mark up, β_2,with some probability, $0 < p_2 < 1$. This implies that with probability, $1 - p_2$, the private agent gets the licence at zero cost. This income re-distribution decreases the taxpayers' after-tax income, $(1 - \varepsilon\tau)x$; therefore, the amount of bribes collected is given by:

$$B_2 = p_2 \beta_2 (1-\varepsilon\tau) x n. \quad (6)$$

Again, it is reasonable to assume that with this type of corrupt behaviour the bureaucrat incurs a cost that increases with the degree of corruption. Similar to collusive corruption, the expected bribe rate, $p_2\beta_2$, can be used as a base to determine the expected cost of a corrupt bureaucrat. This cost includes the fines imposed for being corrupt and other costs which are analogous to the case of collusive corruption. The bribe rate, β_2, depends on the bargaining power of the taxpayer and the bureaucrat involved. For simplicity, it is assumed that as a result of the bargaining process between the taxpayers and the bureaucrats, the equilibrium bribe rate is attained and is well known to both parties. Therefore, the bureaucrat's decision is simply to choose the expected bribe rate, $\overline{\beta}_2 = p_2\beta_2$.

This makes the bureaucrats' cost which stems from non-collusive corruption to be

$$c_{b2} = x\overline{\beta}_2(1-\varepsilon\tau) p_a \xi + \psi p_a w \overline{\beta}_2^2. \quad (7)$$

Given the costs, the bureaucrat chooses $\overline{\beta}_2$, and obtains the expected net bribe from non-collusive corruption:

$$\overline{B}_2 = n x \overline{\beta}_2 (1-\varepsilon\tau)(1-\xi p_a) - \psi p_a w \overline{\beta}_2^2. \quad (8)$$

Analogously to the collusive corruption case, the amount of bribes collected through extortion is also jointly determined by the private agent, the bureaucrat, and the institutional setting. Summing up both types of bribe income, the overall amount of bribes collected net of rent-seeking cost is given as:

$$\overline{B} = \overline{B}_1 + \overline{B}_2.$$

2.3. The households' problem

Since there are two types of households: the bureaucrat and the private agent, their respective problems are considered separately.

2.3.1. The bureaucrat household

Given the preferences and the budget constraint, the bureaucrat's problem is stated as (time variable is omitted for ease of exposition):

$$\max_{c_{1t}, \overline{\beta}_1, \overline{\beta}_2} U_1 = \int_0^\infty e^{-\rho t} u(c_1) dt, \quad (9)$$

s.t. (8), (6),

$$\dot{a}_1 = w_B + \overline{B} + r a_1 - c_1, \quad (10)$$

Here, w_B is the wage of a bureaucrat determined by the government.

To solve this problem, a present-value Hamiltonian, $J(t)$, is constructed,

$$J(t) = u(c_1) e^{-\rho t} + \nu \left[w_B + r a_1 + \overline{B} - c_1 \right].$$

Then, the FOCs of this optimization problem are given by:

$$\frac{\partial J}{\partial c_1} = 0 \Rightarrow \nu_1 = u'(c_1) e^{-\rho t}, \quad (11)$$

$$\frac{\partial J}{\partial \overline{\beta}_1} = 0 \Rightarrow \overline{\beta}_1^* = \frac{x \tau \theta (1-\varepsilon)(1-p_a \xi)}{2 \psi p_a w}, \quad (12)$$

[14] Since labour is supplied inelastically in the model, there is no opportunity cost for the bureaucrats stemming from concealment efforts. Hence, the concealment cost does not depend on the wage rate of the bureaucrats; rather it depends on the wage rate of workers, as the bureaucrats incur costs driven by the non-public sector.

$$\frac{\partial J}{\partial \beta_2} = 0 \Rightarrow \overline{\beta}_2^* = \frac{x(1-\tau\varepsilon)(1-p_a\xi)}{2\psi p_a w}, \tag{13}$$

$$-\dot{\nu} = \frac{\partial J}{\partial a_1} \Rightarrow \dot{\nu} = -\nu r; \tag{14}$$

To rule out non-optimal solutions, the following transversality condition is assumed to be satisfied:

$$\lim_{t\to\infty}[\nu(t)a_1(t)] = 0.$$

Next, one can derive the Euler equation from the first-order conditions, which yields the expression governing the dynamics of consumption. Assuming that the utility function is given by $u(c) = ln(c)$, one can obtain a particular dynamic path of the representative bureaucrat's consumption, given by the following differential equation:

$$\frac{\dot{c}_1}{c_1} = r - \rho. \tag{15}$$

The result is standard for this type of model, although, how the equilibrium interest rate is determined, makes this result peculiar. This will be discussed in Section 2.5.

2.3.2. The worker household

The representative household is identical to the bureaucrat household in terms of preferences, but faces a different budget constraint. The representative household's problem is stated as follows:

$$\max_{c_2} U_2 = \int_0^\infty e^{-\rho t} u[c_2] dt, \tag{16}$$

s.t.

$$\dot{a}_2 = w + a_2 r - c_2. \tag{17}$$

and the transversality condition:

$$\lim_{t\to\infty}[\nu(t)a_2(t)] = 0.$$

It can be verified that the solution to the problem yields an identical dynamic consumption path to that of the bureaucrat agent:

$$\frac{\dot{c}_2}{c_2} = r - \rho. \tag{18}$$

2.4. The firm's problem

The firms produce using the technology given by:

$$y(t) = f[k(t), g(t)], \tag{19}$$

where $k(t)$ is per worker capital stock, and $g(t)$ is per worker public productive input. It is assumed that this function has the constant-returns-to-scale property. The representative firm takes the factor prices and tax administration parameters as given and maximizes its after-tax profits. The firm replaces depreciated capital, and what is left is taxed as gross income. To maximize after-tax profits, the firm chooses the fraction, ε, of output to be reported. This act of non-compliance imposes rent seeking costs to the evader. Again similar to the case with the bureaucrats, it is assumed that the cost schedule faced by the firms is convex with regard to the rate of tax evasion, $(1-\varepsilon)$, and is given by $\zeta(1-\varepsilon)^2$, where ζ is the institutional parameter that drives the cost of tax evasion. Hence, the expected profit is given as:

$$\Pi = \left[(1-\varepsilon\tau) - \zeta(1-\varepsilon)^2 - \overline{\beta}_1(\theta\tau 1 - \varepsilon)\right]x - rk - w. \tag{20}$$

By simplifying, (20) can be written as:

$$\Pi = (1-\widetilde{\tau})x - rk - w,$$

where

$$\widetilde{\tau} = \tau[\varepsilon(1-\overline{\beta}_1\theta) + \overline{\beta}_1\theta] + \zeta(1-\varepsilon)^2.$$

Clearly, $\widetilde{\tau}$ can be seen as the effective burden of taxation borne by the firm. This burden includes taxes, bribes, and fines paid. Given that the bribes paid are the same as the bribes collected by the corrupt bureaucrats, we know the burden of the bribes on the firms. In this form, bribes may appear like taxes, as both reduce private income. However, the main difference here is that the corruption induced tax evasion leads to pure waste due to the rent-seeking cost expressed by $\zeta(1-\varepsilon)^2$, while there is no such social cost associated with taxation.

The expected amount of fines paid by the taxpayer is equal to:

$$F_f = p_a(1-\varepsilon)\theta\tau x.$$

Substituting for x, after-tax profit is given by:

$$\Pi = (1-\widetilde{\tau})[Af(k,g) - \delta k] - rk - w.$$

As explained above, in the course of licencing and monitoring, the predatory bureaucrat extorts, in the form of bribes, a fraction, $\overline{\beta}_2$, of the after-tax profit. This leaves the firms with the net profit which is given as:

$$\Pi^e = (1-\overline{\beta}_2)\{(1-\widetilde{\tau})[Af(k,g) - \delta k] - rk - w\}. \tag{21}$$

In this context, the firm's objective is to maximize its net profit by choosing the per worker capital stock and the income declaration rate. Given the FOC of this optimization with regard to the rate of income declaration, ϵthe optimal rate of income declaration is derived as:

$$\varepsilon = 1 - \frac{\tau(1-\theta\overline{\beta}_1)}{2\zeta}. \tag{22}$$

Substituting for $\overline{\beta}_1^* = \frac{x\tau\theta(1-\varepsilon)(1-p_a\xi)}{2\psi p_a w}$ from (12) and solving for ε yields the equilibrium income declaration rate:

$$\varepsilon^* = 1 - \frac{2\psi p_a w\tau}{4\zeta\psi p_a w + x(\tau\theta)^2(1-p_a\xi)}. \tag{23}$$

From the FOC of the profit maximisation problem we also obtain the equilibrium wage and interest rates:

$$w = f(\cdot) - kAf_k(\cdot), \tag{24}$$

$$r = (1-b)Af_k(\cdot) - \delta, \tag{25}$$

where

$$b = (1-\overline{\beta}_2)\varepsilon\tau + \overline{\beta}_2. \tag{26}$$

This expression of the equilibrium interest rate, captures the effects of both taxation and corruption on the returns to capital. Clearly, by affecting the returns to capital, corruption impacts the growth path of consumption given by (15) and (18).

2.5. Tax evasion

Based on the analysis of the equilibrium expression for the income declaration rate, ε, (23), the following lemma is formulated.

Lemma 2.1. The effect of an increase in tax rates on tax evasion is ambiguous.[15]

Proof. Obtain the derivative

$$\frac{\partial \varepsilon}{\partial \tau} = \frac{2\psi p_a w\left[x(\tau\theta)^2(1-p_a\xi)-4\psi\zeta w p_a\right]}{\left[4\zeta\psi w p_a + x(\tau\theta)^2(1-p_a\xi)\right]^2}.$$

It is clear that the sign of $\frac{\partial \varepsilon}{\partial \tau}$ depends on the sign of the expression $x(\tau\theta)^2(1-p_a\xi) - 4\psi\zeta p_a w$; hence, the effect of the tax rate on tax evasion is ambiguous. ■

One can interpret this result as follows. The higher the cost faced by the corrupt bureaucrat, ψ, and taxpayer, ζ, relative to the penalties imposed for tax evasion captured by, θ, an increase in the tax rate leads to higher tax evasion. At the same time, a higher expected penalty, $p_a\xi$, imposed on the bureaucrats for being corrupt leads to higher tax evasion. It is because, higher effective penalties imposed on bureaucrats lead to a decrease in the effective bribe rates. Taxpayers account for the expected penalty they face for tax evasion, which is a weighted average of the statutory penalty rate, θ and the effective bribe rate, $\overline{\beta}_1$. Thus, a fall in $\overline{\beta}_1$ decreases the effective penalty rate for the taxpayer; hence, tax evasion increases. Moreover, one can see that the marginal effect of an increase in the tax rate depends on the initial tax rate. That is, if the tax rate is high enough so that $x(\tau\theta)^2(1-p_a\xi) > 4\psi\zeta p_a w$ holds, then further increases in the tax rate lead to less tax evasion

By analysing the comparative statics with respect to other policy parameters we derive the following result.

Lemma 2.2. Tax evasion decreases (hence, income declaration rate, ε, increases) with a higher collusive corruption bribe rate, $\overline{\beta}_1$, cost of tax evasion, ζ, and the penalty for tax evasion, θ. Tax evasion increases with an increase in the penalty rate for corrupt behaviour, ξ, the monitoring effort, p_a, and the cost of corrupt behaviour, ψ. That is, the following comparative statics hold. $\frac{\partial \varepsilon}{\partial \overline{\beta}_1}>0, \frac{\partial \varepsilon}{\partial \zeta}>0, \frac{\partial \varepsilon}{\partial \theta}>0, \frac{\partial \varepsilon}{\partial \xi}<0, \frac{\partial \varepsilon}{\partial p_a}<0, \frac{\partial \varepsilon}{\partial \psi}<0.$

Proof. From (22) it is straightforward to obtain that $\frac{\partial \varepsilon}{\partial \overline{\beta}_1}>0$. Further, recall from (23) that

$$\varepsilon^* = 1-\frac{2\tau\psi p_a w}{4\zeta\psi p_a w + x(\tau\theta)^2(1-p_a\xi)}.$$

Then we find the following comparative statics:

$$\frac{\partial \varepsilon}{\partial \zeta} = \frac{8\tau(\psi p_a w)^2}{\left[4\zeta\psi p_a w + x(\tau\theta)^2(1-p_a\xi)\right]^2}>0, \tag{27}$$

$$\frac{\partial \varepsilon}{\partial \theta} = \frac{4\psi\tau^3\theta(1-p_a\xi)p_a w}{\left[4\zeta\psi p_a w + x(\tau\theta)^2(1-p_a\xi)\right]^2}>0, \tag{28}$$

$$\frac{\partial \varepsilon}{\partial \xi} = -\frac{2\psi\tau^3\theta^2 p_a^2 wx}{\left[4\zeta\psi p_a w + x(\tau\theta)^2(1-p_a\xi)\right]^2}<0, \tag{29}$$

$$\frac{\partial \varepsilon}{\partial p_a} = -\frac{2\psi\tau^3\theta\xi}{\left[4\zeta\psi + (\tau\theta)^2(1-p_a\xi)\right]^2}<0. \tag{30}$$

$$\frac{\partial \varepsilon}{\partial \psi} = -\frac{2\tau^3\theta^2(1-p_a\xi)p_a w}{\left[4\zeta\psi p_a w + x(\tau\theta)^2(1-p_a\xi)\right]^2}<0, \tag{31}$$

These results lead us to make an important conclusion about tax administration policies. That is, to improve tax compliance the government needs to increase the cost of tax evasion for the taxpayers, but not for the tax inspectors.

2.6. Development and the burden of corruption

The results obtained above allow us to analyse how the burden of corruption may change due to changes in the level of development. It is reasonable to assume that the wage rate, w, and the level of per worker income, x, are related as, $w = \mu x$; that is, a part of per worker income is labour income. It is a well-known stylized fact that with higher economic development the share of labour income in total income rises. Thus, in the current setting, this implies that there is an increase in the value of μ as the per worker capital stock, k, rises. Given this and observing expressions (13) and (14), the following result is stated:

Lemma 2.3. The burden of corruption decreases with a rise in

- the wage income relative to the non-wage income,
- and tax compliance.

First, recall that the equilibrium expected bribes rates are given as $\overline{\beta}_1^* = \frac{x\tau\theta(1-\varepsilon)(1-p_a\xi)}{2\psi p_a w}$, and $\overline{\beta}_2^* = \frac{x(1-\tau\varepsilon)(1-p_a\xi)}{2\psi p_a w}$. Substitute for $w = \mu x$ and differentiate with regard to μ. This yields,

$$\frac{\partial \overline{\beta}_1^*}{\partial \mu} = -\frac{2\tau\theta(1-\varepsilon)(1-p_a\xi)\psi p_a}{(2\psi p_a)^2}<0,$$

and

$$\frac{\partial \overline{\beta}_2^*}{\partial \mu} = -\frac{2(1-\tau\varepsilon)(1-p_a\xi)\psi p_a}{(2\psi p_a)^2}<0.$$

Thus, as the share of labour income in total income grows, that is, when $\mu = \frac{w}{x}$ rises, both bribe rates unambiguously decline. The second result is straightforward as: $\frac{d\overline{\beta}_j}{d\varepsilon}<0$, where $j = 1, 2$. ■

This finding is interpreted as follows. With an increase in the wage relative to non-wage income, the cost of rent seeking rises, discouraging corruption. The channel via which the level of development affects corruption is complementary to that established by Blackburn et al. (2006) and Haque and Kneller (2009), as they link development and corruption through increasing opportunity cost of bureaucrats with the income level. In addition, the above result indicates that the burden of corruption decreases with the income declaration rate as tax evasion substitutes at the margin the burden of taxation with bribes. In other words, tax evasion is an optimal response by private agents who seek to minimize the burden created by the public sector in both legal and illegal ways. Therefore, policies that reduce the size of the shadow economy also curb corruption through this channel.

2.7. Government optimization

A benevolent government maximises welfare of the citizens. Given the setting employed in this study, growth maximisation coincides with utility maximisation. The proof of this conclusion can be found in Appendix A. Given this, a benevolent government chooses the statutory tax rate and the penalty parameters that maximise the growth rate.

[15] This result shows that accounting for the costs related to tax evasion and corruption, yields a more general result, than the results reported in the tax evasion literature. For example, Yitzhaki (1974) has shown analytically that tax evasion decreases with tax rates in a standard neoclassical model. However, Chen (2003) by accounting for the cost of tax evasion borne by taxpayers obtains a result opposite to that of Yitzhaki (1974).

Recall that the growth rate in this economy is expressed as, $\gamma = (r - \rho)$. For analysis purposes, it is convenient, without losing generality, if the production technology $Af(k,g)$ is expressed as $A\varphi(g/k)k$, where $\varphi(g/k) \equiv f(g/k, 1)$ (Barro, 1990). Taking this notation into account, the after-tax marginal product of capital is written as:

$$r = (1-b)\frac{\partial y}{\partial k} = (1-b)A\varphi(g/k)\left[1-(g/y)\varphi^{'}\right].$$

Denoting by $\hat{\tau} = g/k$, and $\eta = \hat{\tau}\varphi'$ the elasticity of y with respect to g for a given k, we can write the growth rate as:

$$\gamma = [(1-b)A\varphi(1-\eta)-\delta-\rho]. \tag{32}$$

Note that $\hat{\tau} \neq \tau$, as $\hat{\tau}$ is the effective tax rate, not the statutory rate. Assuming that for the given tax rates, the actual tax revenue is determined mainly by the evasion rate, ε, while the revenue collected through penalties is negligible, one can relate the effective tax rate to the statutory tax rate as follows: $\hat{\tau} = \varepsilon\tau$. Therefore, the government treating the income declaration rate, ε, as determined by the taxpayers' optimising behaviour, sets the statutory tax rate, τ. This is equivalent to the government choosing the effective tax rate, $\hat{\tau}$. Then, given the setting with regard to tax evasion and corruption, the optimization problem of the government is stated as:

$$\max_{\hat{\tau},\theta,\xi,p_a}\gamma = [(1-b)A\varphi(1-\eta)-\delta-\rho]. \tag{33}$$

compliance dominates the predatory behaviour caused by corruption, then an optimal government share should be greater than the marginal contribution of the public sector.

Taking the first derivative of γ with regard to $\hat{\tau} = \frac{g}{y}$ yields the following. The derivation is as follows:

$$\begin{aligned}\frac{d\gamma}{d\hat{\tau}} &= \frac{d}{d\hat{\tau}}\{[(1-b)A\varphi(1-\eta)-\rho]\}\\ &= A(1-\eta)\left[-\varphi b^{'} + (1-b)\frac{d}{d\hat{\tau}}(\varphi)\right]\\ &= A(1-\eta)\left[-\varphi b^{'} + \frac{(1-b)\varphi^{'}\varphi}{1-\eta}\right] = 0.\end{aligned}$$

Here, $\frac{d}{d\hat{\tau}}(\varphi)$ is found given that $g/k = \hat{\tau}\varphi\left(\frac{g}{k}\right)$, and denoting by $\varphi^{'} = \frac{\partial\varphi}{\partial(g/k)}$ yields: $\frac{d}{d\hat{\tau}}(\varphi) = \varphi^{'}\left(\varphi + \hat{\tau}\frac{d}{d\hat{\tau}}(\varphi)\right)$ By simplifying, we get $\Rightarrow \frac{d}{d\hat{\tau}}(\varphi) = \frac{\varphi^{'}\varphi}{(1-\hat{\tau}\varphi^{'})} = \frac{\varphi^{'}\varphi}{(1-\eta)}$ Thus, after some manipulation we obtain:

$$\frac{d\gamma}{d\hat{\tau}} = A(1-\eta)\varphi\left[-b^{'}(1-\eta) + \varphi^{'}\left(1-b^{'}\right)\right] = 0. \tag{34}$$

Then one can solve for $\hat{\tau}$:

$$\hat{\tau} = \frac{b^{'}-(1-b)\varphi^{'}}{b^{'}\varphi^{'}}.$$

Corollary 2.4. The optimal size of government spending depends on the level of corruption and the efficiency of government in generating productive inputs for private production.

Proof. It is clear that when the only burden created by the public sector is the tax burden and there is no tax evasion; that is, $\varepsilon = 1$, and $b = \hat{\tau} = \tau$, (where τ is the statutory tax rate), hence, condition (35) reduces to the Barro (1990) result: $\varphi' = 1$. However, if the burden is distorted by corruption and tax evasion and an increase in the tax rate creates an additional burden; that is, $b' > 1$, then $\varphi' > 1$. If an increase in the tax rate results in greater tax evasion relative to extortion, that is, $b' < 1$, then $\varphi' < 1$. Therefore, the optimal size of government spending depends on (i) how corruption alters the public sector burden and (ii) how efficiently the tax revenue is rendered by the government as a productive input. ■

The benevolent government may also choose optimally the enforcement policies, such as the penalty rate for tax evasion, θ, the penalty rate for corruption, ξ, and the monitoring effort, p_a. The analysis of the effects of the enforcement policies on the equilibrium growth rate demonstrates that these effects are ambiguous, in general.

Proposition 2.5. The effect of enforcement policies on growth is ambiguous. That is, $\frac{d\gamma}{d\theta} \lesseqgtr 0$, $\frac{d\gamma}{d\xi} \lesseqgtr 0$, and $\frac{d\gamma}{dp_a} \lesseqgtr 0$.

Proof. See Appendix B. ■

This result indicates that the effectiveness of enforcement polices depends on the quality of governance and in general, does not lead to strictly growth-improving outcomes; and thus, highlights the limitations faced by optimising governments in using enforcement polices to enhance welfare. Namely, combating corruption by setting very harsh penalties is too costly, and hence, is not practical. This seems to be the main reason why there is no evidence of successful elimination of corruption through punitive measures. It should be noted that this finding extends to a more general corruption case a similar result established by Chen (2003) for tax evasion.

3. The effect of corruption on growth

Having solved the problems of agent interaction in the model economy, one can proceed to the analysis of the effect of corruption on economic growth. To address this problem, first the state of equilibrium is defined and then the equilibrium growth rate is derived. Since, the effect of corruption on the economy is transmitted through the public sector, how the incidence of corruption alters the burden and the productive inputs created by the public sector is considered. Next, based on these findings the growth effects of corruption are analysed.

3.1. Equilibrium

Equilibrium in the economy is defined as the streams of consumption $\{c_1(t), c_2(t)\}_0^\infty$, assets, $\{a_1(t), a_2(t)\}_0^\infty$, physical capital, $\{k(t)\}_0^\infty$, prices, $\{r(t), w(t), w_B(t)\}_0^\infty$, evasion rate, $\{\varepsilon(t)\}_0^\infty$, the tax rate, $\tau(t)$, enforcement effort of the government, $\{p_a(t), \theta(t), \xi(t)\}_0^\infty$, and the bribe rates, $\left\{\overline{\beta}_1(t), \overline{\beta}_2(t)\right\}_0^\infty$, such that they satisfy the optimality conditions obtained for household's, firm's, and government's problems, as described above.

3.2. The effect of corruption on the public sector burden and productive input

3.2.1. The public sector burden and corruption

Let us consider how the effective direct burden of the public sector, b, is affected by corruption. For that purpose, Eq. (26) can be expressed as:

$$b = \tau - \tau(1-\epsilon) + \overline{\beta}_2(1-\tau\epsilon). \tag{35}$$

By taking the first-order derivatives of the effective burden, b, with respect to variables that measure behavioural outcomes for the private and public agents, we obtain the following corollary.

Corollary 3.1. The effective burden of the public sector increases with lower tax evasion and higher bribe rates; hence, $\frac{\partial b}{\partial \varepsilon} > 0$, $\frac{\partial b}{\partial \overline{\beta}_1} > 0$ and $\frac{\partial b}{\partial \overline{\beta}_2} > 0$.

Proof. First, let us consider how the effective public sector burden changes if the compliance rate is altered.

$$\frac{\partial b}{\partial \varepsilon} = \tau\left(1-\overline{\beta}_2\right) + \frac{\partial \overline{\beta}_2}{\partial \varepsilon}(1-\tau\varepsilon).$$

Taking into account that $\frac{\partial \overline{\beta}_2}{\partial \varepsilon} = -\frac{\overline{\beta}_2 \tau}{(1-\epsilon\tau)}$, one can write that $\frac{\partial b}{\partial \varepsilon} = \tau(1-2\overline{\beta}_2)$. This implies that $\frac{\partial b}{\partial \varepsilon}<0$ only if $\overline{\beta}_2>\frac{1}{2}$. The rate of extortions of this magnitude is indeed implausible, thus, it is safe to assume that

$$\frac{\partial b}{\partial \varepsilon}>0. \tag{36}$$

That is, the effective public sector burden increases with an increase in tax compliance.

Next, let us analyse the effect of an increase in the bribe rates on the burden.

$$\frac{\partial b}{\partial \overline{\beta}_1} = \tau(1-\overline{\beta}_2)\frac{\partial \epsilon}{\partial \overline{\beta}_1}>0, \tag{37}$$

as $\frac{\partial \varepsilon}{\partial \overline{\beta}_1}>0$, due to Lemma 2.2.

It also can be verified that

$$\frac{\partial b}{\partial \overline{\beta}_2} = (1-\varepsilon\tau)>0.$$

The above results highlight an important fact that when the expected bribe rates increase the effective burden imposed on the private agents strictly increases. However, one needs to be careful not to see it as a proof of the adverse effect of increased corruption. The reason is that the expected bribe rate may actually decline if an increase in the incidence of corruption (more precisely, the probability of taking bribes) is accompanied with a fall in the actual bribe rate. Although, perceived as a rise in corruption, this type of change in corruption results in a reduction of the effective public sector burden, *b*, on the private agent; hence, may be viewed as an efficiency-enhancing outcome. Given this complexity, this study argues that to determine the full effect of corruption one also needs to account for the effect of corruption through its distortion of the productive public inputs. This aspect of the problem is considered in the forthcoming section.

3.2.2. The public sector productive input and corruption

Direct changes in tax compliance or changes in bribe rates affect not only the burden created by the public sector, but also they alter the amount of public inputs provided to private production. To find out the effects of an increase in tax compliance and bribe rates on the productivity contribution made by the public sector, one needs to consider $\frac{\partial f_k}{\partial \varepsilon}$, $\frac{\partial f_k}{\partial \overline{\beta}_1}$, and $\frac{\partial f_k}{\partial \overline{\beta}_2}$. The changes in these three parameters affect the production function through the government productive input, $g = \epsilon\tau x$.

By definition, $\frac{\partial f_k}{\partial g}>0$. Then given that $\frac{dg}{d\varepsilon} = \tau x>0$, the effect of an increase in the income declaration rate should also have a positive effect on production. That is,

$$\frac{\partial f_k}{\partial \varepsilon} = \frac{\partial f_k}{\partial g}\frac{dg}{d\varepsilon}>0. \tag{38}$$

Moreover, recalling that $\frac{d\varepsilon}{d\overline{\beta}_1}>0$, we can also conclude that

$$\frac{\partial f_k}{\partial \overline{\beta}_1} = \frac{\partial f_k}{\partial \epsilon}\frac{d\varepsilon}{d\overline{\beta}_1}>0. \tag{39}$$

While $\frac{d\varepsilon}{d\overline{\beta}_2} = 0$ implies that

$$\frac{\partial f_k}{\partial \overline{\beta}_2} = 0. \tag{40}$$

This discussion is summarized as the following corollary.

Corollary 3.2. An increase in tax compliance and the expected bribe rate for collusive corruption raises the productive contribution of the government, whereas an increase in the expected bribe rate for extortions does not have any effect. That is, $\frac{\partial f_k}{\partial \varepsilon}>0$, $\frac{\partial f_k}{\partial \overline{\beta}_1}>0$, and $\frac{\partial f_k}{\partial \overline{\beta}_2} = 0$ hold.

Clearly, achieving a higher compliance rate by increasing the public sector funds raises the marginal productivity of capital. An interesting finding is that an increase in the bribe rate in collusive corruption also results in higher compliance, and thereby, also leads to a rise in the marginal productivity of capital. This implies, that by decreasing the cost of corruption for bureaucrats, captured by ψ, it is possible to increase both the compliance rate, $\epsilon$and the bribe rate in collusive corruption, $\overline{\beta}_1$. This will result in higher productivity through increased productive public inputs; especially, if the public sector is spending below its optimal level, then this mechanism might be a way to boost revenue collection. This result suggests a further rationale to the recommendation with respect to tax evasion, put forward in Section 2.5, where targeting the private agents rather than the bureaucrats does not only boost public revenue, but also leads to a rise in productivity.

3.3. Growth and corruption

Recall that the growth rate is given by (15) and (18) as $\frac{\dot{c}}{c} = (r-\rho)$, Substituting for *r* from (25) obtains:

$$\gamma = \frac{\dot{c}}{c} = (r-\rho) = [(1-b)Af_k(\bullet)-\delta-\rho]. \tag{41}$$

Let us consider how the growth rate is affected by changes in the burden of corruption captured by the effective bribe rates and the tax evasion rate. For this purpose, one needs to consider the comparative statics based on expression (41).

The derivative of (41) with regard to income declaration rate, $\epsilon$is given by:

$$\frac{\partial \gamma}{\partial \varepsilon} = A\left[-\frac{\partial b}{\partial \varepsilon}f_k + (1-b)\frac{\partial f_k}{\partial \varepsilon}\right]\lesseqgtr 0. \tag{42}$$

Evidently, the sign is ambiguous because $\frac{\partial b}{\partial \varepsilon}>0$ and $\frac{\partial f_k}{\partial \varepsilon} > 0$ due to Corollary (3.1) and Corollary (3.2). Analogously it can be verified that

$$\frac{\partial \gamma}{\partial \overline{\beta}_1} = A\left[-\frac{\partial b}{\partial \overline{\beta}_1}f_k + (1-b)\frac{\partial f_k}{\partial \overline{\beta}_1}\right]\lesseqgtr 0, \tag{43}$$

due to $\frac{\partial b}{\partial \overline{\beta}_1}>0$ and $\frac{\partial f_k}{\partial \overline{\beta}_1}>0$, and

$$\frac{\partial \gamma}{\partial \overline{\beta}_2} = A\left[-\frac{\partial b}{\partial \overline{\beta}_2}f_k + (1-b)\frac{\partial f_k}{\partial \overline{\beta}_2}\right]<0, \tag{44}$$

due to $\frac{\partial b}{\partial \overline{\beta}_2}>0$ and $\frac{\partial f_k}{\partial \overline{\beta}_1} = 0$.

Based on this result, the following proposition is stated:

Proposition 3.3.

i) An increase in the incidence of non-collusive corruption unambiguously deteriorates growth.

ii) An increase in the incidence of collusive corruption and tax compliance is growth enhancing, only if the marginal gain in productivity from lower public sector burden is greater than the marginal loss in productivity due to lower government inputs.

Proof. Part (i) of the proposition is straightforward from (44). Part (ii) stems from combining (42) and (43) with Corollary (3.1) and Corollary (3.2). It can be verified that only if $\frac{\partial b}{\partial \varepsilon}f_k<(1-b)\frac{\partial f_k}{\partial \varepsilon}$ holds, $\frac{\partial \gamma}{\partial \varepsilon}>0$. Similarly, $\frac{\partial b}{\partial \overline{\beta}_1}f_k>(1-b)\frac{\partial f_k}{\partial \overline{\beta}_1}\Rightarrow\frac{\partial \gamma}{\partial \overline{\beta}_1}>0$. ■

This result suggests that for corruption to be growth enhancing, the after-tax marginal product of capital (MPK) in a corrupt environment should be greater than the MPK in a non-corrupt environment. This conclusion can be explained intuitively, since the effect of the public sector burden on productivity is linear, while the positive effect of government spending on productivity exhibits decreasing returns to scale. Therefore, when the government size is below the optimal level, any marginal loss in tax revenue leads to more than a one-for-one loss in the public sector productive externalities; hence, MPK decreases. Conversely, when government size is above the optimal level then any marginal loss in tax revenue causes less than a one-for-one loss in the public sector externalities on production, and in this case, MPK increases. Therefore, the effect of corruption depends on whether the government size is above or below the optimal level. Hence, corruption enhances efficiency only if the government size exceeds the optimal level and any decrease in the public sector burden due to corruption reduces the government size and brings it closer to the optimal level.[16]

This result also helps us to understand how the quality of governance interacts with corruption and growth. Although, the quality of governance directly affects corruption outcomes, its overall effect on growth is driven by how far the actual government spending is deviating from the optimal value. Clearly, as Corollary (2.4) confirms, the marginal public sector positive externalities in a country with a high institutional quality are greater than that of a country with a low institutional quality; the optimal government size is also greater for the former. The empirical results obtained by Karras (1996) demonstrate that low-growth and poor African countries over-provide government services relative to the optimal levels. Baldacci et al. (2004) report that in countries with high levels of corruption, an increase of 10% in the growth of the product of government spending and in the index of corruption reduces the investment ratio by 1.5% of GDP, which leads to lower output growth. Similar findings are reported by Gupta et al. (2005).

In fact, the result in Proposition 3.3, combined with the aforementioned empirical evidence on the difference between poor and rich economies in terms of government size, points out that corruption might be growth-enhancing when the quality of governance is poor, only because in these countries the public sector also tends to be oversized compared to the optimum level. This then explains the empirical findings by Méon and Weill (2010) and Aidt (2009) who report that corruption positively affects growth of poor countries, while its effect on growth for middle and high-income economies is reduced or not significant.[17] Moreover, the above analysis explains why the relationship between government size and corruption is not linear as it is reported in the existing literature (Alesina and Angeletos, 2005; Billger and Goel, 2009; Goel and Nelson, 1998; La *Porta et al.*, 1999; and Rose-Ackerman, 1999). This is because both corruption and optimal government size are endogenous to the quality of institutions, while in less developed economies, the actual government size also tends to be exceeding the optimal level.

The possibility that corruption can be growth-enhancing, depending on the institutional environment, implies the possibility of a growth-maximizing positive level of corruption. This finding is reported as the following corollary.

Corollary 4. A positive, growth-maximizing corruption level is feasible.

Proof. From Proposition 3.3 recall that $-\frac{\partial b}{\partial \overline{\beta}_1} f_k + (1-b)\frac{\partial f_k}{\partial \overline{\beta}_1} = 0$ is possible, which implies $\frac{\partial \gamma}{\partial \overline{\beta}_1} = 0$. Here, $f_k = \frac{\partial f(k,g)}{\partial k}$ To ascertain that $\underset{\overline{\beta}_1}{\operatorname{argmax}}\, \gamma = \left\{\overline{\beta}_1 | \frac{\partial \gamma}{\partial \overline{\beta}_1} = 0\right\}$ is feasible, one needs to show that $\frac{\partial^2 \gamma}{\partial \overline{\beta}_1^2} < 0$ is admissible. This derivative is formulated as follows.

$$\frac{\partial^2 \gamma}{\partial \overline{\beta}_1^2} = A\left(-\frac{\partial^2 b}{\partial \overline{\beta}_1^2} f_k - 2\frac{\partial b}{\partial \overline{\beta}_1}\frac{\partial f_k}{\partial \overline{\beta}_1} + (1-b)\frac{\partial^2 f_k}{\partial \overline{\beta}_1^2}\right).$$

Recall from Corollary (3.1) and Corollary (3.2) that $\frac{\partial b}{\partial \overline{\beta}_1} > 0$, and $\frac{\partial f_k}{\partial \overline{\beta}_1} > 0$. Since the overall public sector burden is a linear function of the bribe rate, it can be verified that $\frac{\partial^2 b}{\partial \overline{\beta}_1^2} = 0$. In the same vein, given that $f(k,g)$ is a concave function in public revenue, it can be verified that $\frac{\partial^2 f_k}{\partial \overline{\beta}_1^2} < 0$. Given this, $\frac{\partial^2 \gamma}{\partial \overline{\beta}_1^2} < 0$ is true. ■

The above finding suggests that, in some circumstances, corruption might be desirable, as it enhances growth. However, the efficiency gains through corruption cannot exceed the gains an economy may enjoy by optimising its public spending. That is, the corruption-maximised growth rate is suboptimal. The following subsection demonstrates a proof of this conjecture.

The policy implications of this result are as follows. Any policy that is designed to combat corruption should consider the institutional and economic development of the country in question, as corruption is endogenous to these factors. The only way to break the persistence of corruption is through simultaneous improvements in public governance and economic productivity. This seems a quite challenging task, nevertheless, in the presence of political will, could prove effective.

3.3.1. Sub-optimality of growth with corruption

Despite the possibility of growth-maximising corruption, as shown by Corollary 4, it creates an impression of the desirability of corruption in certain cases. To show that growth rates in a corrupt environment do not exceed growth rates in a non-corrupt environment, one needs to compare them. To discriminate between an environment with corruption and one without, let us use γ_n, τ_n, and g_n to denote the growth rate, the tax rate, and the government input in the case without corruption; γ, τ, and g — respectively in the case with corruption. Given this notation, one can write the growth rate in the absence of corruption as,

$$\gamma_n = (1-\tau_n)A\varphi(g_n/k)(1-\eta) - \delta - \rho,$$

and with corruption as:

$$\gamma = (1-b)A\varphi(g/k)(1-\eta) - \delta - \rho.$$

By analysing these two growth rates, the following corollary is stated:

Corollary 5. The growth rates maximised by corruption cannot exceed the maximum growth rates achieved in an environment without corruption. That is, $\gamma_n \geq \gamma$.

Proof. There are two possibilities with respect to how corruption alters the burden created by the public sector. That is, either $b > \tau_n$, or $b < \tau_n$. Recall that τ_n is set, so that the growth rate is maximised and hence, $\varphi' = 1$. Let us begin with the case when $b > \tau_n$. In this case, a part of the burden created by the public sector $\hat{\tau} < b$ is used by the government to produce productive inputs.

The value of this effective tax rate, $\hat{\tau}$ may have three different values:

i) If $\hat{\tau} < \tau_n$, then clearly, $g < g_n$, hence, $\varphi(g_n/k) > \varphi(g/k)$, and therefore, $\gamma_n \geq \gamma$.
ii) If $\hat{\tau} = \tau_n$, then clearly(by ignoring the efficiency losses), $g = g_n$,

[16] See e.g. Chen (2006), Futagami et al. (1993), and Barro (1990) for discussions of the effects of the public sector on private productivity. See Lambsdorff (2003) for empirical findings of how corruption affects productivity through public sector involvement in economic activities. It is worth mentioning that corruption inhibits growth also by deteriorating the overall business climate and directly impacting on productivity (see Pulok, 2010). However, based on meta-analysis of a large number of empirical results on corruption and growth, Ugur and Dasgupta (2011) find that indirect effects of corruption on growth through the human capital and public finance channels are larger than the direct effects.

[17] A detailed analytical explanation of this two-way relationship between government spending and corruption is given in Dzhumashev (2013).

hence, $\varphi(g_n/k) = \varphi(g/k)$, but since, $(1 - b) < (1 - \tau_n)$, thus, $\gamma_n \geq \gamma$.

iii) If $\hat{\tau} > \tau_n$, then (by ignoring the efficiency losses), $g_n \leq g$; however, $\varphi'(g/k) < 1$, thus the marginal burden created by the public sector is greater than the marginal benefit. Due to this inefficiency, $\gamma_n \geq \gamma$.

The second case is when $b < \tau_n$. In this case, recall that when τ_n is optimal, $\varphi' = 1$, while $b < \tau_n$, and $\tau < \tau_n$, hence, $\varphi' > 1$. This implies that the marginal gain through the lower public sector burden is more than offset by the marginal loss from lower public sector input. Thus, $\gamma_n \geq \gamma$. ■

The main point of the above result is that corruption is not the solution when it comes to improving economic growth, as in the absence of corruption, the optimising government can achieve higher growth rates. Corruption is rather a private reaction that may enhance growth within a suboptimal growth space, when the government is predatory and burdensome. Note, the above result extends the finding of Blackburn and Forgues-Puccio (2009) by showing that the growth rate of a corrupt economy cannot exceed the growth rate of a non-corrupt economy, even if corruption may enhance growth under certain conditions.

3.4. Calibration

In this section, an attempt is made to find numerical support for the conjectures stemming from the model analysis. The idea is to replicate the relationship identified in the theoretical model between corruption, governance, economic development, and growth rates. As such, the model is calibrated for three different cases of economic and institutional development: low income, middle income and high income case. The calibration of the low income case is based on Kenya, the middle income case on Turkey, and the high income case on the UK. In particular, the average growth rates over 1960–2010 are obtained from the WDI database. The per worker capital, k, and output, x, the share of labour income, w/x, the average tax rate, τ, have been obtained from Easterly and Levine (1999), Gollin (2002), and OECD Statistics web-page, respectively. The parameter values are chosen based on the benchmarks used in the literature (Chen, 2003; Dzhumashev, 2013) allowing for variation where the cost and penalty parameters increase with the increase in income levels (see Table 1). Following Dzhumashev (2013), it is also assumed that in more developed economies the output elasticity of government spending, α, rises. For given parameters and economic structures, corruption outcomes such as the bribe rates, $\overline{\beta}_1, \overline{\beta}_2$, the tax evasion rate, ε, and the government efficiency measure, η, (see Eq. (12), (13), and (23)) are calculated. These calculated values are used to compute the total burden of the public sector, $b = (1-\overline{\beta}_2)\varepsilon\tau + \overline{\beta}_2$, and the growth rate, $\gamma = [(1 - b)A\varphi(1 - \eta) - \delta - \rho]$.

The calibration and simulation are done in the following order. First, the model is calibrated to match the average growth rates of low, middle, and high income economies by adjusting the technology coefficient and the institutional parameters such as ψ and ζ. These benchmark growth rates are given in bold in Table 2. Then, simulated growth rates are calculated for all three economic structures for a range of parameter values $p_a \in [0.1294, 0.1300]$, $\theta \in [1.33, 1.40]$, $\zeta \in [4.13, 7.00]$, $\xi \in [1.18, 2.00]$, $\psi \in [3.54, 8.00]$. The results are given in Table 2 and Fig. 1. For better presentation of the results, instead of using the range of values of all these parameters, an index of misgovernance is used. The reason is that a decrease in all the governance parameter values leads to an increase in corruption outcome measures ($\overline{\beta}_1, \overline{\beta}_2$, and ε); hence, it is more intuitive to use the inverse of the average index of these parameters, which is referred to as a 'misgovernance' index. This index is obtained as follows. By taking highest value as a base, the range for θ in an index form is set as [0.95,1.00]. In a similar fashion, for $p_a \in [0.995, 1.000]$, $\zeta \in [0.59, 1.00]$, $\xi \in [0.59, 1.00]$, $\psi \in [0.44, 1.00]$. A point-wise averaging and subsequent inversion yields the following values of the misgovernance index {1.00,1.08,1.16,1.24, 1.32,1.40}.

The calibration results are consistent with the stylized facts in that middle and low income economies can experience higher incidence of corruption but at the same time enjoy higher economic growth compared with high-income economies (Blackburn and Forgues-Puccio, 2009). The other important result is that growth rates in the presence of corruption are suboptimal. Fig. 1 shows that both middle and low income economies can achieve higher growth by reducing corruption levels from the benchmark points (moving to the left along the curve). Notably, the simulation results indicate a possibility of growth enhancing corruption in the case where there is a transition from a low to a middle income level of development. This is explained by the fact that the curves for low and middle income economies intersect, which implies that when a low income economy makes a transition to middle income range (i.e. a jump to middle-income curve), it can actually gain in terms of growth by allowing for a greater incidence of corruption.

Table 1
Benchmark parameter and economic values.

Parameters	Low income	Middle income	High income	Comments
τ	0.20	0.30	0.35	WDI (2013)
A	0.1060	0.1261	0.1115	Chen (2003), Dzhumashev (2013)
α	0.10	0.12	0.15	Chen (2003)
ρ	0.02	0.02	0.02	Chen (2003)
p_a	0.1296	0.1299	0.1300	Chen (2003), Dzhumashev (2013)
ψ	4.9	6.8	8	Calibrated to match the growth rate
ζ	4.6	6.3	7	Calibrated to match the growth rate
ξ	1.45	1.8	2	Dzhumashev (2013), Chen (2003),
θ	1.35	1.38	1.4	Dzhumashev (2013)
Economic structure				
k	822	7589	21,179	Easterly and Levine (1999)
x	1863	8632	26,55	Easterly and Levine (1999)
w/x	0.4	0.6	0.65	OECD; Gollin (2002)

Table 2
Growth rates.

Misgovernance index	Low income	Middle income	High income
1.00	0.03312	0.03013	**0.01960**
1.08	0.02744	**0.02540**	0.01628
1.16	0.02069	0.02018	0.01234
1.24	**0.01270**	0.01373	0.00763
1.32	0.00313	0.00605	0.00203
1.40	−0.0081	−0.0030	−0.0046

Note: The benchmark cases for high, middle, and low income economies are given in bold.

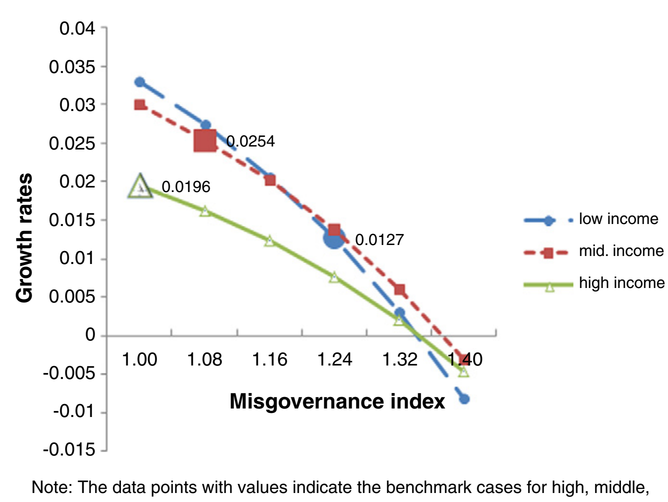

Fig. 1. Growth rates across income and corruption levels. Note: The data points with values indicate the benchmark cases for high, middle, and low income economies.

4. Discussion of the results and conclusion

The results obtained in this paper can be summarised as follows. First, the results point out that corruption affects the economy by altering both the burden of regulations and the efficiency of productive public inputs. Therefore, its overall effect on growth depends on the combined impact on private productivity as a result of the changes in the burden of regulations and the productivity-enhancing inputs provided by the government. The role of governance in shaping the relationship between corruption and economic performance is not straightforward, as it drives not only the incidence of corruption but also the efficiency of public sector activities. Analysing both channels, through which governance works, leads one to establish that the incidence of corruption affects the economy by altering the deviation of the actual government size from the optimal level. Specifically, corruption may enhance efficiency if the size of the government exceeds the optimal level, as, an increase in the incidence of corruption reduces the government size and brings it closer to the optimal level. Hence, in such environments corruption may be beneficial for growth. Moreover, this finding suggests a possible reason for the aforementioned empirical inconsistencies with regard to the role of governance quality. That is, these inconsistencies might be due to the fact that the models employed in those studies ignore the interaction between the government size and the quality of governance. For example, the evidence that corruption might be growth-enhancing when the quality of governance is poor is plausible because in these countries the public sector tends to be oversized compared to the optimum level.[18]

Second, the findings further suggest that depending on the marginal trade-off between the burden and the benefits generated by the government, an increase in collusive corruption might have either positive or negative growth effects. Thus, when marginal effects of corruption on both the burden and the benefit of the public sector are equal, a positive growth-maximizing level of collusive corruption is possible; the results confirm this intuition. However, this does not imply that corruption is desirable, as the study demonstrates the corruption-maximised growth rate is suboptimal.

Third, the paper corroborates and complements the literature that explains the incidence of corruption varying across countries due to the differences in the development and institutional environments. By identifying the wage rate as the main cost factor of corruption related rent seeking, this paper shows why development and corruption are negatively correlated. calibration of the model accounting for differences in the income levels, governance quality, and the incidence of corruption confirms the propositions about the links between corruption, economic and institutional development. In this respect, the findings of this study complement the results obtained by Blackburn et al. (2006, 2010) and Haque and Kneller (2009), who find that through wage rates, the level of development affects corruption as it increases the opportunity cost of bureaucrats; and by Aidt et al. (2008) who establish that in environments with high quality political institutions economic growth and corruption are endogenous.

Finally, the paper gains some insights into the effectiveness of anti-corruption policies in terms of reducing the incidence of corruption and enhancing growth simultaneously. Specifically, findings indicate that targeting tax evaders instead of bureaucrats is more effective in terms of both reducing corruption and improving the growth potential of an economy. This is because, on one hand, targeting taxpayers rather than bureaucrats results in stronger improvements in compliance; and on the other hand, an increase in compliance of taxpayers leads to a reduction of bribe rates and also raises productivity of firms through public spending. However, this strategy works only if the increase in the tax compliance does not result in the public burden exceeding the optimal level for the economy. Thus, the anti-corruption policies should be devised by taking into account the disparity between the actual and the optimal government spending levels. Unfortunately, both the quality of institutions and the government size are not easy to change; furthermore, change can only be implemented gradually. Nevertheless, to be more effective, the efforts to reduce corruption should be intrinsically woven into polices to develop institutional capacity and optimise the size of government spending. To sum up, the policies should account not only for their direct effect on corruption outcomes, but also for their effect on the public sector burden and the productivity-enhancing government spending.

In conclusion, it is important to highlight some limitations of this study and emphasise that as a result of constructing a general model of corruption in the economy, not all trivial but distinct mechanisms discussed in the literature and theory are accounted for in this study. Another shortcoming of the model is that it ignores the uncertainty created by corruption. Shleifer and Vishny (1993) and Wei (1997) have shown the importance of this channel of transmission of the corruption effects. In addition, the model in the current study abstracts from the income distribution aspects. However, we know that Gyimah-Brempong (2002) empirically demonstrates that corruption not only decreases economic growth, but also contributes to income inequality. Incorporating the relationship between corruption and inequality into the model, certainly, will be an interesting extension. Another worthwhile extension would be to consider effect of corruption on growth through the composition of government expenditures (Kagundu, 2006) or by allowing direct impact of corruption on productivity (Pulok, 2010). All of the above-mentioned extensions of the model should provide interesting avenues for further research and may lead to useful insights.

Appendix A Welfare optimization

Assume that the government chooses a set of policy variables, Φ, so that the social welfare is maximised. Since, the economy is populated with identical individuals, this problem reduces to the maximisation of the utility of the representative agent,

$$\max_{\Phi} U(\tau) = \int_0^\infty u(c) exp(-\rho t) dt \tag{A.1}$$

$$s.t.\ \gamma = \frac{\dot{c}}{c} = \frac{\dot{k}}{k} = \left[(1-\tau)\frac{\partial y}{\partial k} - \rho \right], k(0) = k_0$$

In time t capital per capita is given by

$$k(t) = k_0 exp(\gamma t) \tag{A.2}$$

Recall that output is given as

$$y = A\phi(g/k)k \equiv \widetilde{A}k.$$

Thus, one can write

$$\dot{k} = \widetilde{A}k - c - \delta k. \tag{A.3}$$

Dividing both sides of (A.3) by k yields:

$$\frac{\dot{k}}{k} = \widetilde{A} - \frac{c}{k} - \delta.$$

Substituting for $\rho = \widetilde{A} - \frac{k}{k} - \delta$, and after some manipulation one obtains:

$$c(t) = \rho k(t).$$

[18] Karras (1996), Gupta et al. (2005), and Baldacci et al. (2004) find that low-income countries over-provide government services relative to the optimal level.

Now, one can write the representative individuals utility function in the following form:

$$u(c) = ln(\rho k_0 exp(\gamma t)). \tag{A.4}$$

Then the optimization problem becomes

$$\max_{\Phi} \widetilde{U}(\Phi) = \int_0^{\infty} [ln(\rho k_0 exp(\gamma t))] exp(-\rho t) dt \tag{A.5}$$

This is simplified further as

$$\widetilde{U} = \gamma \int_0^{\infty} t exp(-\rho t) dt + ln(\rho k_0) \int_0^{\infty} exp(-\rho t) dt \tag{A.6}$$

We note that the second term of (A.6) is not a function of policy variables. Therefore, this and other constant terms can be ignored. In other words, $\max_{\Phi} \widetilde{U}(\Phi)$ is equivalent to $\max_{\Phi} \hat{U} = \gamma \int_0^{\infty} t exp(-\rho t) dt$. This integration is solved as

$$\int_0^{\infty} t e^{-\rho t} dt = -\frac{t}{\rho} e^{-\rho t}|_0^{\infty} + \frac{1}{\rho} \int_0^{\infty} e^{-\rho t} dt = -\frac{1}{\rho^2} e^{-\rho t}\Big|_0^{\infty} = \frac{1}{\rho^2}$$

Then the first term of (A.6) becomes

$$\hat{U} = \frac{\gamma(\Phi)}{\rho^2} \tag{A.7}$$

It is evident that the welfare maximisation problem given by (A.5) is equivalent to maximisation of the objective function given by (A.7). In other words, the welfare maximisation is equivalent to maximisation of the growth rate of the individual's consumption.

Appendix B Comparative statics for enforcement polices

By taking the derivatives of the growth rate (32) with respect to enforcement policy parameters, one obtains the following comparative statics.

$$B.1 \frac{d\gamma}{d\theta} = A(1-\eta)\left(-\underset{(\pm)}{\frac{\partial b}{\partial \theta}}\varphi + (1-b)\underset{(+)}{\frac{\partial \varphi}{\partial \theta}}\right) \gtreqless 0. \tag{B.1}$$

Here, given that $b = \tau\varepsilon + \overline{\beta}_2(1-\tau\varepsilon)$, and $\frac{\partial \varepsilon}{\partial \theta}>0$, $\frac{\partial \overline{\beta}_2}{\partial \varepsilon}<0$, one can verify that $\frac{db}{d\theta} = \frac{\tau\partial\varepsilon}{\partial\theta}(1-\overline{\beta}_2) + (1-\tau\varepsilon)\frac{\partial\overline{\beta}_2}{\partial\varepsilon}\frac{\partial\varepsilon}{\partial\theta} \lesseqgtr 0$. Next, $\frac{\partial\varphi}{\partial\theta} = \frac{\varphi\varphi'\tau\partial\varepsilon}{1-\eta\partial\theta}$ implies that $\frac{\partial\varphi}{\partial\theta}>0$. Therefore, $\frac{d\gamma}{d\theta} \lesseqgtr 0$.

$$B.2 \frac{d\gamma}{d\xi} = A(1-\eta)\left(-\underset{(\pm)}{\frac{\partial b}{\partial \xi}}\varphi + (1-b)\underset{(+)}{\frac{\partial \varphi}{\partial \xi}}\right) \gtreqless 0. \tag{B.2}$$

In this case, it can be verified that $\frac{db}{d\xi} = \frac{\tau\partial\varepsilon}{\partial\xi}(1-\overline{\beta}_2) + (1-\tau\varepsilon) \times \left(\frac{\partial\overline{\beta}_2}{\partial\xi} + \frac{\partial\overline{\beta}_2}{\partial\varepsilon}\frac{\partial psilon}{\partial\xi}\right) \lesseqgtr 0$ and $\frac{\partial\varphi}{\partial\xi} = \frac{\varphi\varphi'\tau\partial\varepsilon}{1-\eta\partial\xi}<0$. Hence, $\frac{d\gamma}{d\xi} \lesseqgtr 0$.

$$\frac{d\gamma}{dp_a} = A(1-\eta)\left(-\underset{(+)}{\frac{\partial b}{\partial p_a}}\varphi + (1-b)\underset{(-)}{\frac{\partial \varphi}{\partial p_a}}\right) \gtreqless 0. \tag{B.3}$$

One can verify that $\frac{\partial\varepsilon}{\partial p_a}<0$, and $\frac{\partial\overline{\beta}_2}{\partial p_a}<0$, which imply that $\frac{d\overline{\beta}_2}{dp_a} = \frac{\partial\overline{\beta}_2}{\partial p_a} + \frac{\partial\overline{\beta}_2}{\partial\varepsilon}\frac{\partial\varepsilon}{\partial p_a}<0$. Given this, $\frac{\partial b}{\partial p_a} = \frac{\tau\partial\varepsilon}{\partial p_a}(1-\overline{\beta}_2) + (1-\tau\varepsilon)\left(\frac{d\overline{\beta}_2}{dp_a}\right)<0$. Further, $\frac{\partial\varphi}{\partial\xi} = \frac{\varphi\varphi'\tau\,\partial\varepsilon}{1-\eta\partial p_a}<0$. Thus, $\frac{d\gamma}{dp_a} \lesseqgtr 0$.

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