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 offer a novel mechanism on the driving forces behind demographic transition. In particular, we attribute it to the endogenous change in the incidence of bureaucratic corruption that occurs at different stages of an economy's transition towards higher economic development.

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1 Introduction

One of the most striking aspects of demographic transition is the observation that the reduction in birth rates appears to coincide with an increase in the amount of resources that parents devote to the physical and mental development of each of their offspring. This fact has led to the idea that parents face a trade-off between child quantity and child quality – a trade-off whose balance shifts away from the former and towards the latter as an economy goes through the more advanced stages of its development process. Empirical support for this hypothesis has been provided by a plethora of analyses over the years (e.g., Rosenzweig and Wolpin, 1980; Hanushek, 1992; Black *et al.* 2005; Bleakley and Lange, 2009; Becker *et al.*, 2010). Existing theoretical analyses have attributed this outcome to characteristics of more developed economies such as reduced child mortality (Kalemli-Ozcan, 2003; Soares, 2005), the higher efficiency of educated parents in educating their own children (Moav, 2005), the reduced need for the income derived from child labour (Hasan and Berdugo, 2002), and the reduction in income inequality (de la Croix and Doepke, 2003).

In this paper we offer a new explanation for the aspect of demographic transition that we discussed above. In particular, we attribute it to the endogenous change in the incidence of bureaucratic corruption that occurs at different stages of an economy's transition towards higher economic development.

The relationship between bureaucratic corruption and economic development has been investigated extensively in the past – and it continues to do so. 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. Mauro (1995) shows that public sector corruption has a negative effect on growth, mainly through its adverse impact on private investment. Keefer and Knack (1997) find that the lagged convergence of less-developed countries to the growth rates of developed countries is (to a large extent) attributed to deficient institutions and widespread corruption. Gyimah-Brempong (2002) presents evidence of a substantial adverse effect of corruption on the growth rate of real per capita GDP in African countries. Aidt (2009) studies the relationship between corruption, institutions and economic development, and finds evidence which suggests that corruption is a serious impediment to measures of sustainable development that incorporate human capital, natural capital and institutional quality, in addition to physical capital investment. Gundlach and Paldam (2009) employ a novel methodological approach to show that the causality in the relation between economic development and corruption runs from the former to the latter. Bhattacharyya and Hodler (2010) argue that the failing of democratic institutions can increase the incidence of corruption in economies that are rich in natural resources.

The argument we provide in our analysis 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, a demographic transition 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 delivering 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 delivery 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 a demographic transition which is solely 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.

Even though there are several analyses that investigate the incidence of corruption within the context of dynamic general equilibrium models of economic growth (e.g., Ehrlich and Lui, 1999; Baretto, 2000; Alesina and Angeletos, 2005; Blackburn *et al.* 2006; Blackburn and Sarmah, 2008; Eicher *et al.*, 2009; de la Croix and Delavallade, 2011) to the best of our knowledge this is the first analysis to provide an explicit link between corruption, education and fertility choices.[1] Hence, it contributes to three distinct strands of literature – i.e., those analysing the links between education and economic growth, demographic transition and economic growth, and bureaucratic corruption and economic growth.

The remaining paper is organised as follows. In Section 2, we present the basic set-up of our artificial economy. A more detailed discussion on the characteristics of the government, the bureaucrats, and the households are provided in Sections 3, 4 and 5 respectively. Section 6 shows that corruption is endogenously determined and establishes its effect on public services, whereas Section 7 derives the economy's growth rate and attributes demographic transition to the reduction in the incidence of corruption. In Section 8, we conclude.

2 The Economy

Time takes the form of discrete intervals that are indexed by $t = 0,1,2...$. 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

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

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, and e_t^i denotes the amount of time she devotes for the

[1] 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.

improvement of each child's human capital, denoted h_{t+1}^i. The last term of the utility function indicates that adults are imperfectly altruistic towards their offspring. Specifically, a parent gets satisfaction by observing her children's human capital. This is meant to capture the idea that parents care about their offspring's future prospects and social status. The parameter $a^i \in (0,1]$ weights the two arguments of the utility function.

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

$$h_{t+1}^i = v\overline{h}_t + F_t(e_t^i)^{\chi}, \tag{2}$$

where $v \in (0,1)$ and $\chi \in (0,1)$. The first term in (2) is meant to capture the idea that a child can pick-up a fraction v of the economy's average human capital stock (that is, $\overline{h}_t$) 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. 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, the 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. Nevertheless, such occupational opportunity is essential for our analysis. Hence, we restrict our attention to

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

Given the assumptions for the economy's demographics, the restriction in (3) implies 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

$$\frac{N_t^B}{N_t^H} = \frac{\lambda}{1-\lambda}. \tag{4}$$

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 h_{t+1}.

Taking account of (1), (2) and (3), a household member 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

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

subject to

$$c_t^H = w_t[1-(q+e_t)n_t]h_t, \tag{6}$$

and

$$h_{t+1} = v\overline{h}_t + F_t e_t^{\chi}, \tag{7}$$

taking F_t and w_t as given. The parameter $q > 0$ in (6) indicates the fixed cost (in units of time) of raising each child, while h_t is her stock of human capital. Thus, the term $[1-(q+e_t)n_t]h_t$ 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

$$y_t = AL_t, \quad A > 0. \tag{8}$$

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

$$w_t = (1-\tau_t)A. \tag{9}$$

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.

3 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 to

$$g_t = \theta y_t, \quad 0 < \theta < 1. \tag{10}$$

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 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.[2]

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 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. 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.

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 $\frac{g_t}{\varkappa N_t^B}$, where $\varkappa < 1$. 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

[2] For a similar approach in introducing bureaucratic corruption and its implications for the delivery of productive public services, see Blackburn *et al.* (2005).

employees, it is straightforward to establish that the number of bureaucrats hired will be $\varkappa N_t^B$. 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 expropriating part of the public sector resources to which she will gain access.[3] Thus, the government can minimise the cost of hiring the necessary number of $\varkappa N_t^B$ bureaucrats by offering a remuneration that satisfies

$$\omega_t^B = w_t h_t . \tag{11}$$

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

$$\tau_t y_t = g_t + \omega_t^B \varkappa N_t^B . \tag{12}$$

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.

4 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

[3] Recall that bureaucrats supply their unit of time inelastically irrespective of their occupation.

government will randomly pick a fraction $\varkappa$ 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 $p\varkappa N_t^B$ of hired bureaucrats are corruptible while the remaining $(1-p)\varkappa N_t^B$ hired bureaucrats are non-corruptible.

The applicants that are not hired, i.e., a number $(1-\varkappa)N_t^B$ 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 $w_t h_t$ which they subsequently use to consume goods. Thus, their utility is $\ln(w_t h_t)$.

Each hired bureaucrat will be allocated $\frac{g_t}{\varkappa N_t^B}$ 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 $\xi \frac{g_t}{\varkappa N_t^B}$ units of public service with probability π or $\gamma \frac{g_t}{\varkappa N_t^B}$ 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, thus, enjoy utility according to

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

In the latter case, however, a corruptible bureaucrat has the incentive to act as follows: she will only use $\delta \frac{g_t}{\varkappa N_t^B}$ units of the funds allocated to her and operate the Type-2 project, thus delivering $\gamma \frac{g_t}{\varkappa N_t^B}$ of public services. She will falsely claim, however, that she operated the Type-1 project but had a bad realisation of her idiosyncratic shock. Hence, she will gain illegal rents of $(1-\delta)\frac{g_t}{\varkappa N_t^B}$ 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. In response, the government will use an imperfect monitoring technology that can identify, with probability $\eta \in (0,1)$, the bureaucrats whose behaviour was fraudulent. In this case, bureaucrats revealed as being corrupt pay a utility cost for their malversation: particularly, they face a proportional utility cost of $\sigma \in (0,1)$. This cost captures the psychological distress of imprisonment, social stigma, embarrassment etc. Given these, the utility of a corrupted bureaucrat is given by

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

where $m \in (0,1)$ is the proportion of ill-gotten gains lost in the process of concealing them from the authorities (e.g., through money laundering).

5 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

$$n_t = \frac{1-a}{q+e_t}, \tag{15}$$

and

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

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.

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

$$\frac{e_t}{q+e_t} = \frac{\chi F_t e_t^{\chi}}{v\bar{h}_t + F_t e_t^{\chi}} . \tag{17}$$

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.

6 Endogenous Corruption and Productive Public Services

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

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

or, alternatively,

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

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

$$L_t = (1-\varkappa)h_t N_t^B + [1-(q+e_t)n_t]h_t N_t^H , \tag{20}$$

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

$$y_t = Alh_t N_t^H , \tag{21}$$

where $l = (1-\varkappa)\frac{\lambda}{1-\lambda} + a$. 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 equilibrium tax rate as

$$\tau_t = \frac{\theta l + \varkappa \frac{\lambda}{1-\lambda}}{l + \varkappa \frac{\lambda}{1-\lambda}} = \hat{\tau} , \tag{22}$$

where $\hat{\tau} \in (0,1)$ because $\theta \in (0,1)$ by assumption.

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

$$(1-\eta\sigma)\ln\left(h_t\left[(1-\hat{\tau})A+\frac{(1-m)(1-\delta)\theta Al(1-\lambda)}{\varkappa\lambda}\right]\right)>\ln(h_t(1-\hat{\tau})A). \tag{23}$$

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 $\tilde{h}$ such that for $h_t < \tilde{h}$ all corruptible bureaucrats are corrupted while for $h_t \geq \tilde{h}$ none of the corruptible bureaucrats is corrupted.*

Proof. See the Appendix. ■

The result in Proposition 1 reveals that the incidence of corruption is an endogenous outcome that is determined by the economy's level of development. Other things being equal, in an economy with $h_t < \tilde{h}$ 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 $h_t \geq \tilde{h}$. 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. As one can see from equation (A1) in the Appendix (where we provide an explicit expression for $\tilde{h}$) 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. The same applies to economies in which the cost of avoiding detention and concealing ill-gotten gains is higher (a rise in m).

Of course, we expect that the occurrence of corruption will impinge on the provision of productive public services. To determine the extent over which this happens, 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

$$F_t = \frac{f_t}{\mathrm{N}_t^H}, \tag{24}$$

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

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

$$f_t = \Phi(h_t)\, y_t = \begin{cases} \{(1-p)[\pi\xi + (1-\pi)\gamma] + p\gamma\}\theta y_t = \underline{\varphi} y_t & \text{if} \quad h_t < \tilde{h} \\ [\pi\xi + (1-\pi)\gamma]\theta y_t = \overline{\varphi} y_t & \text{if} \quad h_t \geq \tilde{h} \end{cases}, \tag{25}$$

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

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 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. 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 the following Section.

7 Corruption, Growth, and Demographic Transition

Let us go back to equation (17), multiply both sides by $\frac{q+e_t}{e_t}$, use $\overline{h}_t = h_t$ and substitute (21), (24) and (25). Eventually, we get

$$\frac{\chi\Phi(h_t)Ale_t^{\chi}(q+e_t)}{[v+\Phi(h_t)Ale_t^{\chi}]e_t} = 1. \tag{26}$$

We can use equation (26) to derive

Proposition 3. *Suppose that* $\chi(1+q)<1$ *and* $\chi(1+q)<q$ *hold. Then there exists* $e_t = e(h_t) \in (0,1)$ *such that*

$$e(h_t) = \begin{cases} \underline{e} & if \quad h_t < \tilde{h} \\ \\ \overline{e} & if \quad h_t \geq \tilde{h} \end{cases}, \tag{27}$$

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

Proof. See the Appendix. ■

In an economy with relatively low levels of development, the presence of corrupted bureaucrats implies that the provision of public services is lower compared to the situation in which corruption among bureaucrats vanishes at relatively high levels of development. However, these public services determine the parent's utility return on spending time towards each child's human capital formation. Thus, when productive public services increase, households finds optimal to boost their efforts for the improvement of their children's human capital.[4]

Now, let us substitute $h_t = \overline{h}_t$, (21), (24) (25) and (27) in (7) to write the growth rate as

$$\psi(h_t) = \frac{h_{t+1}}{h_t} - 1 = v + Al\Phi(h_t)[e(h_t)]^{\chi} - 1. \tag{28}$$

We can use equation (28) to derive

[4] The restrictions $\chi(1+q)<1$ and $\chi(1+q)<q$ are sufficient to rule out multiple solutions and, therefore, eliminate indeterminacies.

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

$$\psi(h_t)=\begin{cases} v+Al\underline{\varphi}\,\underline{e}^{\chi}-1=\underline{\psi} & if \quad h_t<\tilde{h} \\ v+Al\overline{\varphi e}^{\chi}-1=\overline{\psi} & if \quad h_t\geq\tilde{h} \end{cases}, \tag{29}$$

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

Proof. It follows from equations (25), (27) and (28). ■

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).

In addition to the above, the model's results have significant implications for the optimal fertility rate. In particular, our framework is able to generate a demographic transition which can be attributed to development-induced changes to the incidence of corruption. We can formalise this argument through

Proposition 5. *Consider* $h_0<\tilde{h}$. *There exists a time period* T *such that*

$$n_t=\begin{cases} \overline{n} & for \quad t\in(0,T) \\ \underline{n} & for \quad t\in(T,\infty) \end{cases},$$

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

Proof. Combining equations (15) and (27) we can write

$$n(h_t) = \frac{1-a}{q+e(h_t)} = \begin{cases} \dfrac{1-a}{q+\underline{e}} = \overline{n} & \text{for} \quad h_t < \tilde{h} \\ \\ \dfrac{1-a}{q+\overline{e}} = \underline{n} & \text{for} \quad h_t \geq \tilde{h} \end{cases} . \tag{30}$$

For $v + Al\underline{\varphi}\underline{e}^{\chi} > 1$, the economy's growth rate is always positive. Therefore, as long as $h_0 < \tilde{h}$, there must be a time period T after which the economy will switch regimes and will have $h_t \geq \tilde{h}$ for $t = T+1, T+2, \ldots$. Together with (30), this argument completes the proof. ■

We can see that the economy experiences a demographic transition which is attributed to the change in the occurrence of corruption. As the economy grows, at some point potentially corruptible bureaucrats will find optimal to behave honestly. The absence of corrupt actions among bureaucrats will enhance the provision of productive public services and will induce households to support the formation of their children's human capital. However, the presence of a quantity-quality trade-off implies that households will also decide to rear fewer children. Thus, a demographic transition occurs as a result of reduced corruption in the public sector of the economy.

8 Conclusions

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 driving forces behind demographic transition. 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. Another interesting approach is to give bureaucrats an altruistic motive towards their offspring and use such a framework to examine the issue of nepotism. All these issues are certainly fruitful avenues for future research.

Appendix

Proof of Proposition 1

Assume that the initial value h_0 is sufficiently high so that $h_0(1-\hat{\tau})A > 1$. The terms inside the logarithms are, thus, greater than one and the condition in (23) can be written as

$$h_t^{1-\eta\sigma}\left[(1-\hat{\tau})A + \frac{(1-m)(1-\delta)A\theta l(1-\lambda)}{\varkappa\lambda}\right]^{1-\eta\sigma} > h_t(1-\hat{\tau})A \Leftrightarrow$$

$$h_t^{\eta\sigma} < \frac{\left[(1-\hat{\tau})A + \frac{(1-m)(1-\delta)A\theta l(1-\lambda)}{\varkappa\lambda}\right]^{1-\eta\sigma}}{(1-\hat{\tau})A} \Leftrightarrow$$

$$h_t < \left\{\frac{\left[(1-\hat{\tau})A + \frac{(1-m)(1-\delta)A\theta l(1-\lambda)}{\varkappa\lambda}\right]^{1-\eta\sigma}}{(1-\hat{\tau})A}\right\}^{\frac{1}{\eta\sigma}} \equiv \tilde{h}\,. \qquad \text{(A1)}$$

Thus, we can see that corruptible bureaucrats will (not) be corrupt as long as $h_t < \tilde{h}$ ($h_t \geq \tilde{h}$), where $\tilde{h}$ is defined in (A1). ■

Proof of Proposition 2

Let us begin with the case where $h_t < \tilde{h}$. 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 $\gamma\frac{g_t}{\varkappa N_t^B} = \gamma\frac{\theta y_t}{\varkappa N_t^B}$ units of public service, therefore, with $p\varkappa N_t^B$ 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 $[\pi\xi + (1-\pi)\gamma]\frac{g_t}{\varkappa N_t^B} = [\pi\xi + (1-\pi)\gamma]\frac{\theta y_t}{\varkappa N_t^B}$ because they choose to operate the Type-1 project. Given that there are $(1-p)\varkappa N_t^B$ 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 $h_t \geq \tilde{h}$. 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 $\varkappa N_t^B$ will operate a project with an expected return of $[\pi\xi + (1-\pi)\gamma]\frac{g_t}{\varkappa N_t^B} = [\pi\xi + (1-\pi)\gamma]\frac{\theta y_t}{\varkappa N_t^B}$ units of service per bureaucrat. Therefore, the overall amount of public services is given by

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

where $\overline{\varphi} = [\pi\xi + (1-\pi)\gamma]\theta$. It is straightforward to check that $\overline{\varphi} > \underline{\varphi}$ holds, thus completing the proof. ■

Proof of Proposition 3

Define

$$J(e_t, \Phi(h_t)) = \frac{\chi\Phi(h_t)Ale_t^{\chi}(q+e_t)}{[v+\Phi(h_t)Ale_t^{\chi}]e_t} - 1 . \qquad \text{(A2)}$$

Given (A2) and equation (26), an equilibrium will exist if there is at least one e_t^* for which $J(e_t^*, \Phi(h_t)) = 0$. Using (A2), we can establish that $J(0, \Phi(h_t)) = \infty$. Given $\chi(1+q) < 1$, it is $J(1, \Phi(h_t)) = \frac{\chi\Phi(h_t)Al(q+1)}{v+\Phi(h_t)Al} - 1 < 0$. Furthermore, it is

$$J_{e_t}(\cdot,\cdot) = \frac{\chi\Phi(h_t)Ale_t^{\chi}}{[v+\Phi(h_t)Ale_t^{\chi}]^2 e_t^2}\beta(e_t) , \qquad \text{(A3)}$$

where

$$\beta(e_t) = (q+e_t)v\chi - q[v+\Phi(h_t)Ale_t^{\chi}] . \qquad \text{(A4)}$$

From (A3) and (A4), it is obvious that the sign of $J_{e_t}(\cdot,\cdot)$ depends on the sign of $\beta(e_t)$. Moreover, for an equilibrium e_t^*, with $J(e_t^*, \Phi(h_t)) = 0$, to exist, it is sufficient to establish $\beta(e_t) < 0 \ \forall e_t$. In this case, the equilibrium will be also unique.

From (A4) we have

$$\beta(0) = qv(\chi - 1) < 0 , \qquad \text{(A5)}$$

$$\beta_{e_t}(\cdot) = vx - xq\Phi(h_t)Ale_t^{x-1}, \tag{A6}$$

$$\beta_{e_t e_t}(\cdot) = -(x-1)xq\Phi(h_t)Ale_t^{x-2} > 0. \tag{A7}$$

The results in (A5)-(A7) reveal that, as long as $\beta(1) < 0$ then it will be $\beta(e_t) < 0 \ \forall e_t$, thus $J_{e_t}(\cdot,\cdot) < 0$ as well. It is

$$\beta(1) = (q+1)vx - q[v + \Phi(h_t)Al]. \tag{A8}$$

Since $x(1+q) < q$ also holds by assumption, then from (A8) it is obvious that indeed $\beta(1) < 0$.

Now, let us use implicit differentiation to get

$$\frac{de_t}{d\Phi(\cdot)} = -\frac{J_{\Phi(\cdot)}(\cdot,\cdot)}{J_{e_t}(\cdot,\cdot)} > 0, \tag{A9}$$

given that we can use (A3) to establish that $J_{\Phi(\cdot)}(\cdot,\cdot) > 0$. To complete the proof, we combine (A9) with the result in Proposition 2. ■

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