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Gonzalo F. Forgues-Puccio
University of St Andrews

Ibrahim M. Okumu
University of St Andrews
and Makerere University

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JEL Classification: D73, O11, O31, O41.
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CASTLECLIFFE, SCHOOL OF ECONOMICS & FINANCE, UNIVERSITY OF ST ANDREWS, KY16 9AL
TEL: +44 (0)1334 462445 FAX: +44 (0)1334462444 EMAIL: cdma@st-andrews.ac.uk
www.st-andrews.ac.uk/cdma

Does Size Matter?
Scale, Corruption and Uncertainty

Gonzalo F. Forgues-Puccio[a,*] and Ibrahim M. Okumu[a,b]
[a]School of Economics and Finance
University of St Andrews
[b]College of Business and Management Sciences
Makerere University

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Abstract

We study the role of the size of the economy in mitigating the impact of public sector corruption on economic development. The analysis is based on a dynamic general equilibrium model in which growth occurs endogenously through the invention and manufacture of new intermediate goods that are used in the production of output. Potential innovators decide to enter the market considering the fraction of future profits that may be lost to corruption. We find that depending on the predictability of bribes, the size of the economy may be an important factor in determining the effects of corruption on innovation and economic growth.

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*__Address for correspondence__: Gonzalo F. Forgues-Puccio, School of Economics and Finance, University of St. Andrews, Castlecliffe, The Scores, St Andrews KY16 9AL, United Kingdom. **Tel**: 01334 462 442. **Fax**: 01334 462 444. **E-mail**: gff2@st-andrews.ac.uk.

1 Introduction

The negative link between public sector corruption and economic growth has been widely explored since the seminal contribution of Mauro (1995). There is a consensus in the literature that graft undermines economic progress. This consensus is based on several studies that lend support to this result (e.g., Aidt 2009; Gyimah-Brempong 2003; Keefer and Knack 1997; Knack and Keefer 1995; Li *et al.* 2000; Méon and Sekkat, 2005; Mo 2001). There is also evidence, however, that some countries have grown at impressive rates regardless of exhibiting high levels of corruption. The best example of this is what Wedeman (2002) has labelled the East Asian Paradox. Countries such as China, Indonesia, South Korea and Thailand grew very rapidly during the 1980s and 1990s in spite of exhibiting high levels of corruption. Recent examples of this may be Brazil and India. One possible explanation for this phenomenon is related with the 'speed money' hypothesis. This theory postulates that corruption can be viewed as 'greasing the wheels' of a slow and cumbersome bureaucracy. Other, less conventional explanation, is linked with what we can call 'corruption mitigants', i.e., specific factors that may diminish the impact of corruption on economic development. This paper is related with this second explanation.

We argue that the size of the economy is one of the factors that may mitigate the impact of corruption on growth. Firms that have access to large markets are able to operate on a larger scale and hence generate larger profits. Higher profits mean that the average firm can afford to have an outside option. This situation strengthens the bargaining power of firms when negotiating with corrupt public officials. Higher bargaining power results in lower bribes and a lower impact of corruption on the growth rate of the economy. In contrast, in small economies the average firm is constrained by the size of the market and is not able to generate large enough profits to absorb, for instance, the costs of relocation. In this kind of economies, firms have low bargaining power and are at the mercy of bureaucrats. In line with the existing literature, we also show how uncertainty about the future value of bribes can have devastating effects by creating disincentives to enter the market even in large economies.

In the rest of this section we discuss the literatures on the speed money hypothesis and on corruption mitigants, and elaborate on our proposal.

1.1 The Speed Money Hypothesis

The speed money hypothesis is an application of the second best theory. It views bribes and kickbacks as convenient devices for overcoming institutional obstacles. According to their proponents, corruption may enhance efficiency by 'greasing' the bureaucratic rigidities that characterise a cumbersome institutional framework. A more efficient bureaucracy may potentially have a positive impact on investment and growth.[1]

This theory gained prominence in the 1960s with the works of Leff (1964), Leys (1965) and Bailey (1966). These studies were mainly theoretical and based on casual observations. Leff (1964) stresses that corruption works as a 'hedging mechanism' to reduce the losses associated with bad economic policies. Even though a government may be acting to promote development, it is not guaranteed that its policies will be well designed and implemented. Terrible mistakes have been made in the past and the cost and time of reverting damaging policies is considerably high. Leys (1965) and Bailey (1966) point out that corruption may act as an incentive to attract talented individuals that otherwise would not have opted for a career in the public sector. Leys (1965) also argues that corruption mitigates bureaucratic sluggishness by speeding up the process of starting a new firm.

In the 1980s a second wave of works by Lui (1985), Beck and Maher (1986) and Lien (1986) explored the efficiency enhancing properties of corruption, or at least, the conditions under which corruption is efficiency equivalent to a competitive mechanism. Lui (1985) by using a non-cooperative game with incomplete information shows that corruption can improve efficiency in a queue by allowing those with a higher opportunity cost to pay to save time. The argument is based on the notion that time has a different valuation for each individual. Those who face a large opportunity cost of time are able to pay higher bribes than those to whom time has a low value. Bribery then can be efficiency enhancing by minimising the average value of time costs of the queue. Beck and Maher (1986) also use a non-cooperative game with incomplete information to demonstrate that there is an isomorphism between the outcomes of bribery and competitive bidding in the process of governmental acquisitions of goods and services. They show that under both mechanisms, the same firm (the one with the lowest costs and consequently the highest margin to bribe) wins the contract and the government pays the same net-of-bribes purchase price. After using two different model specifications, Lien (1986) confirms the findings of Beck and Maher (1986) and concludes that competitive bribery in comparison with competitive bidding produces no loss of efficiency in the allocation of resources.

The arguments in favour of the speed money hypothesis are very con-

[1] As Huntington (1968, p. 386) puts it: 'In terms of economic growth, the only thing worse than a society with a rigid, overcentralised, dishonest bureaucracy is one with a rigid, overcentralised, honest bureaucracy.'

vincing. However, they have been challenged conceptually and empirically.[2] From a conceptual point of view there are two main problems with the speed money hypothesis. First, even though bribery may accelerate an individual transaction with a particular official, both the total size of bribes and the number of corrupt transactions may increase producing a net loss in efficiency. Second, bureaucrats may intentionally create delays (red tape) to extract bribes. As a result, bribes may not be seen as mitigating the effects of red tape. On the contrary, bribes may exist due to artificially created bureaucratic delays (Myrdal, 1968; Kurer,1993). From an empirical point of view there is little support for the speed money hypothesis. Ades and Di Tella (1997), Mauro (1995) and Méon and Sekkat (2005) report a negative correlation between growth and corruption which is particularly strong in samples of countries with high levels of red tape. In addition, Kaufman and Wei (2000) report that the time spent negotiating with bureaucrats is increasing in the amount of bribes that are paid. In a new critical survey of the literature, Aidt (2009) re-tests the 'grease the wheels hypothesis' and finds that the evidence that supports this theory is weak. It is not only until very recently that Méon and Weill (2010) found empirical support for the speed money hypothesis from an efficiency point of view. Using a measure of aggregate efficiency the authors present evidence that corruption is less harmful to efficiency in countries with poor institutions. Furthermore, they report that corruption may be even efficiency-enhancing in countries with extremely weak institutions.[3]

1.2 Corruption Mitigants

The literature on the factors that may mitigate the growth-retarding effects of corruption is still under development. One of the first corruption mitigants that can be identified in the literature is predictability. Wei (1997), using an indicator of corruption-induced uncertainty from the 1997 Global Competitiveness Report, finds that higher uncertainty about bribe payments reduces foreign direct investment. Uncertainty about bribe payments may create a situation in which two countries with similar perceived levels of corruption can end up having completely different levels of foreign direct investment.

[2] Méon and Sekkat (2005) and Meon and Weill (2010) offer excellent surveys on this debate.

[3] The work of Méndez and Sepúlveda (2006) also may lend support to this theory from a growth perspective. They find a non-monotonic relationship between corruption and growth in countries with high degree of political freedom. They report that corruption can be growth enhancing at low levels of development and growth-deterrent at high levels of development. Although their results have been challenged by Aidt *et al.* (2008).

It is expected that foreign investors will be asked to pay bribes in corrupt economies. In some countries, however, investors receive the goods and services they are paying for and no further bribes are requested. Whilst in other countries there is no guarantee that the goods and services will be delivered at all, and as a result, additional bribes will have to be paid. Campos *et al.* (1999) extended Wei's work by investigating the impact of the predictability of corruption on investment and growth. Using the same indicator of corruption-induced uncertainty they find that investment and growth are higher in countries in which corruption is more predictable.

Another factor that has received attention in the literature is the organisation of corruption. In their seminal contribution Shleifer and Vishny (1993) argue that the way in which bureaucrats organise themselves affect the impact of corruption on the provision of governmental goods. In order to conduct business, firms may need a set of different goods supplied by bureaucrats with monopoly power over the provision of these goods (licenses, permits, certificates, etc.) In addition, these goods and services may be provided by different corrupt governmental agencies and may be complements to each other. If firms have to deal with disorganised bureaucrats acting as independent monopolists, then each of them will seek to maximise his own individual bribe income without taking into account the negative effects of their actions on the bribe income of others. This effect arises since the demand for a bribe by one bureaucrat in exchange for his own governmental good imposes an externality on other bureaucrats by reducing the demand for their governmental goods. In contrast, if bureaucrats are organised and act as a joint monopoly, then they will maximise their total bribe income internalising the externalities. The implication of this is that a centralised network of corruption can lead to a lower level of bribe payments, a greater provision of governmental goods and services and to a smaller scale of distortions than would arise under a decentralised network of corruption. Blackburn and Forgues-Puccio (2009) seeking to explain the East Asian Paradox incorporated these ideas into a dynamic general equilibrium model to illustrate that corruption has a lower impact on innovation and growth when corruption is organised than when it is disorganised.

Finally, Fisman and Gatti (2006) propose another factor that may mitigate the impact of graft. They report that the deadweight loss of corruption seems to be lower in countries with institutions that limit bargaining frictions allowing for a more efficient bribe negotiation. The authors use a simple model in which firms and bureaucrats negotiate the payment of bribes to avoid regulations. They assume bargaining frictions and a firm-specific exposure to bureaucratic hassle. Under this assumptions they show that bribes are an increasing function of the time spent negotiating with public officials.

In their model a higher degree of bargaining frictions strengthens this result. Furthermore, using the World Bank's World Business Environment Survey they find that factors that may reduce negotiation frictions, like the formality of the legal system, mitigate the effects of corruption on economic growth.

1.3 This Paper

We study the role of the size of the economy in mitigating the impact of corruption on economic growth. The analysis is based on a dynamic general equilibrium model with an expanding variety of intermediate inputs that are used in the production of output. We assume monopolistic competition in the intermediate goods sector. Hence innovation in this economy is motivated by the existence of positive profits in the manufacture of inputs. These profits may be exploited by corrupt bureaucrats that will ask for bribes under the threat of closing down businesses if not paid. In contrast we assume perfect competition in the production of the final good. As a result in equilibrium profits are zero in the final goods sector and there are no bribe opportunities. We assume that potential manufacturers of intermediate goods decide to enter the market by considering the value of the future bribes that may have to pay once they are operating. Assuming a fixed cost of financing relocation we show that in large economies firms generate large enough profits to afford relocation. This situation improves the bargaining power of firms when negotiating for bribes.

Our analysis is based on the empirical evidence reported by Svensson (2003) and Rock and Bonnet (2004). Svensson (2003) using a unique dataset on bribe payments by firms in Uganda finds that: (1) not all firms pay bribes and (2) the size of bribes depend on the firm's bargaining power. This heterogeneity in bribe payments reported by firms offer evidence that bureaucrats can charge different bribes to different firms. The bargaining power of firms is related with the firm's outside option: the ability to relocate, or move to a different activity that requires less contact with bureaucrats. Rock and Bonnet (2004) show that the impact of corruption on investment and growth is lower in the more populous economies. Looking at the impressive growth rates of large countries renown for their levels of corruption one tends to challenge the view that corruption is detrimental to development. Using population as a measure of size like in Rock and Bonnet (2004), casual observation tell us that there are many relatively large corrupt countries that have achieved, and are achieving, long periods of sustained economic growth like China, Brazil, India and Mexico. In contrast, small corrupt countries seemed to be trapped by poor quality governance. In spite of this, Rock and Bonnet (2004) find that even in large economies the benefits of scale may quickly dilute depending on the way in which corruption networks are organised. In countries with weak and fragmented governments with multiple and uncoordinated corruption networks, uncertainty about the payment of bribes may offset the benefits of having access to larger markets. A typical example of this is Nigeria. A large economy in which bribe payments are very difficult to predict. We account for this observation in our model by analysing the impact of uncertainty about future bribes on the firms decision to enter the market.

The theoretical research on corruption at the macroeconomic level has focused on explaining the negative effects of graft on economic progress. Seminal papers in this area are Ehrlich and Lui (1999), Rivera-Batiz (2001) and Sarte (2000). Blackburn *et al.* (2006) show how bureaucratic corruption and economic development may interact with each other producing threshold effects and multiple (history dependant) equilibria. Blackburn and Forgues-Puccio (2007) report analogous results together with showing how corruption can affect inequality by distorting redistributive policy. Apart from Ehrlich and Lui (1999) and Blackburn and Forgues-Puccio (2009) who discuss the impact of different bureaucratic structures on economic performance, no other macroeconomic study has focused on the factors that may lessen the impact of corruption. As far as we know, we are the first ones to propose a theory to explain the role of the size of the economy in determining the impact of corruption on economic growth.

Our paper is also related to the work of Desmet and Parente (2010) in terms of highlighting the importance of the size of the economy. They show that in large economies competition and innovation are greater. They argue that this is the case because in economies with large populations, or open to international trade, the price elasticity of demand tends to be higher due to greater competition. Hence, firms have to sell more products to remain in the market; and by selling more, firms are also able to amortise the fixed cost of innovation over a larger number of products.

The remainder of the paper is structured as follows. In Section 2 we describe the model. In Section 3 we solve for the general equilibrium. In Section 4 we discuss the impact of scale on the relationship between corruption and growth. In Section 5 we discuss the role of uncertainty. In Section 6 we present our concluding remarks.

2 The Model

We consider a small open economy populated by two-period-lived agents belonging to overlapping generations of dynastic families. Agents of each generation are divided into two groups: private citizens (households) and public servants (bureaucrats). Households are differentiated further into skilled and unskilled workers and supply labour inelastically to firms. Bureaucrats work for the government. We assume a fixed population of unskilled workers equal to $L > 1$, and we normalise the population of skilled workers and bureaucrats to 1.[4] There are two sectors in the economy: a final output sector and an intermediate input sector. A single consumption good is produced in the final output sector. A variety of intermediate (non-tradable) goods are designed and manufactured in the intermediate input sector. At any point in time, t, there is a fixed unit mass of final output firms, an endogenously-determined number, M_t, of existing intermediate input firms and an endogenously-determined number, N_t, of potentially new intermediate input firms. Intermediate inputs are indexed by $i \in (0, M_t)$. Research and development increases the number of intermediate goods increasing the efficiency in output production generating endogenous growth. All markets are perfectly competitive, except the market for intermediate inputs in which we assume monopolistic competition.

As in Blackburn and Forgues-Puccio (2009) our focus lies on the production side of the economy. This means that apart from the corrupt activities of public officials, the behaviour of agents is not essential and can be ignored when discussing the growth rate of the economy. In what follows, our description of the model proceeds by focusing exclusively on the behaviour of firms.

2.1 Final Output Producers

Following Romer (1990), we assume that the representative producer of final output combines L_t units of unskilled labour with $X_t(i)$ units of intermediate good i to produce Y_t units of consumption good using the following technology:

$$Y_t = AL_t^{1-\alpha} \int_0^{M_t} X_t(i)^\alpha di, \tag{1}$$

$(A > 0, \alpha \in (0, 1))$. The final output manufacturer pays workers the wage rate W_t and each intermediate input producer the price $P_t(i)$. The profit

[4] We abstain from introducing issues related to occupational choice by assuming that individuals are separated at birth by some random process. We simplify the analysis in this manner to avoid experiencing changes in the size of the bureaucracy and hence on the level of corruption. This assumption has been has been widely used in the macroeconomic literature of corruption. See for example the works of Blackburn *et al.* (2006); Blackburn and Forgues-Puccio (2007, 2009), Rivera-Batiz (2001) and Sarte (2000).

maximisation conditions allow us to express the factor demands as follows:

$$L_t = \frac{(1-\alpha)Y_t}{W_t}, \tag{2}$$

$$X_t(i) = \left[\frac{A\alpha}{P_t(i)}\right]^{\frac{1}{1-\alpha}} L_t \tag{3}$$

By inspecting expressions (2) and (3) we can appreciate that the demand for unskilled labour and intermediate input i are inversely related to their prices. In addition, expression (3) reveals that the demand for each intermediate input is increasing on the use of unskilled labour.

2.2 Intermediate Input Producers

An intermediate good is created through a process of research and development. We assume that any firm which innovates has a perpetual monopoly right over the manufacture and sale of its new product.[5] In this kind of environment the incentive to undertake research and development is always present given that a firm that successfully innovates can expect to profit from its creation indefinitely.

Innovation is a risky activity and the jth research firm interested in creating a new intermediate good succeeds with probability $q \in (0,1)$. As in Blackburn and Forgues-Puccio (2009) we assume that the probability of succeeding in innovation is a function of the number of efficiency units of skilled labour that is used in research, $e_t(j) = H_t(j)M_t$. We denote by $H_t(j)$ the number of skilled labour employed by the jth research firm and the stock of disembodied knowledge is approximated by the existent number of intermediate goods, M_t. As a result, the probability of successful innovation is given by $q(e_t(j))$. We assume that this function satisfies the following properties: (1) $q'(\cdot) > 0$ and $q''(\cdot) < 0$ (concavity); (2) $q(0) \geq 0$ and $\lim_{e_t(j)\to\infty} q(\cdot) \leq 1$ (boundedness); and (3) $e_t(j)q'(\cdot) < q(\cdot)$ (elasticity less than one). Property number (1) captures the idea of diminishing returns to research, or "crowding" (i.e., doubling research input not necessarily result in doubling research output, some research output may be redundant).[6] Property number (2) simply guarantees that the the probability of success in innovation is between 0 and 1.Finally, property number (3) ensures the existence of a unique

[5] To simplify the model we assume that the same firm that innovates produces the intermediate good. Equivalently, we could have assumed separate sectors in which innovators sell their designs to manufacturers but this scenario would only complicate the analysis.

[6] As in other studies (e.g., Blackburn and Hung 1998; Blackburn *et al.* 2000; Jones 1995a; Stokey 1995), we use this property for its plausibility and intuition.

equilibrium with a positive level of innovation.[7] Apart from the risk involved in innovation, we assume that the cost of designing a new intermediate good, Ψ, is proportional to the extra output that would be created by the new variety. Hence, $\Psi = \psi \frac{Yt}{M_t}$, where $\psi > 0$.[8]

We assume an economy in which bureaucratic corruption is the norm and the probability of detection tends to zero. In this economy profit generating firms may be required to pay bribes to bureaucrats regularly to obtain certificates and services. In other words, firms producing intermediate inputs are 'harassed' every period by bureaucrats with the power to shut down their operations if they refuse to pay. This assumption is supported by Reinikka and Svensson (1999) that find evidence that firms are required to pay bribes on a regular basis and not only at entry level.[9] Let $\pi_t(j)$ be the per-period operating profit that the firm could earn from selling a new intermediate good. Then, $b_t(j)$ are the per-period bribe that the firm has to pay to continue in operation. Considering that the wage rate for skilled labour is given by W_t^H it follows that the expected payoff from innovation is

$$V_t(j) = q(e_t(j)) \sum_{\tau=1}^{\infty} (1+r)^{-\tau} \left(\pi_{t+\tau}(j) - b_{t+\tau}(j)\right) - \frac{W_t^H}{M_t} e_t(j) - \Psi. \tag{4}$$

The firm maximises (4) by choosing a level of labour input, $H_t(j)$ such that

$$M_t q'(e_t(j)) \sum_{\tau=1}^{\infty} (1+r)^{-\tau} \left(\pi_{t+\tau}(j) - b_{t+\tau}(j)\right) = W_t^H. \tag{5}$$

In addition, we assume monopolistic competition among intermediate input producers. Hence each jth research firm by taking into account the demand for its product maximises its operating profits, $\pi_t(j)$ by choosing the price $P_t(j)$ at which it will sell its intermediate good. Assuming that it costs one unit of output to produce one unit of intermediate good, operating profits are given by $\pi_t(j) = [P_t(j) - 1]X_t(j)$ and hence the optimal price is the following:

$$P_t(j) = P = \frac{1}{\alpha}. \tag{6}$$

[7] If $q'(0)$ is finite, property number (3) is necessarily satisfied.

[8] These type of models are criticised because they exhibit a scale effect by construction. As in Barro and Sala-i-Martin (2004), we can correct this anomaly by assuming that the cost of designing a new intermediate good is proportional to the extra output generated by the innovation.

[9] We could assume as in Blackburn and Forgues-Puccio (2009) that intemediate input producers also have to pay bribes to start operations. However, this assumption is not crucial for our analysis and will only complicate the algebra.

2.3 Bargaining for Bribes

Firms are proportionally distributed among bureaucrats. Since we normalise the populations of bureaucrats to one, each bureaucrat is in charge of overseeing M_t firms. Bribe income is given by $B_t = M_t b_t$. Bureaucrats negotiate the bribe payment with the firms in each period. We further assume that firms that decide to move face a fixed cost of financing relocation, c, in each period.[10] This assumption is in line with existing empirical evidence. Pennings and Sleuwaegen (2000) find a positive effect of profitability on the firm's relocation decision and Brouwer *et al.* (2004) find that firms that operate in larger markets exhibit a higher frequency of relocation.[11] In addition, we assume that firms that move face lower profits in the alternative location. Per-period operating profits in the new location are equal to a fraction $\eta \in \left(\frac{c}{\pi_t(j)}, 1\right)$ of per-period operating profits generated in the current location.[12] It follows that the Nash bargaining maximisation problem in each period is given by the following expression:

$$\underset{b_t \in \mathbb{R}^+}{Max} \left[b_t(j)\right]^{\lambda} \left[(\pi_t(j) - b_t(j)) - (\eta \pi_t(j) - c)\right]^{1-\lambda}, \tag{7}$$

where $\lambda \in (0,1)$ is the bureaucrat's bargaining power and $(1-\lambda)$ the firm's equivalent. In the first square bracket of expression (7) we can appreciate that the agreement payoff for the bureaucrat is equal to the bribe. We assume that the disagreement value for the bureaucrat is equal to zero. In the second square bracket of expression (7) we can see that the agreement payoff for the firm is the profit net of the bribe payment while the disagreement value is the profit in another location net of relocation costs. Solving the maximisation problem we find that the equilibrium bribe is given by $b_t^{NE}(j) = \lambda\left[(1-\eta)\pi_t(j) + c\right]$. Re-arranging this result we can express the equilibrium bribe as a fraction of the firm's operating profit:

$$b_t^{NE}(j) = \lambda\left[(1-\eta) + \frac{c}{\pi_t(j)}\right]\pi_t(j) = \Lambda\left(\pi_t(j)\right)\pi_t(j), \tag{8}$$

[10] We can think of financing the high cost of relocation by borrowing the funds in the form of a perpetuity that will have to be honoured period after period.

[11] Assuming fixed costs of relocation is the simplest way to model a situation in which larger firms face a lower relative cost of relocation. Alternatively, we could assume a relocation cost function that is increasing on profits but at a diminishing rate. Although, this would only complicate the algebra without adding any new insights to our results.

[12] If $\eta \leq \frac{c}{\pi_t(j)}$ then profits at the alternative location will be less or equal to zero. In this case the firm will not have an outside option.

where $\Lambda\left(\pi_t(j)\right) = \lambda\left[(1-\eta) + \frac{c}{\pi_t(j)}\right]$.[13] We define $\Lambda\left(\pi_t(j)\right)$ as the effective bargaining power of bureaucrats and it provides a measure of the fraction of profit that is lost to corruption in every period. By analogy $1 - \Lambda\left(\pi_t(j)\right)$ is the effective bargaining power of firms. Notice that $1 - \Lambda\left(\pi_t(j)\right)$ is an increasing function of operating profit. In other words, the higher is the operating profit generated by a firm, the higher is its effective bargaining power when negotiating with bureaucrats.

3 General Equilibrium

The solution to the model is symmetric by virtue of (6) which shows that the price of each intermediate good is identical and constant period after period. Using the equilibrium condition in the market for unskilled labour, $L_t = L$, it follows from (1), (2) and (3) that

$$Y_t = AL^{1-\alpha}X^{\alpha}M_t, \tag{9}$$

$$W_t = \frac{(1-\alpha)Y_t}{L}, \tag{10}$$

$$X_t(i) = X = \left(\alpha^2 A\right)^{\frac{1}{1-\alpha}} L. \tag{11}$$

Notice from expressions (9) and (10) that both the final output and wages of unskilled labour grow at the same rate as the number of intermediate goods. Furthermore, we can appreciate from (11) that the demand for of each and every intermediate good is the same and constant through time.

A further implication of (11) is that the operating profit of intermediate input firms and bribe payments to bureaucrats are also identical and constant over time,

$$\pi_t(j) = \pi = (P-1)X = \left(\frac{1-\alpha}{\alpha}\right)\left(\alpha^2 A\right)^{\frac{1}{1-\alpha}} L, \tag{12}$$

$$b_t\left(j\right) = b = \Lambda\pi. \tag{13}$$

Given the above, we can compute the present value of the net of bribes operating profit in the following way $\sum_{\tau=1}^{\infty}(1+r)^{-\tau}\left(\pi_{t+\tau}(j) - b_{t+\tau}(j)\right) = \frac{(1-\Lambda)\pi}{r}$. In addition, free entry into the research and development sector will drive the expected net payoff in (4) to zero. Using the expected payoff

[13] It is important to highlight that $\lambda\left[(1-\eta) + \frac{c}{\pi_t(j)}\right] \in (0,1)$ given that $\lambda \in (0,1)$ and $\left[(1-\eta) + \frac{c}{\pi_t(j)}\right] \in \left(\frac{c}{\pi_t(j)}, 1\right)$. Remember that $\eta \in \left(\frac{c}{\pi_t(j)}, 1\right)$, thus $\left|-\eta + \frac{c}{\pi_t(j)}\right| < 1$.

maximising value of wages for skilled labour in (5), we find that each research firm uses the same fixed amount of efficiency units of skilled labour, $e_t(j) = e$, as determined by

$$[q(e) - eq'(e)]\,(1-\Lambda)\,\pi = r\Psi. \tag{14}$$

Alternative, using (12) and considering that $\Psi = \psi \frac{Y_t}{M_t}$we can re-write the previous expression as:

$$[q(e) - eq'(e)]\,(1-\Lambda) = \frac{r\psi}{(1-\alpha)\,\alpha}. \tag{15}$$

From (15) we can deduce the following:

Lemma 1 *Given that* $\lim_{e\to 0}[q(\cdot) - eq'(\cdot)]\,(1-\Lambda) < \frac{r\psi}{(1-\alpha)\alpha}$, $\exists$ *an* $e = \varepsilon(\Lambda) > 0$ *such that* $\varepsilon'(\cdot) > 0$.

Proof. Define $Q(e) = q(\cdot) - eq'(\cdot)$. Since $Q'(\cdot) = -eq''(\cdot) > 0$, then provided that $\lim_{e\to 0} Q(\cdot)\,(1-\Lambda) < \frac{r\psi}{(1-\alpha)\alpha}$, $\exists$ a unique value of $e > 0$ that satisfies $Q(e)\,(1-\Lambda) = \frac{r\psi}{(1-\alpha)\alpha}$. Hence $e = \varepsilon(\Lambda)$, where $\varepsilon'(\cdot) = \frac{Q(e)}{Q'(\cdot)(1-\Lambda)} > 0$.
■

Thus, we can express the equilibrium level of efficiency units of skilled labour, e, as an increasing function of the bureaucrats effective bargaining power, Λ. We still need to incorporate the equilibrium in the market for skilled workers. Once again due to symmetry all research firms use the same amount of skilled workers, $H_t(j) = H_t$. In equilibrium, the demand for skilled workers is equal the supply for skilled workers, $N_t H_t = 1$ so that $e = \frac{M_t}{N_t}$. Taking into account that the term $[q(\cdot) - eq'(\cdot)]$ in (15) is an increasing function of e or, equivalently, a decreasing function of N_t, we can study what happens with the number of new intermediate input producers N_t when we are not in equilibrium. If $[q(\cdot) - eq'(\cdot)]\,(1-\Lambda) > \frac{r\psi}{(1-\alpha)\alpha}$, the existence of positive profits would be an incentive for more firms to enter the market, implying that N_t would increase until (15) holds with equality. Alternatively, if $[q(\cdot) - eq'(\cdot)]\,(1-\Lambda) < \frac{r\psi}{(1-\alpha)\alpha}$ the prospect of negative profits would be an incentive for firms to leave the market. As a result, N_t would fall until (15) held with equality.

An important implication of equation (15) is that the equilibrium number of new firms engaging in research and development is higher in a non-corrupt economy than in a corrupt economy. In the absence of corruption $\Lambda = 0$, which means that intermediate input producers retain the totality of their operating profits. Given that the term $\frac{r\psi}{(1-\alpha)\alpha}$is constant, e will have to fall, or alternatively N_t will have to increase until $[q(\cdot) - eq'(\cdot)] = \frac{r\psi}{(1-\alpha)\alpha}$. Hence, the number of new intermediate input producers is higher in a non-corrupt than in a corrupt economy.

In equilibrium, the number of new intermediate goods, N_t grows at the same rate as M_t given that e is a constant. In the same way the wages of skilled labour also grow at the same rate since (5) yields $M_t q'(e)\frac{(1-\Lambda)\pi}{r} = W_t$.

Finally we need to determine the equilibrium growth rate of the economy. Research firms work independently, hence the flow of new intermediate inputs is given by $M_{t+1} - M_t = q(\cdot)N_t$. Defining the growth rate of new intermediate inputs as $g_t = \frac{M_{t+1}-M_t}{M_t}$ and using the fact that $e = \frac{M_t}{N_t}$, then it follows that

$$g_t = g = \frac{q(e)}{e} \equiv g(e), \tag{16}$$

where e is determined by equation (15). Notice that the growth rate of the economy is a decreasing function of e given that $g'(\cdot) = \frac{eq'(\cdot)-q(\cdot)}{e^2} < 0$.[14] Alternatively, since e is a decreasing function of N_t, g is an increasing function of N_t. In other words, the growth rate of the economy is higher when innovation is higher. The channel by which corruption reduces economic growth is innovation. As we showed earlier the higher are bribes the lower is innovation. The relationship between corruption and innovation has recently been investigated empirically. Anokhin and Shulze (2009) using longitudinal data for 64 countries find evidence that countries that are more successful in controlling corruption exhibit higher levels of innovation. Mahagaonkar (2010) using data for African firms from the World Bank's Enterprise Survey finds a strong and significant negative link between corruption and product innovation.

4 Scale, Corruption and Growth

After fully specifying the model we study in this section the role of the size of the economy in explaining the impact of corruption on growth. We use population as a measure of scale. Total population in our model is given by the sum of the populations of bureaucrats and workers. The size of the bureaucracy is not relevant provided we assume that there are less civil servants than firms. In the same way, due to our assumption about the probability of succeeding in innovation, it follows trivially that the larger is the population of skilled workers, the higher is the probability of succeeding in innovation, and the higher is the growth rate of the economy. Thus, we adopt

[14] Notice that g is also the growth rate for all other (non-stationary) variables. In the absence of any transitional dynamics, the economy evolves over time along a balanced growth path with an increasing number of firms engaged in research and development.

the number of workers in the final output sector as our population measure to explore how the size of an economy affects the link between bureaucratic malfeasance and economic progress.

Proposition 1 *Bureaucrats have higher effective bargaining power in a small than in a large corrupt economy.*

Proof. Define L^s and L^l as the populations of a small and a large economy respectively, where $L^s < L^l$. From (12) we have that $\pi(L)$ and $\pi'(\cdot) = \left(\frac{1-\alpha}{\alpha}\right)(\alpha^2 A)^{\frac{1}{1-\alpha}} > 0$ then it follows that $\pi(L^s) < \pi(L^l)$. In addition, since $\Lambda(\pi)$ and $\Lambda'(\cdot) = -\lambda c/\pi^2 < 0$ it follows that $\Lambda(\pi(L^s)) > \Lambda\left(\pi\left(L^l\right)\right)$. ■

By inspecting equation (11) we can appreciate that the demand for intermediate goods is greater in more populated economies. Given the symmetry of the model in large economies all intermediate input firms operate at a larger scale and generate higher profits. Firms that generate large profits are in a better position to relocate and this strengthens their position when negotiating for bribes. From the point of view of the bureaucrats, if they deal with firms that serve larger markets, they will inevitably have lower effective bargaining power.

Proposition 2 *Growth is lower in a small than in a large corrupt economy.*

Proof. Using Lemma 1 define $e^s = \varepsilon(\Lambda(\pi(L^s)))$ and $e^l = \varepsilon(\Lambda\left(\pi\left(L^l\right)\right))$.From Lemma 1 and Proposition 1 it follows that $e^s > e^l$. Given that by (16) $g(e)$ and $g'(\cdot) = \frac{eq'(\cdot)-q(\cdot)}{e^2} < 0$ it follows that $g(e^s) < g\left(e^l\right)$. ■

This result is intimately related with the firm's effective bargaining power. In small economies the cost of relocation as a proportion of operating profit is higher than in large economies. This situation weakens the firm's position when bargaining with bureaucrats and implies that a larger fraction of operating profit may be lost to corruption. The total number of research firms is smaller and each firm uses a higher level of efficiency units of skilled labour, e. The implications of this is that under the presence of corruption, innovation and growth is lower in a small than in a large economy. In other words, less research firms will be willing to create new intermediate goods in small corrupt economies resulting in lower innovation and growth.

5 The Role of Uncertainty

We have been assuming so far that intermediate input producers negotiate and pay a bribe only once in each period. Now we turn our attention to the case in which bureaucrats may ask for additional bribes. This situation is not rare and has been modelled by Choi and Thum (2004). In economies in which corruption is chaotic the payment of a bribe does not guarantee the delivery of a service, certificate or permit. Bureaucrats can always create additional regulations with the single purpose to extract further bribes. Hence, an existent intermediate input producer may end up negotiating bribes several times in each period.

In section 3 we found that in general equilibrium firms producing intermediate goods exhibit an identical and constant operating profit over time. In addition, we found that bribe payments may be expressed as a fraction of profits. Hence, if bureaucrats ask for bribes only in one occasion in each period, the net of bribes operating profit (per period) was found to be $\pi - b = (1-\Lambda)\pi$. This result follows from the Nash bargaining maximisation problem presented in expression (7). We can extend the analysis to allow for the negotiation of additional bribes. We start by writing down the Nash bargaining maximisation problem for a firm when a second bribe is required in each period. The Nash bargaining maximisation problem is now:

$$\underset{b_2 \in \mathbb{R}^+}{Max} \, [b_2]^{\lambda} \left[((\pi - b_1) - b_2) - (\eta\pi - c)\right]^{1-\lambda}, \tag{17}$$

notice that $b_1$has already been paid, thus it has to be deducted from operating profit. The equilibrium second bribe is given by $b_2^{NE} = \lambda\left[(1-\eta)\pi + c\right] - \lambda b_1$. Re-arranging this result and taking into account that $b_1 = \lambda\left[(1-\eta) + \frac{c}{\pi}\right]\pi = \Lambda\pi$, the second bribe as a fraction of operating profit is given by the following expression $b_2 = (1-\lambda)\Lambda\pi$. Repeating the same procedure we can find the equilibrium values for further possible bribe payments as $b_3 = (1-\lambda)^2\Lambda\pi$, $b_4 = (1-\lambda)^3\Lambda\pi$, and so on and so forth. If we denote as b_n the nth bribe that has to be negotiated in each period. The net of bribes per-period operating profit when bribes are solicited in S occasions is given by:

$$\pi - \sum_{n=1}^{S} b_n = \left[1 - \Lambda\left(\frac{1-(1-\lambda)^S}{\lambda}\right)\right]\pi. \tag{18}$$

From (18) it follows that the associated present value of the net of bribes operating profit is given by $\left[1 - \Lambda\left(\frac{1-(1-\lambda)^S}{\lambda}\right)\right]\pi/r$. Assuming that with a probability p firms will have to pay bribes on $S > 1$ occasions in each period and with probability $(1-p)$ they pay a bribe only once, we can write down the entry condition to the research and development sector as follows:

$$[q(e)-eq'(e)]\left\{1-\Lambda\left[p\left(\frac{1-(1-\lambda)^S}{\lambda}\right)+(1-p)\right]\right\}=\frac{r\psi}{(1-\alpha)\,\alpha}. \quad (19)$$

Equation (19) is a more general entry condition that also incorporates uncertainty about bribe payments. If we assume that $p=0$, then firms know with certainty that bureaucrats will ask for bribes only once in each period and (19) becomes equation (12). Conversely if $p=1$, firms pay additional bribes in $S>1$ occasions in each period.[15]

Proposition 3 *An increase in the probability of facing additional bribes reduces growth.*

Proof. Define $\widehat{\Lambda}\,(p)=\Lambda\left[p\left(\frac{1-(1-\lambda)^S}{\lambda}\right)+(1-p)\right]$ where $\widehat{\Lambda}'\,(\cdot)=\Lambda\left(\frac{1-(1-\lambda)^S}{\lambda}-1\right)$ >0 . Using lemma 1 we can define $e=\varepsilon\left(\widehat{\Lambda}\,(p)\right)\equiv E\,(p)$. Hence $E'\,(\cdot)=\varepsilon'\,(\cdot)\,\widehat{\Lambda}'\,(\cdot)>0$.Given that by (16) we have that $g\,(e)$, we can write the equilibrium growth rate as $g=\gamma\,(E\,(p))\equiv\Gamma\,(p)$ where $\gamma'\,(\cdot)=\frac{eq'(\cdot)-q(\cdot)}{e^2}<0$. Hence, $\Gamma'\,(\cdot)=\gamma'\,(\cdot)\,E'\,(\cdot)<0$. ∎

Consistent with the results of Wei (1997) and Campos *et al.* (1999) we find that growth is higher in countries in which corruption is more predictable. The higher the uncertainty about the payment of additional bribes in each period the lower is the incentive for firms to enter the research sector. Not knowing if a significant portion of operating profit may just disappear create huge disincentives to participate in this sector. If the probability of paying multiple bribes on each period is considerably high, there will be few research firms each employing a large number of research input, e. Resulting in a low growth rate for the economy. An inspection of equation (19) and Proposition 3's proof reveals that the effect of a high probability of facing additional bribes is stronger in small than in large economies. Notice that $\widehat{\Lambda}'\,(\cdot)$ is increasing in the bureaucrat's effective bargaining power, Λ. In spite of this, even in a large economy a high p may cancel out and more than offset the higher effective bargaining power of firms. A large corrupt economy in which

[15] Notice that if $S=1$ then $\left(\frac{1-(1-\lambda)^S}{\lambda}\right)=1$ and if $S\to\infty$ then $\left(\frac{1-(1-\lambda)^S}{\lambda}\right)=\frac{1}{\lambda}$. Hence $\left(\frac{1-(1-\lambda)^S}{\lambda}\right)\in\left(1,\frac{1}{\lambda}\right)$, implying that the higher is the number of additional bribes the higher the fraction of profits that is lost to corruption.

firms face a high probability of paying additional bribes may end up being comparable to a small corrupt economy in which the probability of additional payments to bureaucrats tends to zero.

6 Conclusions

Entrepreneurship is at the centre of the process of development. The rate at which entrepreneurs generate new ideas is fundamental for economic progress. In corrupt economies firms face bureaucratic obstacles on a day to day basis that can only be ameliorated by the regular negotiation and payment of bribes. In spite of this, firms in certain countries seem to be in a better position to bargain with corrupt public officials than in others. We argue in this paper that the size of the economy plays an important role in this negotiation process and ultimately on the impact of corruption on innovation and growth. In particular, the average firm in a large economy operates at a larger scale thereby generating larger profits. Firms that generate larger profits are in a better bargaining position with bureaucrats. As a result bribes as a fraction of profits are lower and innovation and growth are higher.

In this paper we have also highlighted that size is not everything. We showed how low predictability about future payment of bribes may reduce the incentives to enter the market. Firms may not find attractive entering a market in which there is high uncertainty about the future payment of bribes. As a result the positive effects of size may be reduced, or even totally canceled out.

Like in many other analyses we have taken as given that corruption exists in the economy. It was not our intention to explain why corruption arises and how the incidence of corruption may change when other aspects of the economy evolve. In contrast, we focus on trying to understand why corruption may be more damaging in some countries than in others. An important question that did not receive much attention in the literature so far.

One implication of our analysis is that policy makers in small corrupt economies face a greater challenge than their counterparts in large economies. This is because the average firm in a small corrupt economy may have very little bargaining power with bureaucrats and the stagnation we observe in some of these economies may be the result of powerful civil servants suffocating entrepreneurship.

The other implication of our analysis is that independently of the size of the economy if future bribes are difficult to anticipate entrepreneurs may not have any incentives to enter the market and may prefer to take their business somewhere else where bribes are less uncertain.

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University of St Andrews
Fife, UK, KY16 9AL
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