Corruption, Fertility, and Human Capital*

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Abstract

We build an overlapping generations model in which reproductive households face a child quantity-child quality trade-off and bureaucrats are delegated with the task of delivering public services that support the accumulation of human capital. By integrating the theoretical analyses of endogenous growth, corruption and fertility choices, we show that the negative relation between fertility and economic development may also be affected by differences in the magnitude of bureaucratic corruption.

Keywords: Corruption; Fertility; Human capital; Economic growth

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1 Introduction

The relation between corruption and economic activity has always been at the forefront of the research agenda on the economics of development. Despite the fact that some earlier studies asserted that corruption may benefit economic growth through the role of bribery as ‘speed money’ that reduces the costs associated with red tape (Leff 1964), the most recent evidence establishes a negative association between the incidence of corruption and economic growth. Indeed, a plethora of analyses, such as those by Mauro (1995); Keefer and Knack (1997); Gyimah-Brempong (2002); Aidt (2009); and Bhattacharyya and Hodler (2010), have revealed different mechanisms through which the various manifestations of corruption are serious impediments to the long-term prospects of developing economies.¹ It is for this reason that the World Bank has identified corruption as “the single greatest obstacle to economic and social development.”²

The purpose of our paper is to reveal a previously unexplored link between corruption and economic activity. This link is related to one of the most striking aspects in the comparison between developed and developing economies, i.e., the differences in their demographic characteristics and, in particular, differences in fertility rates. In Figure 1, we plot data that illustrate cross-country differences between fertility rates and corruption during 2012. As a measure of fertility, we use data on the Total Fertility Rate (TFR) extracted from the World Bank, whereas the measure of corruption is Transparency International’s Corruption Perception Index (CPI). Taking account that higher corruption is associated with a lower CPI score, the plot depicts a clear positive correlation between corruption and fertility rates.³ In our analysis, we shall employ a theoretical model to contend that there are reasonable and intuitive arguments to support a causal relation behind the correlation emerging from Figure 1. In this respect, our claim is that corruption may contribute, together with other factors that have already been identified in the literature (e.g., Soares

¹ Gundlach and Paldam (2009) argue that this relation is two-way causal. In particular, they show that corruption is more prevalent in less developed countries.

²<http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTPOVERTY/EXTPOWERMENT/0,contentMDK:20312308~menuPK:543262~pagePK:148956~piPK:216618~theSitePK:486411~isCURL:Y,00.html>

³ The data includes 178 countries for which both a CPI score and data on the TFR were available for 2012. It should be noted that this is the latest year for which, at the time of this manuscript’s preparation, the World Bank had available data for the TFR.

2005; Azarnert 2008; Varvarigos and Zakaria 2013; Neanidis and Papadopoulou 2013) in determining differences in fertility rates among different (groups of) countries.⁴

Figure 1. Cross-country correlation between the CPI and the TFR (2012)

The mechanism we propose is the following. The return to the resources that parents offer for the mental development of their children (for example, their human capital) is supported by the delivery of such productive services as public education, public health and other forms of public infrastructure investment. Insofar as bureaucratic corruption hinders the delivery and the quality of such services, parents will have a reduced incentive in providing resources that support child quality. Hence, they will find optimal to divert their resources towards child quantity. As the incidence of bureaucratic corruption may decline at advanced stages of economic development, lower fertility rates may occur as a direct outcome of reduced corruption in the public sector of the economy.

We verify this assertion in the context of an overlapping generations model in which households face a child quantity-child quality trade-off and bureaucrats are delegated with the task of procuring public services that support the accumulation of human capital. At low stages of development, some bureaucrats find optimal to choose low quality public projects because this allows them to embezzle part of the funds that are otherwise devoted to the

⁴ Blackburn and Sarmah (2008) analyse demography and corruption in a growth model, but they do not consider endogenous fertility. In their framework, each parent gives birth to one child exogenously and demographic changes are only due to variations in life expectancy. Our framework is rather different in that we focus on an aspect of demographic transition for which the endogeneity of fertility choices is of paramount importance.

procurement of public services. At higher stages of development, the incentive for this type of malversation disappears. As a result of the two-way causal effects between economic growth and the incidence of corruption, the model admits a threshold effect that is responsible for multiple growth equilibria. Furthermore, this threshold effect is translated into differences in fertility rates that are attributed to the fall in the incidence of bureaucratic corruption: as the economy grows, the endogenous decline in corruption will improve the provision of productive public services, thus inducing households to substitute child quality for child quantity.⁵

It should be noted that our results do not rest on any alien assumptions regarding preferences or technologies. In fact, when it comes to the parental choices of child rearing and education per child, we adopt the same specification of utility that has been employed by all the existing papers for which the quantity-quality trade-off is an important element in the theoretical explanation of broad issues regarding the process of economic development (e.g., Galor and Weil 2000; Hazan and Berdugo 2002; Kalemli-Ozcan 2003; Soares 2005; Lagerlöf 2006; de la Croix and Doepke 2009; Fioroni 2010; Galor 2011). This specification of utility may admit a wide range of interpretations to explain why parents care about both the size of their family and the human capital with which each of their offspring is equipped. When these are combined into a composite input, the interpretation is that parents care about the qualitative characteristics of each child or the lifetime income of each child. Alternatively, one may consider these arguments as being separable in the utility function of an agent. In this case, human capital investments are induced by an impurely altruistic motive that translates warm-glow giving (see Andreoni 1989) into resources spent to improve the education of each child, rather than direct income transfers. Since we employ logarithmic preferences to ensure the analytical tractability of the model (again, in line with the aforementioned literature) both interpretations can be equally applied.

⁵ The theoretical model of Fioroni (2010) makes a distinction between private and public spending towards human capital improvements. Under the private education regime, unfavourable initial conditions may lead to a poverty (Malthusian) trap. Moreover, reductions in child mortality can cause an increase in fertility and a reduction in private human capital investment, thus inhibiting economic growth. Under the public education regime the poverty trap disappears, while the absence of a child quantity-child quality trade-off implies that reductions in child mortality do not inhibit economic growth. Our model differs in that, apart from incorporating the issue of corruption, we consider the case where the resources of both the private and the public sector contribute to the accumulation of human capital. Furthermore, we abscond from the issue of child mortality.

As expected, allowing parents the choice of both child rearing and educational investments per child triggers a child quantity-child quality trade-off in the sense that any structural characteristic that affects the return to education will induce a change in fertility choices. But then why is corruption the critical issue in eliciting such optimal responses by parents and not just the insufficient delivery of productive public services? The answer is straightforward: in this context, corruption *is* the reason why funds towards education infrastructure are insufficient (due to embezzlement by corrupt public officials), thus hindering the quality of public services. As it will become evident during the main part of our analysis, it is when bureaucrats are corrupt that the expropriation of public funds deteriorates the qualitative characteristics of public education, thus affecting the quantity-quality trade-off in such a way as to reduce private education resources and increase the fertility rate. In other words, the mitigating effect of corruption on the return to human capital accumulation is the crucial link in the emergence of the model's mechanism, ultimately generating the two distinct regimes of either high growth/low fertility or low growth/high fertility. The empirical analysis of Mauro (1998) substantiates this mechanism since his cross country econometric study that examines the effect of corruption on the composition of public spending suggests that corruption is a serious impediment to public spending on education.

We should note that the child quantity-child quality trade-off represents the transmission mechanism through which we introduce the novel aspect of our analysis and its contribution, i.e., the manner through which corruption impinges on this choice, thus having important effects on both the economy's demographics and human capital accumulation. These particular effects of corruption are novel and have not been identified in the existing literature. The reason we view the quality-quantity trade-off as an important and highly relevant transmission mechanism in identifying novel effects when it comes to the corruption-growth nexus is because, as a means of explaining aspects of an economy's transition from low to high stages of economic development, the quantity-quality trade-off is not just a theoretical curio. On the contrary, there is strong empirical support for this hypothesis by a plethora of analyses over the years (e.g., Rosenzweig and Wolpin 1980; Hanushek 1992; Black *et al* 2005; Bleakley and Lange 2009), while in recent years it has become an essential characteristic of theoretical frameworks that lie on the forefront of the research agenda on the dynamics of growth/development.

Some additional implications of our model relate to the possibility of strategic interactions in the determination of corruption incentives among bureaucrats. Particularly, there are circumstances for which the bureaucrats' decisions regarding their actions while in public office (i.e., whether they will engage in illegal rent-seeking or not) are either strategic complements or strategic substitutes. Despite the fact that the set of possible equilibria is enriched in this case, the main message from our analysis remains qualitatively intact: higher corruption hinders the quality of productive public services, thus eliciting a response through the child quantity-child quality trade-off that is directed towards higher fertility rates.

Our analysis is related to other contributions that employ dynamic models in order to examine the relationship between corruption and long-term macroeconomic outcomes. None of them, however, examine the implications of corruption for the child quality-child quantity trade-off, thus its importance for the nexus between economic growth and fertility. In Ehrlich and Lui (1999), agents can accumulate either human or political capital, the latter allowing them access to rents associated with operating in the high ranks of the public sector. They find that the accumulation of political capital retards the rate of growth. Alesina and Angeletos (2005) show that corruption increases income inequality because wealthier agents have better access to illegal rent seeking activities. A similar theme is explored by Blackburn and Forgues-Puccio (2007) who argue that corruption amplifies income inequality as the tax evasion from the rich reduces the subsidies offered to the poor. Blackburn *et al* (2006) show the possibility of multiple, path-dependent equilibria in the joint determination between tax evasion, corruption and economic development, whereas Blackburn and Forgues-Puccio (2009) show that, as long as corrupt bureaucrats demand bribes to grant licences to innovators undertaking R&D, then reduced innovation can provide a transmission mechanism through which corruption inhibits economic growth. Eicher *et al* (2009) illustrate the importance of human capital accumulation for the nexus between corruption and economic development, while Blackburn *et al* (2011) argue that corruption can retard the process of economic development due to the reduction on public sector provision of infrastructure investment. Dzhumashev (2014a) makes a distinction between collusive corruption (related to tax evasion) and non-collusive corruption (capturing a bureaucrat's abuse of power in public office). He shows that, whereas the latter unambiguously lowers the rate of growth, the former may actually increase growth as long as the marginal productivity of public infrastructure is relatively low. In Dzhumashev (2014b)

an overall increase in public spending increases the fraction that is directed towards rent seeking, while the growth maximising tax rate increases with corruption. These bi-directional effects explain why public spending reduces growth in low income countries.

The remaining paper is organised as follows. In Section 2 we present the basic set-up of our economy, with detailed discussion on the characteristics of the government, the bureaucrats, and the households. Section 3 shows that corruption is endogenously determined and establishes its effect on public services, whereas Section 4 derives the economy's growth rate and shows how incidence of corruption can affect fertility rates. In Section 5 we offer an extension regarding the reproductive characteristics of bureaucrats and discuss the equilibrium implications. In Section 6 we conclude.

2 The Economy

Time takes the form of discrete intervals that are indexed by $t = 0, 1, 2, \dots$. The economy is populated by overlapping generations of agents who face a finite lifespan of two periods – *childhood* and *adulthood*. Each period, nature divides the population of newly-born agents into two separate groups: a fraction $\lambda \in (0, 1)$ become *bureaucrats* and the remaining fraction $(1 - \lambda) \in (0, 1)$ become *households*. Henceforth, these two types of agents are going to be distinguished by a superscript $i = \{B, H\}$: for $i = B$ the person is a bureaucrat while for $i = H$ the person is a household. When they reach adulthood, all agents receive an endowment of a time unit which (depending on their type) they may allocate to various activities in a manner that will be described shortly.

Agents do not make any decisions during their childhood. All decisions are made during their adulthood. In particular, each adult will behave optimally by maximising her utility function

$$u_t^i = a^i \ln(c_t^i) + (1 - a^i) \ln(n_t^i b_{t+1}^i), \quad (1)$$

where c_t^i is the adult's consumption of the economy's homogeneous good, n_t^i is the number of children she wants to rear, b_{t+1}^i denotes each child's human capital and $a^i \in (0, 1]$ weights the two arguments of the utility function. The last term of the utility function indicates that adults enjoy utility from both the number of children they rear and the human capital of each offspring. Note that, due to the choice of preferences, the last term can be alternatively

written as $(1-a^i)[\ln(n_t^i) + \ln(b_{t+1}^i)]$. In this respect, the preferences reflect some form of impure altruism on behalf of parents – a warm-glow characteristic, similar to Andreoni (1989), which in this context will be manifested by the resources that families spend to improve the education levels of each child, instead of direct income transfers. Nevertheless, this type of altruism can be more broadly interpreted once we consider $n_t^i b_{t+1}^i$ to be a composite term, i.e., as it appears in (1). Particularly, one may think that the utility that the parents enjoy from their children is measured in *effective* terms, i.e., each child is augmented by qualitative characteristics that are captured by human capital.⁶ This is meant to capture the idea that parents care about their offspring's future prospects and social status.⁷ Alternatively, we could equivalently follow Galor and Weil (2000) by writing the last term in Equation (1) as $(1-a^i)\ln(n_t^i w_{t+1} b_{t+1}^i)$, where w_{t+1} is the wage per unit of effective labour, and assume (like they do) that parents enjoy utility from the wealth/disposable income of their children – again an idea that appeals to the fact that parents also care about the prospects of their offspring, since rearing them is not the only source of utility. Note that due to log-separability, in which case $(1-a^i)\ln(n_t^i w_{t+1} b_{t+1}^i) = (1-a^i)[\ln(n_t^i b_{t+1}^i) + \ln(w_{t+1})]$, and the presence of a technology that is linear in effective labour in order to guarantee the existence of long-run growth (see Lucas 1988), this specification would not affect our subsequent results; instead, these would remain identical.⁸

By devoting e_t^i units of time per child, the parent improves the human capital of each child according to

$$b_{t+1}^i = v\bar{b}_t + F_t(e_t^i)^x, \quad (2)$$

⁶ One may think of some relevance to production technologies where the measurement of labour units is in effective terms, i.e., raw labour augmented by the stock of human capital.

⁷ To be more precise, a complete representation of social status would entail comparisons over a reference point. The paper by Bishnu (2013) utilises this idea and its implications for the accumulation of human capital. Particularly, he employs an OLG model to show that as long as there are social status considerations in the consumption of goods and services - captured by the idea that higher utility is an outcome associated with the difference of own consumption against a reference value related to the average level of consumption during the same period – the optimal investment in education in a competitive equilibrium differs from the corresponding one under the social optimum. As a result, social status considerations generate the scope for government intervention in the accumulation of human capital, even in the absence of any intragenerational or intergenerational externalities.

⁸ One could consider the case of perfect altruism – a scenario in which parents care about the utility of their offspring. As argued by Galor and Weil (2000), such an assumption would greatly undermine the tractability of the model, given the added complication from the fact that families would need to make predictions on the fertility and education choices of their children, without changing the qualitative message of the current set-up.

where $\nu \in (0,1)$ and $\varkappa \in (0,1)$. The first term in (2) is meant to capture the idea that a child can pick-up a fraction ν of the economy's average human capital stock (that is, $\bar{b}_t$) even in the absence of any parental effort towards human capital improvements. The variable F_t captures the benefit from the productive public services that the government will offer in support of the adults' efforts to educate their children. We do not need to associate these services solely with education. There can be other services that promote the efficiency of resources towards human capital and higher productivity – services such as public health; transportation; information technology infrastructure etc.⁹ The provision of these public services requires that the government employs people that are able to deliver them – this is where the distinction between households and bureaucrats becomes important. We assume that the only group of adults with the innate ability to use their labour in order to deliver public services are the bureaucrats; households do not possess this ability. However, all adults (households and bureaucrats) have the ability to work for private sector firms.

We shall also assume that, if hired by the government, bureaucrats will have to devote their whole unit of time inelastically in the process of delivering public services. For this reason, most of our remaining analysis will be making use of the assumption that nature does not bestow any altruistic motives to bureaucrats; only households are characterised by the altruistic motive to raise and educate children. Without this restriction, no bureaucrat would wish to work for the public sector because the time they would require for raising and educating their offspring would not allow them to devote the (required) unit of time in the process of procuring public services. Nevertheless, such occupational opportunity is essential for our analysis. Hence, we restrict our attention to

$$a^H = a \quad \text{and} \quad a^B = 1. \quad (3)$$

On the outset, this may appear to be a restrictive assumption. To appease the reader's concerns, in Section 5 we revise the original set-up so as to allow bureaucrats to be reproductive and to face a child quantity-child quality trade-off, exactly as households do. It will be shown that all the main results and their corresponding mechanisms remain intact even if we allow bureaucrats to be reproductive and altruistic towards their children. The reason why the results remain intact is because bureaucrats do not internalise the effect of

⁹ The supporting effect of public spending on private effort towards education, captured by the term $F_t(e_t^i)^\varkappa$ in our model, is widely used in the existing literature. For instance, see the analyses of Kaganovich and Zilcha (1999); Blankenau and Simpson (2004); and Palivos and Varvarigos (2013).

their own (potentially corrupt) behaviour on the *aggregate* provision of public services and on the benefit that these services entail for their offspring. As we shall see later in more detail, each bureaucrat operates a single public investment project that is infinitesimally small as a part of the total mass of projects that comprise aggregate public services. For this reason, her fertility decisions would be qualitatively identical to that of a household. Nevertheless, this scenario generates additional outcomes entailing the presence of strong interactions among bureaucrats when they make their individual decision on whether to be corrupt or not. Given that these outcomes merit a discussion of their own, as well as our desire not to blur the intuition on the pure effect of economic development on the emergence of corruption, we shall proceed to the main part of the analysis utilising the assumption in (3). Then, we shall use Section 5 to establish that the main implications of our model remain unaffected, even when we generalise the fertility choices of the population by including bureaucrats in the reproductive cohort.

The assumptions for the economy's demographics together with the restriction in (3) imply that the populations of adult households and adult bureaucrats in any period t are given by $N_t^H = (1 - \lambda)N_{t-1}^H n_{t-1}^H$ and $N_t^B = \lambda N_{t-1}^H n_{t-1}^H$ respectively. Consequently, we have

$$\frac{N_t^B}{N_t^H} = \frac{\lambda}{1 - \lambda}. \quad (4)$$

Furthermore, in what follows we are going to remove the superscripts from variables over which only a household makes a choice, i.e., n_t , e_t and b_{t+1} .

Taking account of (1), (2) and (3), a household will choose how many children to rear, how much time to devote for the human capital of each child, as well as her consumption of the economy's homogeneous good in order to maximise her utility

$$u_t^H = a \ln(c_t^H) + (1 - a) \ln(n_t b_{t+1}), \quad (5)$$

subject to

$$c_t^H = w_t [1 - (q + e_t) n_t] b_t, \quad (6)$$

and

$$b_{t+1} = v \bar{b}_t + F_t e_t^x, \quad (7)$$

taking F_t and w_t as given. The parameter $q > 0$ in (6) captures the fixed cost (in units of time) of raising each child, while b_t is her stock of human capital. Thus, the term

$[1-(q+e_t)n_t]b_t$ is her labour (measured in efficiency units) for which she receives a wage rate w_t .

The economy's homogeneous good is produced by a large mass (normalised to one) of perfectly competitive firms who employ *effective* labour, denoted L_t , to produce y_t units of output according to

$$y_t = AL_t, \quad A > 0. \quad (8)$$

Firms face a flat tax $\tau_t \in (0,1)$ per unit of revenue. Therefore, the wage per unit of effective labour is equal to

$$w_t = (1-\tau_t)A. \quad (9)$$

As mentioned previously, these firms represent the only occupational option for households, whereas bureaucrats have two such options: they can be employed either in private sector firms or in the public sector. Thus, the equilibrium level of L_t (which will be derived later) will take account of both households and bureaucrats employed in the private sector.

2.1 The Government

As we explained above, the government delegates the task of public service delivery to adults that have the ability to undertake such a task, i.e., to the bureaucrats. Every period, the government will devote g_t units of output towards this purpose. We further assume that the government's spending on public services is proportional to the economy's GDP according to¹⁰

$$g_t = \theta y_t, \quad 0 < \theta < 1. \quad (10)$$

The funds available for public service delivery will be equally allocated among public sector employees. The government will instruct them to use all these funds, together with their unit of time, in order to finance a project that delivers the desired public services. In exchange, each bureaucrat employed in the public sector will receive a remuneration equal to ω_t^B .

There are two types of public projects that a bureaucrat can use in order to deliver public services. The Type-1 project's return is random: it will deliver $\xi > 1$ units of service with

¹⁰ See Barro (1990).

probability $\pi \in (0,1)$, or $\gamma < 1$ units of service with probability $(1-\pi) \in (0,1)$, for every unit of output invested to it. Note that the shock is not aggregate but idiosyncratic to each bureaucrat operating the project.¹¹ The Type-2 project can deliver $\frac{\gamma}{\delta}$ units of service with certainty for every unit of output invested to it. Note that $1 > \delta > \gamma > 0$ so that $\frac{\gamma}{\delta} < 1$. The government instructs each employed bureaucrat to operate the project that has the higher expected rate of return (in terms of services) per unit of invested output. Assuming that $\pi\xi \geq 1$, the government will instruct all bureaucrats to operate the Type-1 project.¹²

We shall assume that each bureaucrat's ability restricts the size of a project that she can undertake. In particular, the maximum project size that a bureaucrat can handle is $\frac{g_t}{\kappa N_t^B}$, where $\kappa < 1$. It is also natural to assume that the government will wish to ensure a given amount of public services at the minimum possible cost. This entails that the government employs the minimum number of bureaucrats necessary to guarantee that public projects can be operated at the minimum possible salary. With respect to the number of public sector employees, it is straightforward to establish that the number of bureaucrats hired will be κN_t^B .¹³ With respect to their remuneration, bureaucrats will only be willing to accept a contract that will offer them $\omega_t^B \geq w_t h_t$. Given that bureaucrats could earn a salary of w_t per unit of efficient labour by working in the private sector, any person accepting a contract with $\omega_t^B < w_t h_t$ would immediately convey to government authorities her opportunistic nature: she can only be willing to work for $\omega_t^B < w_t h_t$ if she expects to cover the shortfall by

¹¹ Naturally, we also assume that this idiosyncratic shock is private information (i.e., not observable by the government) as well.

¹² Note that, as in Blackburn *et al* (2011), the products of public projects are qualitative units of public service. Thus, the parameters ξ and γ are shift parameters that describe how many units of public services can result for each unit of income (i.e., the input to the public investment process) devoted to the project. Essentially, there is a technology transforming inputs (public funds) into output (public services) and these parameters describe the productivity of such technologies, in a similar manner as a production technology transforms labour and capital into goods/services, a human capital technology transforms income and time/effort into units of intangible human capital, or an R&D technology transforms income and time/effort into ideas and designs. In this respect, there is no reason to restrict the values of these shifts parameters to unity.

¹³ When $\kappa = 0$, the model is reduced to a standard one in which the government delivers services directly without the need of public workers. This is because an infinitesimal number of bureaucrats are sufficient to handle projects of any possible scale. We abscond from this scenario due to its limited interest.

expropriating part of the public sector resources to which she will gain access.¹⁴ Thus, the government can minimise the cost of hiring the necessary number of κN_t^B bureaucrats by offering a remuneration that satisfies¹⁵

$$\omega_t^B = w_t h_t. \quad (11)$$

Every period, the government abides by a balanced-budget rule. Formally,

$$\tau_t y_t = g_t + \omega_t^B \kappa N_t^B. \quad (12)$$

According to (12), the government allocates its tax revenues between its spending for the delivery of public services and the total labour costs of the public sector.

Before we proceed to the next section, we should note that bureaucrats receive human capital exactly in the same manner as private sector workers do. Both bureaucrats and workers are reared by parents who decide how many resources to spend on their education. These resources, together with the quality of public services and an intergenerational externality, determine the stock of human capital that will be available to an agent, whether a worker or a bureaucrat, when she becomes an adult. Formally, human capital formation is given in Equation 7. Also note that h_t denotes the stock of human capital that will benefit an agent who is adult in period t , h_{t+1} denotes the stock of human capital that will benefit an agent who is adult in period $t+1$ and so on. Thus, those who are adults in period t have a predetermined stock of human capital h_t . Their decisions concerning the education of their offspring determines the stock of human capital that will be available to the agent who will be an adult next period, i.e. in $t+1$. This structure is inherent to the overlapping generations set-up we employ, implying that human capital improvements entail intergenerational externalities and transmission of resources (that is, parents invest resources and effort for the education of their children). This approach is consistent with the majority of the existing literature that employs issues pertaining to the combined effects of fertility and education investments by parents (e.g., Galor and Weil 2000; Hazan and Berdugo 2002; Kalemli-Ozcan 2003; de la Croix and Doepke 2009 among others).

¹⁴ Recall that bureaucrats supply their unit of time inelastically irrespective of their occupation.

¹⁵ The subsequent results would remain qualitatively identical, had we assumed a more general specification $\omega_t^B = \varrho w_t h_t$, where $\varrho \geq 1$.

2.2 The Bureaucrats

In this section we are going to discuss the characteristics of bureaucrats in more detail. We shall assume that they are heterogeneous in their moral attitudes concerning the option of misconduct that materialises when they work for the public sector. In particular, a fraction $p \in (0,1)$ of bureaucrats are *corruptible* in the sense that, when the opportunity arises, they may find optimal to illegally expropriate public resources for their own personal benefit. The remaining fraction $(1-p) \in (0,1)$ of bureaucrats are *non-corruptible* in that they have a strong moral stance that deters them from considering the embezzlement of public funds. This innate characteristic is private information to each bureaucrat and it is not observable by the government.

As we mentioned in the preceding part of the analysis, the government offers a contract of $\omega_t^B = w_t h_t$ that induces all bureaucrats to apply for a public sector job. Given its inability to observe each applicant's innate characteristic (whether she is corruptible or not) the government will randomly pick a fraction κ of applicants and employ them in the public sector, instructing them to deliver public services according to the description of the previous section. Therefore, a number $p\kappa N_t^B$ of hired bureaucrats are corruptible while the remaining $(1-p)\kappa N_t^B$ hired bureaucrats are non-corruptible.

The applicants that are not hired, i.e., a number $(1-\kappa)N_t^B$ of them, will work for the private sector: by supplying their whole unit of time, they offer efficient labour of h_t for which they receive labour income $w_t h_t$. They subsequently use this income to purchase consumption goods. Thus, their utility is $\ln(w_t h_t)$.

Each hired bureaucrat will be allocated $\frac{g_t}{\kappa N_t^B}$ units of funds with the instruction to operate the Type-1 project. Each non-corruptible bureaucrat will abide by the government's instructions and operate the Type-1 project, thus delivering $\xi \frac{g_t}{\kappa N_t^B}$ units of public service with probability π or $\gamma \frac{g_t}{\kappa N_t^B}$ units of public service with probability $1-\pi$. As noted above, she will devote her whole unit of time in operating the project and will receive an income of ω_t^B . Her utility is therefore $\ln(\omega_t^B)$.

Corruptible bureaucrats have the choice to behave either honestly or dishonestly. In the former case, they behave identically to non-corruptible bureaucrats and enjoy utility according to

$$u_t^{B (honest)} = \ln(\omega_t^B). \quad (13)$$

In the latter case however, a corruptible bureaucrat has the incentive to act as follows: she will only use $\delta \frac{g_t}{\kappa N_t^B}$ units of the funds allocated to her and operate the Type-2 project, thus delivering $\gamma \frac{g_t}{\kappa N_t^B}$ of public services. Yet, she will falsely claim that she operated the Type-1 project but had a bad realisation of her idiosyncratic shock. Hence, she will gain illegal rents of $(1-\delta) \frac{g_t}{\kappa N_t^B}$ in addition to her remuneration ω_t^B .

Of course, by observing the aggregate outcomes in terms of public service delivery, the government will realise that some public sector workers engaged in wrongful conduct. With probability $\eta \in (0,1)$, the bureaucrats whose behaviour was fraudulent will be detected. In this case, bureaucrats revealed as being corrupt pay a cost for their malversation. This cost can be broadly interpreted. One interpretation is that they face a cost in terms of lost consumption. Formally

$$c_t^{B (dishonest)} = \begin{cases} \omega_t^B + (1-\delta) \frac{g_t}{\kappa N_t^B} & \text{with prob. } (1-\eta) \in (0,1) \\ \left(\omega_t^B + (1-\delta) \frac{g_t}{\kappa N_t^B} \right)^{1-\sigma} & \text{with prob. } \eta \in (0,1) \end{cases},$$

assuming that initial conditions and parameter values are such that $\omega_t^B + (1-\delta) \frac{g_t}{\kappa N_t^B} > 1$ together with the additional assumption that $\sigma \in (0,1)$. In that case, the expected utility of a corrupted bureaucrat is given by

$$u_t^B (\text{dishonest}) = \begin{cases} \ln \left(\omega_t^B + (1-\delta) \frac{g_t}{\kappa N_t^B} \right) & \text{with prob. } (1-\eta) \in (0,1) \\ (1-\sigma) \ln \left(\omega_t^B + (1-\delta) \frac{g_t}{\kappa N_t^B} \right) & \text{with prob. } \eta \in (0,1) \end{cases} . \quad (14)$$

Alternatively, one can interpret (14) as a case where bureaucrats who are revealed as being corrupt face a proportional utility cost of $\sigma \in (0,1)$. In this scenario, (14) gives the utility of the bureaucrat in each of the realised states of nature regarding the authorities' success in detecting cases of bureaucratic corruption. Given this, the proportional utility cost $\sigma \in (0,1)$ captures the psychological distress of imprisonment, social stigma, embarrassment etc.

At this point we should reemphasise that fact that the amount of illegal rents that the corrupt bureaucrat can expropriate is dictated by the varying characteristics of the two projects. A corruptible bureaucrat makes a discreet choice of whether to behave honestly or to expropriate the amount of public funds associated with the decision to adopt the low-productivity project, while masquerading as an honest public official that adopted the high-productivity project but had an unfortunate realisation of the project-specific shock.¹⁶ In this respect, our framework differs from other analyses (e.g., Blackburn and Forgues-Puccio 2007, 2009) in which there are convex costs associated with the total amount of ill-gotten gains (taking the form of bribes in their models) – costs that are meant capture the effort to conceal from authorities the spoils of corrupt activities. We do not view this difference as a limitation though. Firstly, the introduction of such costs in the aforementioned analyses is, to some extent, also a technical device that limits the amount of bribes demanded down to a level that (under certain parameter specifications) guarantees the willingness of potential bribe-payers to engage in an illegal collusion with the corrupt bureaucrat. In our model, corruption does not entail any collusion between two parties and, therefore, there is no bribery involved. Secondly, there are still potential costs of bureaucratic malfeasance in our framework, i.e., the utility cost of being detected and revealed as a corrupt bureaucrat plus the opportunity cost of the utility associated with being honest. These (direct and indirect) costs depend on various structural characteristics as well as the level of income in the

¹⁶ The parameter δ is taken as given and allows the bureaucrat to make a credible claim that she operates the Type-1 project, while doing otherwise in reality. This characteristic is under the influence of neither agents nor the government.

economy and they are an inherent part of the decision process through which the bureaucrat will decide whether to be corrupt or not, by comparing the utility associated with each choice. In this respect, the determination of corruption in our model is consistent with the approach followed by many analyses in the existing literature (e.g., Blackburn *et al* 2006; Blackburn and Forgues-Puccio 2007, 2009).

2.3 The Households

Households allocate their unit of time optimally by solving the problem described in Equations (5)-(7). We can use the first-order conditions associated with this problem to get

$$n_t = \frac{1-a}{q+e_t}, \quad (15)$$

and

$$\frac{an_t}{1-(q+e_t)n_t} = \frac{(1-a)\alpha F_t e_t^{\alpha-1}}{v\bar{h}_t + F_t e_t^\alpha}. \quad (16)$$

Equation (15) reveals that the marginal utility cost and the marginal utility benefit of having children must be equal. The former is the total time (rearing and education) that the household devotes to her offspring. The latter is equal to the relative weight of the altruistic motive in the adult's utility function. Given that this is constant, the result in (15) shows that the parent faces a quantity-quality trade-off in the determination of her family size. In order to understand the intuition, think of an event that raises the marginal productivity of parental resources towards education. Such an event will naturally increase the utility benefit of devoting resources towards each offspring's improvement in human capital. The reason why there is a subsequent reduction in fertility is because the total fraction of income that parents optimally forego in the process of having a family (with the costs including both child-rearing and human capital investment per child) is inversely related to the relative utility weight of the non-altruistic component in parental utility, i.e., to the relative utility weight of the parents' consumption. This is the underlying source of the trade-off: any desired increase in e_t requires that the equilibrium is restored through a reduction in n_t . In other words, the increase in educational investments per child leads to a reduction of the parents' consumption. Given that the marginal utility of consumption increases, parents will counteract the decrease in consumption spending by opting for lower fertility, hence

reducing child rearing expenses and increasing the income available for their own consumption back to the desired level. As we also argued in the Introduction, later it will become evident that the emergence of corruption, with its corresponding repercussions for the quality of public education infrastructure, is a critical aspect in triggering the aforementioned sequence of events, thus leading to multiple equilibria in terms of both economic growth and demographics.

Substituting (15) in (16) and multiplying both sides by e_t yields

$$\frac{e_t}{q + e_t} = \frac{x F_t e_t^x}{v \bar{h}_t + F_t e_t^x}. \quad (17)$$

This result will determine the optimal amount of time that parents devote to the education of their offspring. By Equation (15), this will also determine the number of children that each household gives birth to. From Equation (17) we can see that productive public services represent an important element in the determination of these outcomes, as this is manifested by the presence of the variable F_t . Nevertheless, the ultimate provision of such public services depends on the extent of corruption among the bureaucrats who are delegated with the task of delivering them. In the next section, we turn our attention to this issue.

3 Endogenous Corruption and Productive Public Services

From Equations (13) and (14), it is obvious that a corruptible bureaucrat will act dishonestly as long as

$$u_t^{B(dishonest)} > u_t^{B(honest)}, \quad (18)$$

or alternatively

$$(1 - \eta\sigma) \ln \left(\omega_t^B + (1 - \delta) \frac{g_t}{\alpha N_t^B} \right) > \ln(\omega_t^B). \quad (19)$$

Equivalently, the problem can be stated as a bureaucrat j choosing her strategy by deciding on the probability of being corrupt, say $\beta_{jt} \in [0, 1]$. Since there is a continuum of

corruptible bureaucrats, while doing so she takes the actions of all others, say $\beta_{j_t} \quad \forall j' \neq j$ as given. Formally, β_{j_t} is chosen so as to solve the following problem:

$$\begin{aligned} \max_{\beta_{j_t}} & \beta_{j_t} u_t^B(\text{dishonest}) + (1 - \beta_{j_t}) u_t^B(\text{honest}) = \\ & \max_{\beta_{j_t}} \beta_{j_t} \left[(1 - \eta\sigma) \ln \left(\omega_t^B + (1 - \delta) \frac{g_t}{\kappa N_t^B} \right) \right] + (1 - \beta_{j_t}) \ln(\omega_t^B). \end{aligned}$$

Given that, in this case, none of the variables comprising the corresponding utilities depends on the *contemporaneous* choices for β_t , the solution to this maximisation problem is either

$$\begin{aligned} \beta_{j_t} = 1 \quad \forall j \quad \text{if} \quad (1 - \eta\sigma) \ln \left(\omega_t^B + (1 - \delta) \frac{g_t}{\kappa N_t^B} \right) > \ln(\omega_t^B) \quad \text{or} \quad \beta_{j_t} = 0 \quad \forall j \quad \text{if} \\ (1 - \eta\sigma) \ln \left(\omega_t^B + (1 - \delta) \frac{g_t}{\kappa N_t^B} \right) < \ln(\omega_t^B). \end{aligned}$$

This is the condition presented in (19). In other

words, this is an equilibrium of pure strategies where bureaucrats decide whether to be corrupt or not. Note that in the extended version of the model that we present in Section 5, the utility associated with each action will depend on the *contemporaneous* realisation for β_t , thus we will also obtain a mixed strategy equilibrium.

Given our previous discussion, the total amount of efficient labour in the economy will be

$$L_t = (1 - \kappa) b_t N_t^B + [1 - (q + e_t) n_t] b_t N_t^H, \quad (20)$$

i.e., it is the sum of the efficient labour supplied by bureaucrats that are not employed in the public sector and by households. Substituting (20), together with (4) and (15) in (8) yields

$$y_t = \mathcal{A} l b_t N_t^H = y(b_t), \quad (21)$$

where $l = (1 - \kappa) \frac{\lambda}{1 - \lambda} + a$. Next, we can substitute (21), together with (4), (9), (10) and (11), in the government's budget constraint which is given in (12). This will determine the tax rate as

$$\tau_t = \frac{\theta l + \kappa \frac{\lambda}{1 - \lambda}}{l + \kappa \frac{\lambda}{1 - \lambda}} = \hat{\tau}, \quad (22)$$

where $\hat{\tau} \in (0,1)$ because $\theta \in (0,1)$ by assumption. We should note that, being consistent with the existing literature, we let the balanced budget condition determine the value of fiscal instruments. Indeed, this is what happens in the model of Blackburn *et al* (2006) where the tax rate is determined as a composite parameter term derived from the government's balanced budget rule. In Blackburn and Forgues-Puccio (2007) the fiscal instrument that is determined in a similar manner is the rate of income subsidisation, while the income tax rate is assumed to be exogenously given.

Now, we can use (4), (9), (10), (11), (21) and (22) in (19) to get

$$(1-\eta\sigma) \ln \left(b_t \left[(1-\hat{\tau})\mathcal{A} + \frac{(1-\delta)\theta\mathcal{A}l(1-\lambda)}{\kappa\lambda} \right] \right) > \ln(b_t(1-\hat{\tau})\mathcal{A}). \quad (23)$$

As explained before, this condition determines a corruptible bureaucrat's incentive to be corrupted. It allows us to derive

Proposition 1. *There is a threshold $\tilde{b}$ such that for $b_t < \tilde{b}$ all corruptible bureaucrats are corrupted while for $b_t \geq \tilde{b}$ none of the corruptible bureaucrats is corrupted.*

Proof. Assume that the initial value b_0 is sufficiently high so that $b_0(1-\hat{\tau})\mathcal{A} > 1$. The terms inside the logarithms are therefore greater than one and the condition in (23) can be written as

$$\begin{aligned} b_t^{1-\eta\sigma} \left[(1-\hat{\tau})\mathcal{A} + \frac{(1-\delta)\mathcal{A}\theta l(1-\lambda)}{\kappa\lambda} \right]^{1-\eta\sigma} &> b_t(1-\hat{\tau})\mathcal{A} \Leftrightarrow \\ b_t^{\eta\sigma} &< \frac{\left[(1-\hat{\tau})\mathcal{A} + \frac{(1-\delta)\mathcal{A}\theta l(1-\lambda)}{\kappa\lambda} \right]^{1-\eta\sigma}}{(1-\hat{\tau})\mathcal{A}} \Leftrightarrow \\ b_t &< \mathcal{A}^{-1} \left\{ \frac{\left[1-\hat{\tau} + \frac{(1-\delta)\theta l(1-\lambda)}{\kappa\lambda} \right]^{1-\eta\sigma}}{1-\hat{\tau}} \right\}^{\frac{1}{\eta\sigma}} \equiv \tilde{b}. \end{aligned} \quad (24)$$

Thus, we can see that corruptible bureaucrats will (not) be corrupt as long as $b_t < \tilde{b}$ ($b_t \geq \tilde{b}$), where $\tilde{b}$ is defined in (24). ■

The result in Proposition 1 reveals that corruption is an endogenous outcome that is determined by the economy's level of development. Other things being equal, in an economy with $b_i < \tilde{b}$ some bureaucrats have the incentive to raid on the economy's public coffers in order to maximise their own personal benefit. Such incentive does not exist in an economy for which $b_i \geq \tilde{b}$. The intuition behind this outcome is straightforward: as the economy develops and improves its stock of human capital, diminishing marginal utility implies that the increase in the marginal benefit from being corrupted becomes progressively smaller compared to the increase in the marginal benefit from being honest.

Note that the result in Proposition 1 has interesting implications on how institutional characteristics may affect the long-term prospects of an economy, despite the fact that they do not impinge on the accumulation of human capital directly. They do so indirectly by determining the incentive for illegal rent-seeking by corruptible bureaucrats. For instance, one can check Equation (24) to establish that in economies where the punishment for this type of misdemeanour is more severe (higher σ) and more certain (higher η) the scope for misconduct in public office is limited.

A similar analysis can be conducted in terms of other structural parameters of the model. For example, we can focus on the share of the economy's GDP devoted towards public spending (i.e., θ) and see how it determines corruption incentives as follows. Firstly note that, by Equation (22), it is $\hat{\tau} = \tau(\theta)$ such that $\tau_\theta > 0$. Then we can rewrite the condition in (24) as

$$(\mathcal{A}b_i)^{\eta\sigma} < \frac{\left[1 - \tau(\theta) + \frac{(1-\delta)\theta l(1-\lambda)}{\kappa\lambda}\right]^{1-\eta\sigma}}{1 - \tau(\theta)} \equiv \zeta(\theta),$$

from which it is straightforward to verify that

$$\begin{aligned} \zeta_\theta = & \frac{\left[1 - \tau(\theta) + \frac{(1-\delta)\theta l(1-\lambda)}{\kappa\lambda}\right]^{-\eta\sigma}}{(1 - \tau(\theta))^2} \times \\ & \left\{ \tau_\theta \left[\eta\sigma(1 - \tau(\theta)) + \frac{(1-\delta)\theta l(1-\lambda)}{\kappa\lambda} \right] + (1 - \tau(\theta))(1 - \eta\sigma) \frac{(1-\delta)l(1-\lambda)}{\kappa\lambda} \right\} > 0. \end{aligned}$$

What the above result implies is that, other things being equal, high corruption is more likely when public spending occupies a greater share of the economy's output. The intuition rests on two distinct effects that work on the same direction. On the one hand, a higher θ increases the amount of ill-gotten gains that a corrupt bureaucrat can extract directly. On the other hand, a higher θ increases the tax rate of the economy as it increases the government's financing requirements. This effect reduces disposable labour income and offers greater incentives for bureaucrats to cover the shortfall through illegal rent-seeking. In fact, this analysis implies that we may also write condition in (24) in terms of a threshold for θ , say $\tilde{\theta}_t$, defined implicitly from the condition $\zeta(\tilde{\theta}_t) = (Ab_t)^{\eta\sigma}$. In this case, the implications regarding the crucial impact of economic development on corruption would still be the same of course. Particularly, in economies with lower b_t the threshold $\tilde{\theta}_t$ above which bureaucrats are corrupt will be relatively low as well, meaning that high corruption will be a more likely outcome.¹⁷

What should also be noted here is that the dependence of the threshold $\tilde{b}$ on the economy's structural characteristics implies that the level of development below which corruption materialises may be either high or low. For example, if σ and η are high, or the composite term characterising the tax rate $\hat{\tau}$ is low, then the threshold level could be so low that corruption could be alleviated even at low levels of human capital and, therefore, income. Similarly, if such parameter values are conducive to a high threshold $\tilde{b}$ (i.e., σ and η low or $\hat{\tau}$ high etc.) then corruption may be manifested among the bureaucracy even at relatively high levels of human capital and income. Nonetheless, the idea that the level of development may govern the presence of corruption works on the basis of *ceteris paribus*, i.e., the pure effect of development on corruption, taking all other factors as given. This explanation is consistent with the implications of numerous theoretical analyses on threshold

¹⁷ The results are not equally unambiguous when a similar analysis is undertaken in terms of the parameter λ , i.e., the share of the population who can potentially find employment in the public sector. Particularly, using the composite parameter term l in $\hat{\tau}$ and the condition in (24), this condition can be written as $(Ab_t)^{\eta\sigma} < (\varsigma(\lambda) + \varrho(\lambda))^{1-\eta\sigma} / \varsigma(\lambda) \equiv \zeta(\lambda)$, where $\varsigma(\lambda)$ and $\varrho(\lambda)$ are functions of λ that satisfy $\varsigma_\lambda, \varrho_\lambda < 0$. Given these, it is $\zeta_\lambda = (\varsigma(\lambda) + \varrho(\lambda))^{-\eta\sigma} / (\varsigma(\lambda))^2 [(1-\eta\sigma)\varsigma(\lambda)(\varsigma_\lambda + \varrho_\lambda) - (\varsigma(\lambda) + \varrho(\lambda))\varsigma_\lambda]$ – an expression that cannot be signed with certainty, meaning that the effect of λ on the emergence of corruption is ambiguous. The intuition for this result is as follows. On the one hand, a higher λ will increase the tax rate (thus reducing the legal part of a bureaucrat's disposable income) because it increases the government's financing needs. On the other hand, by increasing the number of public sector employees, a higher λ decreases the pool of potential rents that a bureaucrat can extract by confiscating part of the funds allocated to her for public investment purposes.

effects in the process of development, from the seminal work of Azariadis and Drazen (1990) onwards. Even more so, if we consider the possibility that some of the structural characteristics themselves may differ depending on the level of development, the implications of the current analysis can be reinforced. For example, as long as the probability of detection η is higher in more developed economies (an idea with which the existing evidence concurs; see the discussion on Section 3.1), then the result that views relatively low levels of development as conducive to the presence of high corruption will be strengthened.

Of course, we expect that the occurrence of corruption will impinge on the provision of productive public services. In order to establish this, let us derive the equilibrium for the variable F_t . First of all, we shall assume that the public services offered by the government are non-excludable but rival: as more families try to access them, the benefit to each family becomes limited due to congestion. Formally, we can write

$$F_t = \frac{f_t}{N_t^H}, \quad (25)$$

where f_t denotes the overall amount of public services.¹⁸ Given the assumption about the two different types of projects through which bureaucrats can procure public services, we can associate the ultimate provision of these services with the incidence of corruption through

Proposition 2. *The overall amount of public services, f_t , is equal to*

$$f_t = f(h_t) = \Phi(h_t)y(h_t) \begin{cases} \{(1-p)[\pi\xi + (1-\pi)\gamma] + p\gamma\}\theta y(h_t) = \underline{\varphi}y(h_t) & \text{if } h_t < \tilde{h} \\ [\pi\xi + (1-\pi)\gamma]\theta y(h_t) = \bar{\varphi}y(h_t) & \text{if } h_t \geq \tilde{h} \end{cases}, \quad (26)$$

where $\bar{\varphi} > \underline{\varphi}$ are composite parameter terms. Thus, $f'(h_t) > 0$.

Proof. See the Appendix. ■

As expected, the amount of productive public services that the government is able to offer depends on the occurrence of corruption among public sector workers. Insofar as

¹⁸ This is an innocuous assumption, employed purely as a device to remove scale effects from the accumulation of human capital.

some bureaucrats have the incentive to mislead authorities and expropriate funds away from productive investments, the economy will not be able to achieve its full potential in terms of public service delivery. The evidence provided by Mauro (1998) actually corroborates with the result of Proposition 2.

Looking at Equations (15) and (16), it is logical to expect that the effect of corruption on public service delivery will impinge on the economy's demographics as well as the accumulation of human capital. These are outcomes that we analyse in Section 4.

3.1 An Alternative Scenario for the Presence of Threshold Effects in the Emergence of Bureaucratic Corruption

The result in Proposition 1 demonstrates the idea of a threshold effect in the emergence of corruption. As the economy develops, the relative cost of being corrupt (captured by the loss of utility in the event of detection by authorities) becomes more pronounced. At some point, characterised by the threshold $\tilde{b}$, that cost is high enough so that for $b_i > \tilde{b}$ bureaucrats decide to behave honestly. This idea was based on a set-up where the costs of getting detected are measured either in terms of a non-linear cost of lost consumption or a proportional cost in terms of overall utility, capturing the psychological impact (such as social stigma; loss of freedom due to incarceration etc.) of being revealed as a corrupt official – an impact that can certainly permeate every aspect of the activities that could otherwise give her utility. The second interpretation is indeed a valid assumption for various reasons. Firstly, the strategy of ‘naming and shaming’ is an important tool that governments use in the fight against corruption. In fact, Treisman (2000) argues that because norms evolve in the process of development, social stigma can be an important characteristic in explaining why corruption decreases as economies develop – a conjecture that is in accordance with the result in Proposition 1. Secondly, there are existing analyses that have identified psychological factors, such as social stigma, as important in influencing optimal behaviour (e.g., Moffit 1983; Gordon 1989).

Nevertheless, in order to increase the applicability of our results so far, we will modify our set-up slightly to examine how the result of Proposition 1 can emerge in an alternative setting where the consumption cost of being revealed as a corrupt bureaucrat is measured in terms of a proportional loss of consumption, not just a non-linear one. Effectively, what is

assumed here is that a corrupt bureaucrat who gets caught will incur a cost measured as a fraction $\sigma \in (0,1)$ of her consumption c_t^B . Under such a setting, and given that both the wage and the public funds devoted for public investment infrastructure (hence, the potential illegal rents as well) are proportional to the economy's output, the condition in (18) will eventually end up being determined by structural parameters that do not affect the economy solely through their direct effect on current output y_t . In other words, the stock of human capital (as well as the parameter A) would not impinge on the condition determining the incentives to be corrupt.

However, the result in Proposition 1 can still emerge with an additional modification to the original set-up – a modification that is reasonable and supported empirically. In particular, we will assume that the probability of detection is an increasing function of output per capita. This may capture the fact that richer countries have more resources and a better know-how to detect and prosecute successfully cases of bureaucratic malfeasance.¹⁹ Indeed, the World Justice Project's (<http://worldjusticeproject.org/>) Rule of Law Index for the year 2014 reveals that developed countries rank uniformly higher in categories such as 'regulatory enforcement', 'civil justice', and 'criminal justice'.²⁰ Formally, let $\eta_t = \eta(\hat{y}_t)$ where

$\hat{y}_t = \frac{y_t}{N_t^H + N_t^B}$ is output per capita (the total population is composed of both households and bureaucrats) and $\eta'(\hat{y}_t) > 0$. In this case, a bureaucrat will be corrupt if the expected utility from doing so exceeds the utility from being honest. That is,

$$(1 - \eta_t) \ln \left(\omega_t^B + (1 - \delta) \frac{g_t}{\lambda N_t^B} \right) + \eta_t \ln \left((1 - \sigma) \left[\omega_t^B + (1 - \delta) \frac{g_t}{\lambda N_t^B} \right] \right) > \ln(\omega_t^B).$$

Substituting all our existing results in this condition, we can eventually write it as

$$\eta_t < \frac{J}{R},$$

¹⁹ In terms of its use in a theoretical framework, this assumption is reminiscent of a similar specification in Somanathan and Rubin (2004). In their model, they assume that a dishonest worker's private gain from shirking is reduced at higher stages of development. One of the possible reasons they cite is the more efficient monitoring at higher levels of capital per person.

²⁰ The overall results by individual country can be accessed electronically through the following link: http://worldjusticeproject.org/sites/default/files/files/country_profiles.pdf.

where $J \equiv -\ln \left(\frac{1-\hat{\tau}}{1-\hat{\tau} + \frac{(1-\delta)\theta l(1-\lambda)}{\lambda}} \right)$ and $R \equiv -\ln(1-\sigma)$. Furthermore, note that

$\hat{y}_t = \lambda l(1-\lambda)b_t$, meaning that $\eta_t = \eta(\lambda l(1-\lambda)b_t)$ such that $\eta_{b_t} > 0$. Hence, the condition determining the presence of corruption can be written as

$$\eta(\lambda l(1-\lambda)b_t) < \frac{J}{R},$$

from which we can define the threshold $\tilde{b}$ as the value of b_t for which a bureaucrat is indifferent between being honest or engaging in illegal rent-seeking, i.e., $\eta(\lambda l(1-\lambda)\tilde{b}) = \frac{J}{R}$.

Given that $\eta_{b_t} > 0$, the preceding analysis implies that potentially corruptible bureaucrats will be dishonest for $b_t < \tilde{b}$, whereas for $b_t > \tilde{b}$ they will avoid the opportunity for illegal rent-seeking.

All in all, the above analysis demonstrates that the result of Proposition 1, and therefore the implications that derive from it – implications whose formal analysis is presented in Proposition 2 and the subsequent section – can survive under alternative settings. Thus, there can be a broader set of assumptions under one can derive the empirically supported result, according to which corruption tends to be reduced at higher stages of economic development (e.g., Treisman 2000).

4 Corruption, Growth, and the Fertility Rate

Let us go back to Equation (17), multiply both sides by $\frac{q+e_t}{e_t}$, use $\bar{b}_t = b_t$ and substitute (21), (25) and (26). Eventually, we get

$$\frac{x\Phi(b_t)\lambda l e_t^x (q+e_t)}{[\nu + \Phi(b_t)\lambda l e_t^x]e_t} = 1. \quad (27)$$

We can use Equation (27) to derive

Proposition 3. *There exist $e_t = e(b_t)$ and $n_t = n(b_t)$ such that*

$$e(b_t) = \begin{cases} \underline{e} & \text{if } b_t < \tilde{b} \\ \bar{e} & \text{if } b_t \geq \tilde{b} \end{cases}, \quad (28)$$

and

$$n(b_t) = \begin{cases} \bar{n} & \text{for } b_t < \tilde{b} \\ \underline{n} & \text{for } b_t \geq \tilde{b} \end{cases}. \quad (29)$$

where $\bar{e} > \underline{e} > 0$ and $\bar{n} > \underline{n} > 0$ are composite parameter terms.

Proof. See the Appendix. ■

In a less-developed economy, the presence of corrupted bureaucrats implies that the quality of public services is lower compared to the situation in which corruption among bureaucrats vanishes at relatively high stages of development. However, these public services determine a parent's utility return on spending resources towards each child's human capital formation. Thus, when productive public services increase, households find optimal to boost their efforts for the improvement of their children's human capital. Nevertheless, the presence of a quantity-quality trade-off implies that households will also decide to rear fewer children.

It should be noted that all the results we have obtained so far find strong support from existing empirical studies. The negative association between economic growth/development and corruption (see the literature cited in the Introduction), the adverse effect of corruption on public education spending (Mauro 1998), and the inverse relation between economic development and fertility rates (Galor 2005) are occurrences that are so widely observed that they almost represent stylised facts. Our model promotes the idea that, to some extent, there is a link to these empirical regularities that conventional wisdom had previously viewed as being determined separately.

Now, let us substitute $b_t = \bar{b}_t$, (21), (25) (26) and (28) in (7) to write the growth rate as

$$\psi(b_t) = \frac{b_{t+1}}{b_t} - 1 = v + A\kappa\Phi(b_t)[e(b_t)]^\alpha - 1. \quad (30)$$

We can use Equation (30) to derive²¹

Proposition 4. *There are multiple growth equilibria for which*

$$\psi(b_t) = \begin{cases} v + A l \underline{\varphi} e^x - 1 = \underline{\psi} & \text{if } b_t < \tilde{b} \\ v + A l \overline{\varphi} e^x - 1 = \overline{\psi} & \text{if } b_t \geq \tilde{b} \end{cases}, \quad (31)$$

where $\overline{\psi} > \underline{\psi}$.

Proof. It follows from Equations (26), (28) and (30). ■

The reason why there are multiple, path-dependent growth equilibria in this economy rests on the two-way causal relation between corruption and development. On the one hand, a positive growth rate brings forth the relatively high level of development necessary to reduce the incentive for transgression by corruptible bureaucrats. On the other hand, the reduction of corruption implies a higher provision of productive public services which improves the growth rate both directly and indirectly (through the higher effort that parents devote for the human capital improvements of their offspring).

At this point, it is important to reemphasise why the incidence of corruption is the critical aspect that, channelled through parental choices for the education of their children, leads to multiple equilibria that demonstrate an inverse relation between economic (i.e., output growth) and demographic (i.e., fertility rates) outcomes. All in all, from (28) and (29) we see two distinct regimes for education and fertility where, due to the presence of the child quantity-child quality trade-off, when the former is low (high) then the latter is high (low). Nevertheless, it is the difference in the extent of bureaucratic corruption, captured by the presence of the threshold $\tilde{b}$ (see Proposition 1) that ultimately creates the distinction between these two different regimes and the corresponding repercussions regarding

²¹ Note that as long as both $\overline{\psi}$ and $\underline{\psi}$ are positive (implying positive growth rates in any scenario) then an economy with $b_0 < \tilde{b}$ will eventually exceed the threshold above which corruption is decreased. Naturally, how long it will take for this to happen depends on its initial conditions and on the value of the structural parameters determining the threshold. Nevertheless, if $\underline{\psi} < 0$ (implying negative growth rates under corruption) the interplay between high corruption and high fertility will keep the economy permanently trapped in this situation.

differences in growth performance (see Equation 31). Other things being equal, corruption *is* the reason behind the low return on parental resources towards education, due to the embezzlement of funds that should be otherwise devoted to improving the quality of public infrastructure, hence inducing parents to opt for higher fertility, in addition to impeding the economy's growth performance due to the reduction in the rate of human capital accumulation. Hence the intuition on why agents opt for a higher number of children even after knowing that the quality of public services is not good enough (under corruption) rests on the fact that the altruistic component of parents incorporates their care for both the size of their family and the qualitative characteristics of each child. If the quality of public service provision is not conducive to private investments in human capital, parents will find optimal to support their altruistic motives by having a larger family.

5 The Case of Reproductive Bureaucrats

For reasons of concreteness, we shall use this section in order to show that our main results (and their corresponding mechanisms) survive in a scenario where both households and bureaucrats are reproductive. As we shall establish below, this is indeed the case as long as bureaucrats do not internalise the effect of their own actions on *aggregate* public service delivery. This is a realistic assumption, given the large population mass and the corresponding mass of individual public investment projects that comprise the aggregate level of public services.

Let us denote the fertility rates of households and bureaucrats by n_t^H and n_t^B respectively. Retaining the assumption that a fraction $\lambda \in (0,1)$ of newly born agents are bureaucrats and the remaining fraction $(1-\lambda) \in (0,1)$ of newly born agents are households, we have $N_t^H = (1-\lambda)(N_{t-1}^H n_{t-1}^H + N_{t-1}^B n_{t-1}^B)$ and $N_t^B = \lambda(N_{t-1}^H n_{t-1}^H + N_{t-1}^B n_{t-1}^B)$, meaning that Equation (4) still holds. Now let us assume that each individual is born with an endowment of $K > 1$ units of time. For households, the lifetime utility maximisation problem is the same apart from the fact that we have increased the time endowment to K . Therefore, denoting the household's education resources per child by e_t^H , the results in Equations (15) and (16) are replaced by

$$n_t^H = \frac{(1-a)K}{q + e_t^H}, \quad (32)$$

and

$$\frac{an_t^H}{K - (q + e_t^H)n_t^H} = \frac{(1-a)\alpha F_t(e_t^H)^{\alpha-1}}{v\bar{b}_t + F_t(e_t^H)^\alpha}, \quad (33)$$

respectively. It is also straightforward to combine (32) and (33) to establish that the result in Equation (17) remains intact.

Now, let us revise our original set-up so as to consider a child quantity-child quality trade-off for bureaucrats. Similarly to our original set-up, we can assume that the operation of a public investment project requires that each bureaucrat devotes a unit of time. Therefore, she is left with $K - 1$ units of time which she allocates between child-rearing and education effort per child (measured in units of time) denoted by e_t^B . Thus, the bureaucrat will choose e_t^B and n_t^B to maximise

$$u_t^B = E[a^B \ln(c_t^B) + (1-a^B) \ln(n_t^B b_{t+1})], \quad (34)$$

subject to

$$(q + e_t^B)n_t^B = K - 1, \quad (35)$$

and

$$b_{t+1} = v\bar{b}_t + F_t(e_t^B)^\alpha, \quad (36)$$

taking F_t as given. In fact, the latter is now equal to

$$F_t = \frac{f_t}{N_t^H + N_t^B}, \quad (37)$$

an expression that corresponds to Equation (25) of Section 3. The difference in (37) is that we consider reproductive bureaucrats as an additional source of congestion effects determining the productivity of public services. Note that, similarly to the original set-up, we have $c_t^B = \omega_t^B$ if a bureaucrat decides to behave honestly (or if she is non-corruptible on the outset) and $c_t^B = \omega_t^B + (1-\delta)\frac{g_t}{\alpha N_t^B}$ if the bureaucrat is corrupt. Given that the latter case entails the possibility of being caught, in which case we retain the assumption that the bureaucrat faces a proportional loss of her utility, the term $E[\cdot]$ indicates the expected utility

that encompasses all the possible outcomes that stem from her disposition while employed as a public servant.

As it is evident from this set-up, the bureaucrat does not internalise the effect of her own actions on the aggregate quality of public services, irrespective of whether she is corrupt or not. In other words, she takes F_t as given whatever her actions as a bureaucrat. As we argued before, this is the more realistic assumption since the aggregate amount of public services is comprised of a large number of projects, each operated by a different bureaucrat. For this reason, the utility maximisation problem leads to

$$\frac{e_t^B}{q + e_t^B} = \frac{\alpha F_t (e_t^B)^\alpha}{\nu \bar{h}_t + F_t (e_t^B)^\alpha}, \quad (38)$$

from which we can implicitly derive the optimal amount of resources devoted to each child's education. Obviously, this expression is identical to Equation (17), i.e., the corresponding solution for households. Furthermore, it can also be used to derive the optimal solution for fertility after combining it with (35). This allows us to establish that bureaucrats face a child quantity-child quality trade-off, exactly as households do.

Finally, we can complete this section by considering the decision making process of a corruptible bureaucrat. Her decision to act honestly will lead to $u_t^{B(honest)} = a^B \ln(\omega_t^B) + (1 - a^B) \ln(n_t^B h_{t+1})$. If she decides to engage in illegal rent-seeking by operating a low-quality public project and confiscating funds that are otherwise intended for public investment, she can increase her overall income but she faces a probability $\eta \in (0, 1)$ of being found out. Following the original set-up, in this case she suffers a proportional utility cost of $\sigma \in (0, 1)$. Thus, her lifetime utility is

$$u_t^{B(dishonest)} = (1 - \eta\sigma) \left[a^B \left(\omega_t^B + (1 - \delta) \frac{g_t}{\alpha N_t^B} \right) + (1 - a^B) \ln(n_t^B h_{t+1}) \right].$$

Given these, the condition $u_t^{B(dishonest)} > u_t^{B(honest)}$ will determine the conditions for which a corruptible bureaucrat will be corrupt. Substituting Equations (4), (8)-(11), (22) and (36)-(38), we can manipulate this condition and write is as

$$b_t < A^{-1} \left\{ \frac{\left[1 - \hat{\tau} + \frac{(1-\delta)a^B \theta l (1-\lambda)}{\kappa \lambda} \right]^{(1-\eta\sigma)a^B}}{(1-\hat{\tau})^{a^B} [(K-1)d_t l (1-\lambda)]^{(1-a^B)\eta\sigma}} \right\}^{\frac{1}{\eta\sigma}} \equiv \hat{b}_t = \hat{b}(d_t), \quad (39)$$

where $\hat{b}'(d_t) < 0$ and $d_t = (e_t^B)^{x-1} \varphi_t$ being a composite term. The presence of this composite term enriches the set of possible outcomes emerging from our framework. To see this, denote $d^C = \underline{e}^{x-1} \underline{\varphi}$ and $d^{NC} = \bar{e}^{x-1} \bar{\varphi}$, while recalling that, according to the results in Propositions 2 and 3, e_t^B is either $\underline{e}$ or $\bar{e}$ and φ_t is either $\underline{\varphi}$ or $\bar{\varphi}$ depending on whether corruptible bureaucrats are corrupt or not corrupt respectively.²² Given these, it is possible that d^C is either lower or higher compared to d^{NC} , with corresponding implications for the characterisation of the different equilibrium outcomes. Nevertheless, it will shortly transpire that the main message concerning the qualitative impact of corruption on fertility rates does not change compared to the results of the previous sections.

Let us begin with the scenario whereby $d^C < d^{NC} \Leftrightarrow \hat{b}(d^C) > \hat{b}(d^{NC})$. In this case, it becomes evident that the decision on whether to be corrupt or not entails the presence of strategic complementarities. In particular, the anticipation of high corruption increases the threshold below which a corruptible bureaucrat decides to embezzle public funds, thus intensifying the extent of corrupt practices among bureaucrats.²³ These strategic complementarities mean that we can focus on the pure strategy equilibria in order to derive

Proposition 5. *Suppose that $d^C < d^{NC}$ holds. Then there are two thresholds $\hat{b}^1$ and $\hat{b}^2$, satisfying $\hat{b}^1 > \hat{b}^2$, such that:*

- i. *For $b_t < \hat{b}^2$, all corruptible bureaucrats are corrupted;*
- ii. *For $\hat{b}^2 \leq b_t < \hat{b}^1$, either all corruptible bureaucrats are corrupted or none of the corruptible bureaucrats is corrupted;*
- iii. *For $b_t \geq \hat{b}^1$, none of the corruptible bureaucrats is corrupted.*

²² Note that the composite term l is given by $l = aK \left[\frac{(1-\kappa)\lambda}{1-\lambda} + 1 \right]$ in this case.

²³ This result echoes the argument of Andvig and Moene (1990).

Proof. See the Appendix. ■

This result leads to the outcomes described in

Proposition 6. *There exist $e_t = e(h_t)$ and $n_t = n(h_t)$ such that*

$$e(h_t) = \begin{cases} \underline{e} & \text{if } h_t < \hat{b}^2 \\ \text{either } \underline{e} \text{ or } \bar{e} & \text{if } h_t \in [\hat{b}^2, \hat{b}^1), \\ \bar{e} & \text{if } h_t \geq \hat{b}^1 \end{cases}$$

and

$$n(h_t) = \begin{cases} \bar{n} & \text{if } h_t < \hat{b}^2 \\ \text{either } \underline{n} \text{ or } \bar{n} & \text{if } h_t \in [\hat{b}^2, \hat{b}^1), \\ \underline{n} & \text{if } h_t \geq \hat{b}^1 \end{cases}$$

where $\bar{e} > \underline{e} > 0$ and $\bar{n} > \underline{n} > 0$ are composite parameter terms.

Proof. This is evident after combining Proposition 5 with the proofs of Propositions 2 and 3.

■

Evidently, the main message from the previous analysis remains unaffected. Less developed economies will experience higher degrees of corruption and higher fertility rates, compared to developed economies. The additional implication here is that, at intermediate stages of development, there is some equilibrium indeterminacy associated with the self-fulfilling nature of decisions that entail strategic complementarities. In fact, there is evidence in support of this outcome. Particularly, Blackburn (2012) argues that whereas the CPI is uniformly high among high income countries and uniformly low among low income countries, a closer inspection among middle income economies reveals a large variation on the value of the CPI and thus the presence of corruption – ranging from low to high. As a matter of illustration, the following table presents some examples of countries in which, although they have comparable levels of GDP per capita, the extent of the corruption problem (as this is captured by the CPI) differs considerably.

Country	GDP per capita 2012	Corruption Perception Index (CPI) 2012	Country	GDP per capita 2012	Corruption Perception Index (CPI) 2012
Brazil	\$11,319	4.3	Libya	\$13,302	2.1
Seychelles	\$11,689	5.2	Russia	\$14,090	2.8
Kazakhstan	\$12,120	2.8	Lithuania	\$14,172	5.4
Poland	\$12,270	5.8	Argentina	\$14,679	3.5
Venezuela	\$12,728	1.9	Uruguay	\$14,727	7.2
Croatia	\$13,158	4.6	Slovakia	\$16,892	4.6

Table 1: CPI for countries with GDP per capita between \$11,000 and \$17,000 in 2012

The presence of multiple equilibria due to the two-way causal effects between corruption and long-term economic outcomes is also a feature of other analyses on the corruption-development nexus (e.g., Blackburn *et al* 2006; Dzhumashev 2014b). Nevertheless, none of these models have provided a link to the relation between fertility and economic growth – an issue that is central to our analysis. Furthermore, these models also differ in the underlying source of bureaucratic corruption as they focus on tax evasion whereas our focus is on its damaging effect on the quality of public infrastructure.

Returning to our analysis, note that there is also the possibility that $d^C > d^{NC} \Leftrightarrow \hat{b}(d^C) < \hat{b}(d^{NC})$. In this case, the decisions of bureaucrats regarding on whether they will be corrupt or not are strategic substitutes. In this case, the equilibrium that emerges is a mixed strategy equilibrium according to which a fraction $\beta_i \in (0,1)$ of corruptible bureaucrats will be corrupt while the remaining fraction $(1-\beta_i) \in (0,1)$ will not. The outcomes that transpire in this case are formally described in

Proposition 7. *It is $\beta_i = \beta(h_i)$ such that $\beta'(h_i) < 0$. Consequently, there exist $e_i = e(h_i)$ and $n_i = n(h_i)$ such that $e'(h_i) > 0$ and $n'(h_i) < 0$.*

Proof. See the Appendix. ■

In the mixed strategy equilibrium, the condition in (39) must hold as an equality. Suppose now that the human capital stock is higher. As a result, the incentive to be corrupt is

reduced. Each bureaucrat will take an action that will restore the equality and keep all other bureaucrats indifferent between being corrupt or not. Given the strategic substitutability inherent in this scenario, a greater fraction of bureaucrats will decide against engaging in illegal rent-seeking. However, this outcome will improve the quality of productive public services, thus generating a child quantity-child quality trade-off that will ultimately result in lower fertility rates. Despite the fact that the nature of equilibrium outcomes differ, the main qualitative implication concerning the impact of corruption on differences in fertility rates between relatively rich and relatively poor economies remains intact.

Finally, we would like to clarify the two cases presented in Propositions 6 and 7 by means of presenting the bureaucrat's problem as the choice of a strategy β_{jt} (i.e., the probability of being corrupt) that maximises $\max_{\beta_{jt}} \beta_{jt} u_t^B(\text{dishonest}) + (1 - \beta_{jt}) u_t^B(\text{honest})$. Note that, given the continuum of bureaucrats, in equilibrium we will have $\beta_{jt} = \beta_t \quad \forall j$. What is different here compared to the scenario presented in Sections 3 and 4 is that the contemporaneous incidence of corruption impinges on the variables that comprise the utilities corresponding to each action. Thus in addition to the pure strategy equilibria $\beta_t = 1$ and $\beta_t = 0$, we also get a mixed strategy equilibrium characterised by the $\beta_t \in (0,1)$ for which $u_t^B(\text{dishonest}) = u_t^B(\text{honest})$. In the case summarised in Proposition 6, decisions among bureaucrats are strategic complements. As it has been shown by Echenique and Edlin (2004), when decisions are strategic complements, the mixed strategy equilibrium is unstable. Hence, in this case, the only stable equilibria are the pure strategy ones. On the contrary, Proposition 7 deals with the scenario where decisions among bureaucrats are strategic substitutes – a case where the mixed strategy equilibrium $\beta_t \in (0,1)$ defined from $u_t^B(\text{dishonest}) = u_t^B(\text{honest})$ is a stable one.

6 Conclusion

In this paper, we have sought to integrate the theoretical analyses of endogenous growth, corruption and fertility choices. We have thus offered a novel mechanism on the differences between fertility rates in less developed economies, when compared to developed ones. In particular, we argued that one of the causal links between economic development and fertility reductions is the decline in the occurrence of bureaucratic corruption.

Our analysis has focused in only one of the many facets through which public sector corruption may actually materialise. Apart from the obvious need for analytical tractability, this approach allowed us to present a theory in which all the analytical mechanisms are clarified and the intuition is not blurred. It would be interesting however to examine a framework in which corruption may permeate the highest ranks of public administration, i.e., the government.

Whereas we are not aware of any existing empirical analyses that examine the relation between corruption and fertility choices, there is strong evidence in support of the elements that jointly constitute the main mechanism of our result (e.g., the negative relation between corruption and economic growth/development; the mitigating effect of corruption on public education spending; the reduction in population growth rates at later stages of development). Thus, although this is a paper whose focus is theoretical, we are confident that it offers empirically relevant ideas that, on the one hand, certainly improve our current understanding on relevant issues and on the other hand, they offer important policy implications.

Appendix

Proof of Proposition 2

Let us begin with the case where $b_t < \tilde{b}$. As we have seen from Proposition 1, all corruptible bureaucrats choose the Type-2 project in order to expropriate public funds. Each corruptible bureaucrat will deliver $\gamma \frac{g_t}{\kappa N_t^B} = \gamma \frac{\theta y_t}{\kappa N_t^B}$ units of public service, therefore, with $p\kappa N_t^B$

corruptible bureaucrats, their total delivery of public services will be $p\gamma\theta y_t$. Each non-corruptible bureaucrat is expected to deliver an amount of public services equal to $[\pi\xi + (1-\pi)\gamma] \frac{g_t}{\kappa N_t^B} = [\pi\xi + (1-\pi)\gamma] \frac{\theta y_t}{\kappa N_t^B}$ because they choose to operate the Type-1 project.

Given that there are $(1-p)\kappa N_t^B$ of such bureaucrats, their overall expected delivery of public services is equal to $(1-p)[\pi\xi + (1-\pi)\gamma]\theta y_t$. Summing up these effects we get

$$f_t = \underline{\varphi} y_t,$$

where $\underline{\varphi} = \{(1-p)[\pi\xi + (1-\pi)\gamma] + p\gamma\}\theta$.

Now, let us consider the case where $b_i \geq \tilde{b}$. In this case, none of the bureaucrats (whether corruptible or not) decides to embezzle public funds – all of them operate the Type-1 project. Therefore, all κN_i^B will operate a project with an expected return of $[\pi\xi + (1-\pi)\gamma] \frac{g_i}{\kappa N_i^B} = [\pi\xi + (1-\pi)\gamma] \frac{\theta y_i}{\kappa N_i^B}$ units of service per bureaucrat. Therefore, the overall amount of public services is given by

$$f_i = \bar{\varphi} y_i,$$

where $\bar{\varphi} = [\pi\xi + (1-\pi)\gamma]\theta$. It is straightforward to check that $\bar{\varphi} > \underline{\varphi}$ holds. Furthermore, Equation (21) reveals that $y_i = y(b_i)$ such that $y'(b_i) > 0$, thus completing the proof. ■

Proof of Proposition 3

Define

$$J(e_i, \Phi(b_i)) = \frac{x\Phi(b_i)Ae_i^x(q+e_i)}{[v + \Phi(b_i)Ae_i^x]e_i} - 1. \quad (\text{A1})$$

Given (A1) and Equation (27), an equilibrium will exist if there is at least one e_i^* for which $J(e_i^*, \Phi(b_i)) = 0$. Using (A1), we have $J(0, \Phi(b_i)) = \infty$. Furthermore, using L'Hôpital's rule we can establish $J(\infty, \Phi(b_i)) = \lim_{e_i \rightarrow \infty} \frac{x\Phi(b_i)Al}{(1-x)ve_i^{-x} + \Phi(b_i)Al} - 1 = x - 1 < 0$. Furthermore, it is

$$J_{e_i}(\cdot, \cdot) = \frac{x\Phi(b_i)Ae_i^x}{[v + \Phi(b_i)Ae_i^x]^2 e_i^2} \beta(e_i), \quad (\text{A2})$$

where

$$\beta(e_i) = (q+e_i)vx - q[v + \Phi(b_i)Ae_i^x]. \quad (\text{A3})$$

From (A2) and (A3), it is obvious that the sign of $J_{e_i}(\cdot, \cdot)$ depends on the sign of $\beta(e_i)$. Moreover, given $J(0, \Phi(b_i)) > 0$, $J(\infty, \Phi(b_i)) < 0$ and $\beta(0) = qv(x-1) < 0$, for an equilibrium e_i^* with $J(e_i^*, \Phi(b_i)) = 0$ to exist, it is sufficient to establish that $\beta(e_i)$ – and consequently $J_{e_i}(\cdot, \cdot)$ – will change sign only once. In this case, the equilibrium will be also unique.

From (A3) we have

$$\beta_{e_t}(\cdot) = vx - xq\Phi(b_t)Ale_t^{x-1}, \quad (\text{A4})$$

$$\beta_{e_t e_t}(\cdot) = -(x-1)xq\Phi(b_t)Ale_t^{x-2} > 0. \quad (\text{A5})$$

The results in (A4) and (A5) reveal that, indeed, $\beta(e_t)$ changes sign only once. Thus, there is a unique e_t^* for which $J(e_t^*, \Phi(b_t)) = 0$ and $J_{e_t}(\cdot, \cdot) < 0$. Next, let us use implicit differentiation to get

$$\frac{de_t^*}{d\Phi(\cdot)} = -\frac{J_{\Phi(\cdot)}(\cdot, \cdot)}{J_{e_t^*}(\cdot, \cdot)} > 0, \quad (\text{A6})$$

given that we can use (A1) to establish that $J_{\Phi(\cdot)}(\cdot, \cdot) > 0$. The proof of the first part of the proposition is completed after combining (A6) with the result in Proposition 2. The result regarding fertility follows from (15) and (28). Combining these, it is straightforward to establish that

$$n_t = \frac{1-a}{q+e(b_t)} = \begin{cases} \frac{1-a}{q+\underline{e}} = \bar{n} & \text{for } b_t < \tilde{b} \\ \frac{1-a}{q+\bar{e}} = \underline{n} & \text{for } b_t \geq \tilde{b} \end{cases},$$

thus completing the proof. ■

Proof of Proposition 5

Let us consider the decision problem facing a corruptible bureaucrat. Given that all potentially corrupt bureaucrats are identical, each of them will consider two possible scenarios. First, let us assume that a corruptible bureaucrat expects all the others to be corrupt. In this case, it is $d_t = d^C$. Therefore, according to (39) she will also have the incentive to be corrupt as long as $b_t < \hat{b}^1$ where $\hat{b}^1 = \hat{b}(d^C)$. Secondly, we will consider the case where the corruptible bureaucrat expects all the others to act honestly. Naturally, in this case it is $d_t = d^{NC}$. Given (39), she will also decide to behave honestly as long as $b_t \geq \hat{b}^2$ where $\hat{b}^2 = \hat{b}(d^{NC})$. Taking account that $\hat{b}(d_t) < 0$ and $d^C < d^{NC}$, we have $\hat{b}^1 > \hat{b}^2$. Thus, for $b_t < \hat{b}^2$ the pure strategy Nash equilibrium entails that all corruptible bureaucrats decide

to be corrupt, whereas for $b_i \geq \hat{b}^1$ the pure strategy Nash equilibrium is one where all of them will avoid being corrupt. For $\hat{b}^2 \leq b_i < \hat{b}^1$, there are two possible equilibria: bureaucrats will (not) be corrupted insofar as they believe that the others will (not) be corrupted as well. ■

Proof of Proposition 7

In this case, we focus on the mixed strategy equilibrium, meaning that a fraction β_i of corruptible bureaucrats will be corrupt. This implies that the overall quality of public services

is derived from $F_i = \frac{\{(1-p)[\pi\xi + (1-\pi)\gamma] + p(\beta_i\gamma + (1-\beta_i)[\pi\xi + (1-\pi)\gamma])\}\theta y_i}{N_i^H + N_i^B}$ or

$F_i = \frac{\varphi_i y_i}{N_i^H + N_i^B}$ where $\varphi_i = \Phi(\beta_i) = \theta[\pi\xi + (1-\pi)\gamma - p\beta_i\pi(\xi - \gamma)]$ such that $\Phi'(\beta_i) < 0$. By

virtue of Proposition 3 (recall that the solution for e_i is *qualitatively* the same even in this more expanded set-up), the effect of public services impinges on the quality-quantity trade-off so that $e_i = e(\beta_i)$. Given that the two constituent terms of d_i are functions of β_i then $d_i = d(\beta_i)$. In this case, we focus on the scenario where the decisions among bureaucrats are strategic substitutes, i.e., $d'(\beta_i) > 0$. Now, consider the expression in (39) as an equality.

Applying the Implicit Function Theorem, it is straightforward to establish that $\frac{\partial \beta_i}{\partial b_i} < 0$. It

follows that $\beta_i = \beta(b_i)$ where $\beta'(b_i) < 0$. With the result in mind, and given

$\Phi'(b_i) = \Phi'(\beta_i)\beta'(b_i) > 0$, we can combine (17), (32), (37) and (38), to get $\frac{\partial e_i^i}{\partial b_i} > 0$ and

$\frac{\partial n_i^i}{\partial b_i} < 0$ for $i = \{B, H\}$. ■

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