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Corruption, mortality rates, and development: policies for escaping from the poverty trap

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Abstract

We construct a three-period overlapping generations model in which corruption, mortality and fertility rates, and economic development are determined endogenously. We consider a less developed economy suffering from a high degree of corruption and high mortality and fertility rates in a poverty trap. We focus on two policies: raising public sector wages as a means of reducing corruption and increasing public health spending as a means of improving the mortality rate. Our aim is to examine what effects each policy has on an economy and how governments can achieve economic development using one, or both, of these policies. Our theoretical analysis shows that implementing both policies simultaneously is essential for less developed economies to escape from the poverty trap and achieve economic development.

Keywords Corruption · Public sector wage · Public health · Development

JEL Classification D73 · I18 · J38 · O41

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1 Introduction

Both corruption and high mortality rates are considered major obstacles to economic development. Studies have shown the negative effects of each; see, for example, Mauro (1995) for evidence of the negative effects of corruption and Lorentzen et al. (2008) for the negative effects of high mortality. In this study, we consider two economic development policies: raising public sector wages as a means of reducing corruption and increasing public health spending as a means of improving mortality rates. Our aim is to examine what effects each policy has on an economy and how governments can achieve economic development using one, or both, of these policies.

Developing countries suffer from higher corruption and higher mortality rates than developed ones. We use the Corruption Perception Index (CPI) published by Transparency International as the measure of corruption, male adult mortality rates, and per capita GDP (PPP, constant 2011 international dollars)[1] to confirm the negative correlation between corruption and development and between mortality rates and development, as shown in Fig. 1[2]. The CPI uses a scale of 0 (highly corrupt) to 100 (very clean). The figures show that less developed countries are associated with lower CPI scores and higher mortality rates. In response to these facts, the need to take action, especially in these less developed countries, has been acknowledged worldwide. For example, the United Nations' Sustainable Development Goals, adopted in September 2015, propose reducing corruption substantially, reducing mortality from various causes, such as hazardous air and water pollution, and achieving universal access to adequate and equitable sanitation and hygiene[3].

In the literature on demography and economic development, it is a well-established fact that mortality and fertility rates are strongly related, and changes in the two rates influence development. Some studies develop theoretical models with endogenous mortality and fertility rates and focus on the role of public health expenditure in improving the mortality rate (e.g., Blackburn and Cipriani (1998), Hashimoto and Tabata (2005), Blackburn and Sarmah (2008), Fanti and Gori (2014), Agénor (2015), and Okada (2020))[4]. Blackburn and Cipriani (1998) and Agénor (2015) conduct comparative statics analyses of increasing public health expenditure[5]. According to their analyses, a policy that increases these expenditures

[1] The CPI is available at https://www.transparency.org. The data on mortality rates and on per capita GDP are available at https://data.worldbank.org/indicator.

[2] Even if we plot the mortality rate of those under five or that of female adults as the mortality rate measure, the negative correlations between mortality rates and development can still be confirmed.

[3] https://sustainabledevelopment.un.org.

[4] Other studies determine the mortality rate using the level of human capital or private payments for healthcare; for example, see Cigno (1998), Blackburn and Cipriani (2002), Kalemli-Ozcan (2002), Lagerlöf (2003), Galor and Moav (2005), Hazan and Zoabi (2006), Cervellati and Sunde (2007), Fioroni (2010), and Futagami and Konishi (2019). To be exact, both private and public health expenditures affect the mortality rate in Blackburn and Cipriani (1998) and Agénor (2015).

[5] There are also studies that construct models in which public spending affects mortality rate, and these studies examine the effects of increasing public spending. A few notable studies include Chakraborty (2004), Aisa and Pueyo (2006), and Bhattacharya and Qiao (2007). However, they do not take fertility rates into account.

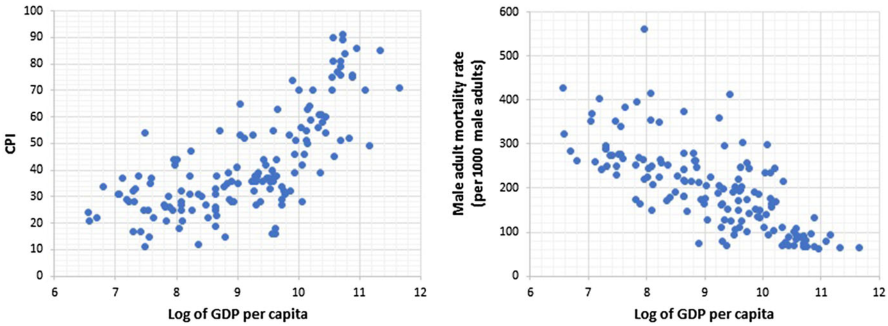


Fig. 1 Negative correlation between corruption and development in 2015 (left) and negative correlation between mortality rate and development in 2015 (right)

can contribute to higher growth rates. In addition, Okada (2020) examines the effects of increasing public health expenditure in an R&D-based growth model.

Although public spending can play a role in accelerating economic development, some studies show that the level of corruption determines the effectiveness of public spending. Rajkumar and Swaroop (2008) provide empirical evidence that a one percentage point increase in the share of GDP spent on public health yields a smaller impact if governance is weak[6]. The finding concurs with the arguments by World Bank (2003), which state that governments in developing countries struggle to translate public funds into effective services. These sources imply that it is not only essential to increase public spending, but governments must also conduct policy in a way that reduces corruption.

The literature on corruption focuses on some methods of preventing corruption. These methods include imposing severe punishment on corrupt behavior, rewarding a lack of corruption, or improving the effectiveness of monitoring systems. In line with Becker and Stigler (1974), Besley and McLaren (1993), Acemoglu and Verdier (1998), and Wadho (2016), we concentrate on the role of an efficiency wage. Becker and Stigler (1974) show that offering public workers a higher wage than they can get elsewhere (i.e., an opportunity wage or a reservation wage) reduces corruption. At the empirical level, Goel and Nelson (1998), Van Rijckeghem and Weder (2001), and Di Tella and Schargrodsky (2003) provide evidence on the negative effects of high public sector wages on corruption.

To the best of our knowledge, however, there is no theoretical study that examines the effects of a higher public sector wage on corruption and economic development by constructing a dynamic general equilibrium model[7]. This indicates that the question of whether offering a higher public sector wage can help an

[6] Rajkumar and Swaroop (2008) measure governance by using two indicators: quality of bureaucracy and level of corruption.

[7] There are, however, theoretical studies that examine corruption and economic development in dynamic models, such as Ehrlich and Lui (1999), Sarte (2001), Alesina and Angeletos (2005), Blackburn et al. (2006, (2011), Blackburn and Forgues-Puccio (2007, (2009), Blackburn and Sarmah (2008), Eicher et al. (2009), Spinesi (2009), Blackburn (2012), Dzhumashev (2014a, (2014b), and Varvarigos and Arsenis (2015).

economy eradicate high levels of corruption and move that economy beyond a less developed stage remains unanswered.

The aim of our present study is to investigate what policy is effective in helping an economy escape from corruption and a high mortality rate and move toward development by constructing a dynamic general equilibrium model in which corruption, mortality and fertility rates, and development are determined jointly. To achieve this aim, we first examine the effects of raising public sector wages and increasing public spending on public health.

We construct a three-period overlapping generations model in which agents live through childhood, adulthood, and old age. In each period, newly born agents are divided into two groups, households and bureaucrats. Households decide their number of children, and they work in the private sector. Bureaucrats are employed in the public sector and produce public services by using public funds provided by the government. They can engage in corruption by misallocating a share of public funds as illegal income. Public services contribute to the quality of public health, which determines the mortality rate. The key assumption we impose is that households are subject to the mortality rate in adulthood, while bureaucrats die at the end of adulthood. This makes our model tractable since only households save a portion of their income, which simplifies the dynamic equations. In a dynamic general equilibrium model with endogenous corruption and development, a policy often has both positive and negative effects on an economy through a variety of channels. As such, it is difficult to identify the net effects and each channel. This may be one of the reasons that previous theoretical studies have not fully explored the effects of most policies, including the two policies we consider in this paper. By imposing the assumption, our analysis can abstract from a few of the channels and effects. However, it would still be interesting and important to analytically clarify other effects and their channels.

In an equilibrium, two stable steady states can exist. One steady state in the early stage of development is characterized by a high degree of corruption and high mortality and fertility rates, that is, a poverty trap. The other, the late stage of development, is characterized by no corruption and low mortality and fertility rates. In this study, we consider an economy caught in the poverty trap. The economy needs to craft policy that will enable its escape from the trap and place it on a path toward the other steady state. The government has two methods of accomplishing these goals, raising public sector wages and increasing public health spending. Under a balanced-budget rule, both policies are financed by increasing the tax rate imposed on output.

We assume that the public sector wage is equal to the private sector wage and the share of public spending to total output is low at the initial steady state. We, then, demonstrate the following two cases. In the first case, only increasing public spending is sufficient to escape from the trap. In the second case, it is necessary to not only increase public spending but also to raise public sector wages. By doing so, the economy escapes from the trap and takes a path that converges to a new steady state. At the new steady state, no corruption, low mortality and fertility rates, and high development will be realized. In this case, merely increasing public spending is not worthwhile and raising public sector wages plays an important role; that is, it heightens the effectiveness of translating public funds into public services. By focusing on certain structural parameters related to corruption, we discuss how the second case can be applied to developing countries. Therefore, while previous studies have not fully explored the effects of a policy meant to reduce corruption in a dynamic general equilibrium model, our present study shows that raising public sector wages, as a way to reduce corruption, is essential for developing countries to achieve economic development.

The remainder of this paper is organized as follows. Section 2 constructs the model. Section 3 examines an equilibrium and derives the dynamics of an economy. Section 4 is the main part of this paper. In it, we conduct the comparative statics analysis and show the effects of raising public sector wages and increasing public spending on public health. After that, we explore what policy is effective in helping an economy escape from the poverty trap. Section 5 presents concluding remarks.

2 Model

Our model is based on those of Blackburn and Sarmah (2008) and Varvarigos and Arsenis (2015). We construct a three-period overlapping generations model. The economy consists of firms, the government, and agents. Agents go through childhood, adulthood, and old age. Children do not make any decisions. Adult agents work, consume goods, raise children, and save a part of their income. Old agents withdraw savings and consume goods. N_t stands for the labor force in period t; in other words, N_t is the number of adults in period t. In each period, newly born agents are divided into two groups, bureaucrats and households[8]. The population of each group in period t, N_t^B and N_t^H, is as follows:

$$N_t^B = \lambda N_t \quad \text{and} \quad N_t^H = (1-\lambda)N_t, \tag{1}$$

where $\lambda \in (0,1)$. In addition, two types of bureaucrats exist: corruptible and non-corruptible. The proportion, $b \in (0,1)$, is corruptible, while the remaining proportion, $1-b$, is non-corruptible. Corruptible bureaucrats can engage in corruption. We call a corruptible bureaucrat who is actually corrupt a dishonest bureaucrat and a corruptible bureaucrat who is not corrupt an honest bureaucrat. Proportion σ_t become dishonest bureaucrats, while proportion $1-\sigma_t$ become honest bureaucrats. σ_t is an endogenous variable. Households, corruptible bureaucrats, and non-corruptible bureaucrats are represented by a superscript $i \in \{H, CB, NB\}$. The types of agents and their numbers are summarized in the tree-type graph. All agents are endowed with one unit of labor, and they supply it inelastically. Households work for the private sector, while bureaucrats work for the public sector. In addition,

[8] We can consider the endogenous occupational choice as follows. There are λN_t seats in the public sector. Agents decide whether they will apply for jobs in the public sector at the end of childhood. If they do not apply, they become households. If the number of applications is less than or equal to the number of seats, all applicants can become bureaucrats. On the other hand, if the number of applicants is higher than the number of seats, the applicants will be randomly selected by the government. Introducing the endogenous occupational choice into the model does not change our results. Thus, for simplicity, we assume that newly born agents are divided into bureaucrats and households exogenously.

agents face the mortality rate in adulthood determined by the quality of public health.

2.1 Production

Firms produce final goods by using labor and capital. The production function is $Y_t = AL_t^{1-\alpha}K_t^{\alpha}$, where $\alpha \in (0, 1)$. Y_t, L_t, and K_t denote total output, labor, and capital, respectively. Output per capita is represented by

$$y_t = Al_t^{1-\alpha}k_t^{\alpha}. \tag{2}$$

y_t, l_t, and k_t are Y_t/N_t, L_t/N_t, and K_t/N_t, respectively. Profit maximizing yields the first order conditions:

$$r_t = (1 - \tau_t)\alpha Al_t^{1-\alpha}k_t^{\alpha-1}, \tag{3}$$

$$w_t = (1 - \tau_t)(1 - \alpha)Al_t^{-\alpha}k_t^{\alpha}. \tag{4}$$

r_t, w_t, and τ_t represent the interest rate, private sector wage, and tax rate, respectively. The tax rate is imposed on output.

2.2 Government

The government has three roles in this model. The first is to supply public services that affect the quality of public health. The second is to determine a wage rate for bureaucrats. The third is to set a tax rate.

First, we explain the supply of public services and corruption. This follows Varvarigos and Arsenis (2015). The government devotes G_t units of public funds to public services. This spending is proportional to total output:

$$G_t = \theta Y_t, \quad \text{where} \quad \theta \in (0, 1). \tag{5}$$

The government delegates the production and supply of public services to bureaucrats. Each bureaucrat is provided with G_t/N_t^B units of funds. When producing and supplying public services, he/she can use two types of projects, Type-1 and Type-2. The return of a Type-1 project is random, while that of a Type-2 project is constant. If a bureaucrat invests one unit of funds in the Type-1 project, he/she obtains $\xi > 1$ units of public services with probability p and $\gamma < 1$ units with probability $1 - p$. Without loss of generality, the expected return is set to one; that is, $p\xi + (1 - p)\gamma = 1$. In contrast, if a bureaucrat invests one unit of funds in the Type-2 project, he/she produces γ/δ units of services with probability 1. We assume that $0 < \gamma < \delta < 1$ so that $\gamma/\delta < 1$. Since the Type-1 project creates higher expected returns than the Type-2 project, the government instructs bureaucrats to operate the Type-1 project.

A non-corruptible bureaucrat complies with these instructions; that is, he/she invests all his/her funds in the Type-1 project. Then, we obtain $(1 - b)N_t^B \cdot G_t/N_t^B \cdot 1 = (1 - b)G_t$, which is supplied by non-corruptible bureaucrats. On the other hand, corruptible bureaucrats can engage in corruption in the following steps. A dishonest bureaucrat invests $\delta G_t/N_t^B$ units of funds in the Type-2 project and supplies $\gamma G_t/N_t^B$ units of public services. Subsequently, he/she insists that he/she conducted the Type-1 project but unfortunately achieved a bad result because of an idiosyncratic shock. Finally, he/she obtains illegal income $(1-\delta)G_t/N_t^B$. Thus, $\sigma_t b N_t^B \cdot \delta G_t/N_t^B \cdot \gamma/\delta = \sigma_t \gamma b G_t$ units of public services are supplied by dishonest bureaucrats. Conversely, an honest bureaucrat who is not corrupt behaves in the same manner as a non-corruptible bureaucrat. That is, $(1-\sigma_t)bN_t^B \cdot G_t/N_t^B \cdot 1 = (1-\sigma_t)bG_t$ units of public services are supplied by honest bureaucrats. Thus, the total amount of public services supplied by all bureaucrats is $(1-b)G_t + \sigma_t\gamma bG_t + (1-\sigma_t)bG_t = [1-\sigma_t b(1-\gamma)]G_t$. Then, the per capita public services, f_t, are as follows:

$$f_t = [1-\sigma_t b(1-\gamma)]\theta y_t. \tag{6}$$

Second, the government offers a wage contract to bureaucrats[9]. To supply the public services, the government must employ N_t^B bureaucrats. Bureaucrats will work in the public sector if they can obtain a higher wage rate, ω_t, than that in the private sector. Thus, to attract bureaucrats, the government offers

$$\omega_t = \rho w_t, \quad \text{where} \quad \rho \in [1, \infty). \tag{7}$$

Since the government cannot differentiate between bureaucrat types, it offers the same contract to all bureaucrats[10].

Third, the government sets a tax rate to follow the balanced budget rule:

$$\tau_t Y_t = G_t + \omega_t N_t^B. \tag{8}$$

ρ and θ are important policy parameters in this model. Section 4 conducts comparative statics analyses to examine the effects of raising public sector wages (i.e., an increase in ρ) and increasing public spending on public health (i.e., an increase in θ). τ_t is determined to keep the government's budget balanced.

2.3 Public health and the mortality rate

The public services supplied by bureaucrats affect the quality of public health. The quality of public health is given by

[9] The public sector wage rate is not determined by a market mechanism. The assumption that the government decides the wage rate is in line with macroeconomic literature on corruption (e.g., Blackburn et al. 2006).

[10] If the government offers $\omega_t < w_t$, only corruptible bureaucrats who expect to receive compensation through illegal income will work in the public sector and are identified as being dishonest. Thus, offering a lower public sector wage implies that the government accepts corruption. Since our analysis seeks to examine methods to escape from the poverty trap, we focus only on $\rho \in [1, \infty)$.

$$h_t = \frac{f_t}{y_t}. \tag{9}$$

Production activity has potential negative effects on public health, such as air and water pollution. Providing public services can mitigate these negative effects. This idea is widely supported in the existing literature. For instance, see Blackburn and Cipriani (1998), Osang and Sarkar (2008), and Dioikitopoulos (2014)[11].

The quality of public health determines the survival rate in period t, π_t, as follows:

$$\pi_t = \Pi(h_t), \quad \Pi(h_t) \in [0, 1], \quad \Pi'(h_t) > 0. \tag{10}$$

An improvement in the quality of public health in period t increases the survival rate in this period. That is, higher quality public health yields a lower mortality rate.

2.4 Agents

We consider agents born in period $t-1$. We make the assumptions that bureaucrats do not give birth and that they die at the end of adulthood[12]. These assumptions allow us to analytically clarify and examine the essential effects of the government's policies on the economy. In "Appendix A", we extend the basic model by making the assumption that bureaucrats give birth and face a mortality rate, just as households do. In the extended model, we obtain similar results about the relationships between corruption, mortality and fertility rates, and development as well as the dynamics of an economy and multiple steady states.

2.4.1 Households

Households choose the number of children n_t as well as their consumption in adulthood $c^H_{a,t}$ and in old age $c^H_{o,t+1}$ to maximize the following expected utility:

$$a \ln n_t + (1-a)[\ln c^H_{a,t} + \beta \pi_t \ln c^H_{o,t+1}].$$

They survive into old age with probability π_t. β is the discount factor and a is their preference between children and consumption. High a implies a high preference toward their children.

Households allocate their income between consumption, savings, and child rearing. Following Fioroni (2010), we assume that raising each child requires e proportion of income. As such, the budget constraints of households are as follows:

[11] As explained later, public health in (9) is an increasing function of per capita capital. Economic development, represented by k_t, has negative effects on the quality of public health through greater production and positive effects through more public services. In equilibrium, the positive effects dominate. Thus, as capital accumulates, the quality of public health improves.

[12] Similar assumptions are used in Blackburn and Sarmah (2008) and Varvarigos and Arsenis (2015). The analysis of Blackburn and Sarmah (2008) assumes that households face a mortality rate, whereas bureaucrats enjoy a whole lifetime. The analysis of Varvarigos and Arsenis (2015) assumes that only households give birth and raise their children.

$$c_{a,t}^{H} + s_t = w_t - en_t w_t \quad \text{and} \quad c_{o,t+1}^{H} = \frac{R_{t+1}}{\pi_t} s_t,$$

where s_t is savings and R_{t+1} is the gross interest rate. Maximizing the utility level subject to these two constraints yields the optimal level of consumption and savings:

$$c_{a,t}^{H} = \frac{1-a}{1+(1-a)\beta\pi_t} w_t, \qquad c_{o,t+1}^{H} = \frac{(1-a)\beta}{1+(1-a)\beta\pi_t} R_{t+1} w_t,$$

and

$$s_t = \frac{(1-a)\beta\pi_t}{1+(1-a)\beta\pi_t} w_t. \tag{11}$$

The optimal number of children is given by

$$n_t = \frac{a}{e[1+(1-a)\beta\pi_t]}. \tag{12}$$

Equations (11) and (12) show that a decline of π_t decreases s_t and increases n_t. A high mortality rate implies that households have a low probability of living to old age. To consume more in adulthood, they decrease their savings. In addition, to derive higher utility in adulthood, they give birth to several children.

2.4.2 Bureaucrats

Bureaucrats derive their utility only from consumption in adulthood. Their utility is as follows:

$$\ln c_{a,t}^{i}, \quad i \in \{CB, NB\}.$$

Non-corruptible bureaucrats consume $c_{a,t}^{NB} = \omega_t$. Honest bureaucrats behave in the same way as non-corruptible bureaucrats. Thus, their consumption level is ω_t, and their utility is given by

$$U_t^{CB(honest)} = \ln \omega_t. \tag{13}$$

In contrast, dishonest bureaucrats receive not only labor income ω_t but also illegal income $(1-\delta)G_t/N_t^B$. Their consumption level is $\omega_t + (1-\delta)G_t/N_t^B$. In addition, following Varvarigos and Arsenis (2015), we assume that dishonest bureaucrats face a cost, and the cost is proportional to their utility. Therefore, their utility is given by

$$U_t^{CB(dishonest)} = (1-\chi)\ln\left[\omega_t + \frac{(1-\delta)G_t}{N_t^B}\right]. \tag{14}$$

$\chi \in (0,1)$ stands for the cost of engaging in corruption. It can be broadly interpreted. One interpretation is that χ is the probability of being accused by the government. With probability χ, dishonest bureaucrats are caught, and their utility becomes zero. With probability $1-\chi$, they can avoid accusations and derive the utility. Thus, their expected utility is represented by (14). Another interpretation is that χ represents psychological distress related to the degree of severity of corruption in a society (i.e., cultural norms against corruption). If the public tolerates corruption, dishonest bureaucrats would feel less psychological distress.

Last, we consider the maximization problem of a corruptible bureaucrat. A corruptible bureaucrat j becomes a dishonest bureaucrat with probability $\sigma_{jt} \in [0, 1]$ and becomes an honest bureaucrat with probability $1 - \sigma_{jt}$. He/She chooses his/her strategy, σ_{jt}, to maximize U_{jt}, which is defined by

$$U_{jt} = \sigma_{jt} U_t^{CB(dishonest)} + (1 - \sigma_{jt}) U_t^{CB(honest)}.$$

3 Equilibrium

The labor market clearing condition is $L_t = N_t^H = (1 - \lambda)N_t$. Therefore, the per capita labor force becomes constant:

$$l_t = l = 1 - \lambda. \tag{15}$$

Substituting (4), (5), (7), and (15) into the government's balanced budget constraint, (8), we obtain the following tax rate:

$$\tau_t = \tau = \frac{\theta(1 - \lambda) + \rho\lambda(1 - \alpha)}{1 - \lambda + \rho\lambda(1 - \alpha)}. \tag{16}$$

Since $\theta \in (0, 1)$, $\tau \in (0, 1)$. We note that $\partial\tau/\partial\rho > 0$, $\lim_{\rho\to\infty} \tau = 1$, $\partial\tau/\partial\theta > 0$, and $\lim_{\theta\to 1} \tau = 1$. Substituting (15) and (16) into (2), (3), and (4), respectively, the per capita output, interest rate, and private sector wage are rewritten:

$$y(k_t) = Al^{1-\alpha}k_t^{\alpha}, \tag{17}$$

$$r(k_t) = (1 - \tau)\alpha A l^{1-\alpha} k_t^{\alpha-1}, \tag{18}$$

$$w(k_t) = (1 - \tau)(1 - \alpha)Al^{-\alpha}k_t^{\alpha}. \tag{19}$$

Since the government offers contract $\omega_t = \rho w_t$, the public sector wage is given by

$$\omega(k_t) = \rho(1 - \tau)(1 - \alpha)Al^{-\alpha}k_t^{\alpha}. \tag{20}$$

We note that $\partial\omega(k_t)/\partial\rho > 0$ and $\partial\omega(k_t)/\partial\theta < 0$.

3.1 Endogenous corruption and its effects

We consider a strategy of corruptible bureaucrat j. He/she becomes honest if $U_t^{CB(dishonest)} \leq U_t^{CB(honest)}$, or from (13) and (14),

$$(1-\chi)\ln\left[\omega_t + \frac{(1-\delta)G_t}{N_t^B}\right] \le \ln\omega_t.$$

However, he/she becomes dishonest if $U_t^{CB(honest)} < U_t^{CB(dishonest)}$. Thus, from (1), (5), (17), and (20), he/she chooses $\sigma_{j,t} = 1$ for $k_t < \hat{k}$ where

$$\hat{k} \equiv \left\{ [\rho(1-\tau)(1-\alpha)Al^{-\alpha}]^{-1}\left[1 + \frac{\theta(1-\lambda)(1-\delta)}{\rho\lambda(1-\tau)(1-\alpha)}\right]^{\frac{1-\chi}{\chi}} \right\}^{\frac{1}{\alpha}}. \tag{21}$$

In addition, $\sigma_t = 1$ is realized since all the other corruptible bureaucrats choose the same strategy. For $k_t \ge \hat{k}$, he/she chooses $\sigma_{jt} = 0$, and then $\sigma_t = 0$ is realized. Hence, solving the maximization problem of a corruptible bureaucrat yields

$$\sigma(k_t) = \begin{cases} 1 & \text{for } k_t < \hat{k}, \\ 0 & \text{for } k_t \ge \hat{k}. \end{cases} \tag{22}$$

This shows that as capital accumulates, corruption stops occurring. The mechanism for this is as follows. The public sector wage and illegal income increase in k_t, and thus the level of consumption for dishonest bureaucrats increases. Although this leads to higher utility, the cost of engaging in corruption also increases since dishonest bureaucrats lose a part of their utility. When there is enough stock of per capita capital, satisfying $k_t \ge \hat{k}$, the cost is high, so no bureaucrats will engage in corruption. This result can explain the data on the negative correlation between corruption and economic development in Fig. 1. Moreover, it concurs with the findings of empirical studies. For example, Chong and Calderon (2000) and Treisman (2000) show that political institutions become less corrupt as an economy grows.

$\sigma(k_t)$, which represents the degree of corruption, has the following effects in the economy. From (6), (17), and (22), the per capita public services supplied by bureaucrats becomes

$$f(k_t) = \begin{cases} [1-b(1-\gamma)]\theta y(k_t) & \text{for} \quad k_t < \hat{k}, \\ \theta y(k_t) & \text{for} \quad k_t \ge \hat{k}. \end{cases} \tag{23}$$

In the early stage of development, $k_t < \hat{k}$, all corruptible bureaucrats behave dishonestly. They take a proportion of public funds as illegal income, so the level of public services is low. As capital accumulates, no corruption occurs, so all public funds are devoted to public services. The level of per capita public services determines the quality of public health. That is, from (9) and (23), h_t is as follows:

$$h(k_t) = \begin{cases} [1-b(1-\gamma)]\theta & \text{for } k_t < \hat{k}, \\ \theta & \text{for } k_t \ge \hat{k}. \end{cases} \tag{24}$$

When the stock of per capita capital is small, the quality worsens because insufficient public services are supplied. This results in a low survival rate, $\underline{\pi}$. After the stock of per capita capital exceeds the threshold, the survival rate reaches the maximum level, $\bar{\pi}$. From (10) and (24), $\pi(k_t)$ is given by

$$\pi(k_t) = \begin{cases} \underline{\pi} & \text{for } k_t < \hat{k}, \\ \bar{\pi} & \text{for } k_t \geq \hat{k}, \end{cases} \tag{25}$$

where $\underline{\pi} = \Pi([1 - b(1-\gamma)]\theta)$, $\bar{\pi} = \Pi(\theta)$, and $\underline{\pi} < \bar{\pi}$. The fertility rate is also indirectly affected by corruption. From (12) and (25), the fertility rate is given by

$$n(k_t) = \begin{cases} \bar{n} & \text{for } k_t < \hat{k}, \\ \underline{n} & \text{for } k_t \geq \hat{k}, \end{cases} \tag{26}$$

where $\bar{n} = a/\{e[1 + (1-a)\beta\underline{\pi}]\}$, $\underline{n} = a/\{e[1 + (1-a)\beta\bar{\pi}]\}$, and $\underline{n} < \bar{n}$.

The preceding results can be summarized in the following proposition.

Proposition 1 *The equilibrium is described as follows.*

1. *For early stages of economic development, that is, $k_t < \hat{k}$, all corruptible bureaucrats engage in corruption, and the mortality and fertility rates are high.*
2. *For late stages of economic development, that is, $k_t \geq \hat{k}$, no corruptible bureaucrats engage in corruption, and the mortality and fertility rates are low.*

Our theoretical results replicate empirical facts on the relationships between corruption, mortality and fertility rates, and economic development. That is, developing countries suffer from a higher degree of corruption and higher mortality and fertility rates.

3.2 Dynamics of the economy

The rest of this section derives the dynamics of per capita capital. The capital market clearing condition is $K_{t+1} = s_t N_t^H$. From (11) and (19), the condition is rewritten as follows:

$$k_{t+1} = \frac{1-a}{a} e\beta(1-\tau)(1-\alpha)Al^{-\alpha}\pi(k_t)k_t^{\alpha}.$$

To obtain the equation, we use $N_{t+1} = n_t(1-\lambda)N_t$. By substituting (25) into the dynamics, we obtain the following dynamics equations:

$$k_{t+1}^{C} = \frac{1-a}{a} e\beta(1-\tau)(1-\alpha)Al^{-\alpha}\underline{\pi}k_t^{\alpha} \quad \text{for} \quad k_t < \hat{k} \tag{27}$$

and

$$k_{t+1}^{NC} = \frac{1-a}{a} e\beta(1-\tau)(1-\alpha)Al^{-\alpha}\bar{\pi}k_t^{\alpha} \quad \text{for} \quad k_t \geq \hat{k}. \tag{28}$$

We note that $\partial k_{t+1}/\partial k_t > 0$, $\partial^2 k_{t+1}/\partial k_t^2 < 0$, and $k_{t+1}^C = 0$ if $k_t = 0$ hold.

Drawing the two dynamics in the $k_t - k_{t+1}$ plane shows the transition of this economy and steady states, as depicted in Fig. 2. We show that two steady states can exist. We denote the points at which the 45-degree line intersects with the dynamics k^C_{t+1} and k^{NC}_{t+1} as E_C and E_{NC}. These steady states are stable. Therefore, the economy will converge to E_C (E_{NC}) if its initial stock of per capita capital is less (higher) than $\hat{k}$. The stable steady states are characterized as follows: E_C has corruption, low quality of public health, and high mortality and fertility rates, whereas E_{NC} has no corruption, high quality of public health, and low mortality and fertility rates.

4 Policies for escaping from the poverty trap

This section considers a less developed economy caught in a poverty trap at E_C and studies how the economy escapes from the trap and achieves economic development. The government decides public sector wages, public health spending, and the tax rate: that is, ρ, θ, and τ[13]. We first examine the effects of raising the wage rate (i.e., increased ρ) and increasing public spending (i.e., increased θ). The tax rate is set to keep the budget balanced. At the initial steady state, E_C, the economy has the stock of per capita capital, $k^*(\rho, \theta)$. Equation (27) yields

$$k^*(\rho,\theta) = \left[\frac{1-a}{a} e\beta(1-\lambda)^{1-\alpha}(1-\alpha)A \frac{\underline{\pi}(\theta)(1-\theta)}{1-\lambda+\rho\lambda(1-\alpha)}\right]^{\frac{1}{1-\alpha}}. \tag{29}$$

Substituting (15) and (16) into (21), the threshold under which all corruptible bureaucrats engage in corruption is given by

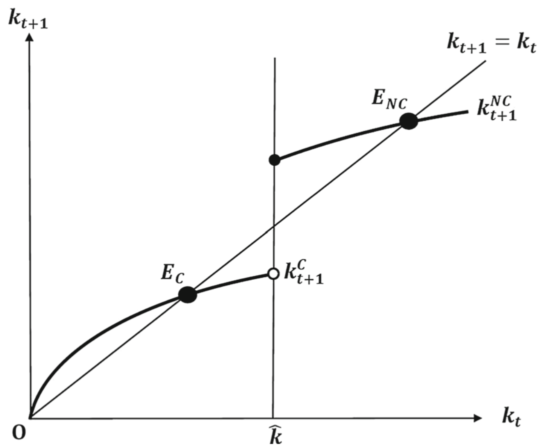
$$\hat{k}(\rho,\theta) = \left\{\frac{1-\lambda+\rho\lambda(1-\alpha)}{\rho(1-\theta)(1-\lambda)^{1-\alpha}(1-\alpha)A}\left[1+\frac{\theta(1-\delta)[1-\lambda+\rho\lambda(1-\alpha)]}{\rho\lambda(1-\theta)(1-\alpha)}\right]^{\frac{1-\chi}{\chi}}\right\}^{\frac{1}{\alpha}}. \tag{30}$$

We assume that the economy sets $\rho = 1$ and $\theta = \theta_0$ at the initial steady state, E_C. In addition, we note that θ_0 is sufficiently small, so steady state E_C exists. The initial stock of per capita capital is $k^*(1, \theta_0)$, and the threshold is $\hat{k}(1, \theta_0)$.

First, we examine the effects of ρ and θ on $\hat{k}(\rho, \theta)$. From this, we can obtain the following lemma.

[13] Although our analysis concentrates on raising public sector wages as a method of preventing corruption, we could also consider other methods. One example is paying out a bonus to bureaucrats for successful execution of a Type-1 project. No bureaucrats engage in corruption if the government pays out a bonus, B_t, that is large enough to satisfy $p\ln(\omega_t + B_t) + (1-p)\ln\omega_t \geq (1-\chi)\ln[\omega_t + (1-\delta)G_t/N^B_t]$, where the left-hand side is the expected utility if a bureaucrat does not engage in corruption and the right-hand side is the utility if he/she engages in corruption. Incorporating a bonus into the model yields the government's balanced budget constraint, $\tau_t Y_t = G_t + \omega_t N^B_t + B_t N^B_t p(1-\sigma_t b)$. In this case, it would be complicated to clarify the macroeconomic effects of policies. Hence, in line with Becker and Stigler (1974), Besley and McLaren (1993), Acemoglu and Verdier (1998), and Wadho (2016), we concentrate on the role of public sector wages in the present study.

Fig. 2 Multiple steady states



Lemma 1 *$\hat{k}(\rho, \theta)$ decreases with ρ and increases with θ. Moreover, when ρ approaches infinity, $\hat{k}(\rho, \theta)$ converges to a finite value.*

Proof See "Appendix B". □

Raising the public sector wage decreases the incentive for corruptible bureaucrats to engage in corruption. Since dishonest bureaucrats lose a part of their utility, a higher wage increases the costs of corruption. Thus, the threshold decreases. However, even if ρ goes to ∞, the threshold level does not approach to zero. This is because, as ρ goes to infinity, the public sector wage converges to a finite value; that is, $\lim_{\rho \to \infty} \omega_t = (1-\theta)\lambda^{-1}(1-\lambda)^{1-\alpha} A k_t^{\alpha}$. Therefore, even if the government sets ρ at as high a value as possible, corruptible bureaucrats still have incentive to engage in corruption. On the other hand, an increase in θ increases the threshold since it increases illegal income. A high θ means that the government spends a large amount of public funds on public health and distributes the large funds to each bureaucrat. Thus, dishonest bureaucrats obtain high illegal incomes since they illegally retain a certain proportion of the public funds for themselves.

Second, we examine the effects of ρ and θ on $k^*(\rho, \theta)$. As is usual in the literature on demography and development (e.g., Blackburn and Cipriani (2002), Hashimoto and Tabata (2005), Fioroni (2010), and Fanti and Gori (2014)), we specify the survival rate as follows:

$$\pi_t = \Pi(h_t) = \frac{h_t}{1 + h_t},$$

$\Pi'(h_t) > 0$, $\Pi''(h_t) < 0$, $\Pi(0) = 0$, and $\lim_{h_t \to \infty} \Pi(h_t) = 1$. From (25), $\underline{\pi}$ becomes

$$\underline{\pi}(\theta) = \frac{\phi\theta}{1 + \phi\theta}, \tag{31}$$

where $\phi = 1 - b(1-\gamma)$. $\underline{\pi}'(\theta) > 0$, $\underline{\pi}''(\theta) < 0$, $\underline{\pi}(0) = 0$, and $\underline{\pi}(1) = \phi/(1+\phi)$. Thus, we can obtain the following lemma.

Lemma 2 *$k^*(\rho, \theta)$ decreases with ρ and is hump-shaped in θ.*

Proof See "Appendix C". □

An increase in ρ affects $k^*(\rho, \theta)$ by increasing τ. To keep the budget balanced, the government must raise the tax rate. This decreases households' after-tax income, w_t, and savings, s_t. Thus, $k^*(\rho, \theta)$ decreases. On the other hand, an increase in θ has positive or negative effects on $k^*(\rho, \theta)$. Through the same channel as a higher ρ does, a higher θ negatively affects $k^*(\rho, \theta)$. At the same time, by setting θ at a higher value, the government can improve the mortality rate, which causes a decline in the fertility rate. As a result, households will save a larger portion of their income. If θ is lower than $\hat{\theta}$, the positive effect caused by improved survival rate is larger, and the increase in θ increases $k^*(\rho, \theta)$. In contrast, if θ is higher than $\hat{\theta}$, the negative effect caused by an increased tax rate is larger, and the increase in θ decreases $k^*(\rho, \theta)$.

Next, we consider what policy is most effective in helping the less developed economy escape from the poverty trap in which corruption is rampant and the mortality and fertility rates are high. By enacting a policy, the economy can escape from the trap if the threshold becomes lower than the steady state level of per capita capital. Figure 3 depicts $\hat{k}(1, \theta)$, $\lim_{\rho \to \infty} \hat{k}(\rho, \theta)$, and $k^*(1, \theta)$. We focus on the following two cases. The first case is that in which $k^*(1, \theta)$ intersects with both $\hat{k}(1, \theta)$ and $\lim_{\rho \to \infty} \hat{k}(\rho, \theta)$. The second case is that in which $k^*(1, \theta)$ intersects with $\lim_{\rho \to \infty} \hat{k}(\rho, \theta)$ but not with $\hat{k}(1, \theta)$. We explore a policy to escape from the poverty trap in each case[14].

Figure 4 shows the first case. We define the level of θ at each point that $k^*(1, \theta)$ intersects with $\lim_{\rho \to \infty} \hat{k}(\rho, \theta)$ as θ_1 and θ_4. Furthermore, $k^*(1, \theta)$ intersects with $\hat{k}(1, \theta)$. We also define the level of θ at each point that these lines intersect as θ_2 and θ_3. In this case, increasing just public health spending is sufficient. When the government raises θ from θ_0 to $\tilde{\theta} \in [\theta_2, \theta_3]$, $\hat{k}(1, \tilde{\theta}) \leq k^*(1, \tilde{\theta})$ holds true. That is, the economy escapes from the trap and converges to a new steady state. At the new steady state, no corruption, low mortality and fertility rates, and high development are realized. In this case, while increasing public spending increases bureaucrats' incentives to engage in corruption, the positive effects on the level of per capita capital caused by the improved mortality rate are much larger. Hence, only increasing public spending is enough to escape from the trap.

Figure 5 shows the second case. $k^*(1, \theta)$ intersects with $\lim_{\rho \to \infty} \hat{k}(\rho, \theta)$ twice. We define the level of θ at each point that the two lines intersect as θ_5 and θ_6. In this case, only increasing public spending is not worthwhile since given $\rho = 1$, $k^*(1, \theta) < \hat{k}(1, \theta)$ holds for all $\theta \in (0, 1)$. To escape from the trap, the economy must not only increase public spending but also raise public sector wages. We explain the transition of this economy by drawing the phase diagrams in Figures 6 and 7. As depicted in Fig. 6, when the government increases θ_0 to $\tilde{\theta} \in [\theta_5, \theta_6]$, the dynamic

[14] The case in which $k^*(1, \theta)$ intersects with neither $\hat{k}(1, \theta)$ nor $\lim_{\rho \to \infty} \hat{k}(\rho, \theta)$ is not considered since no policy will be effective.

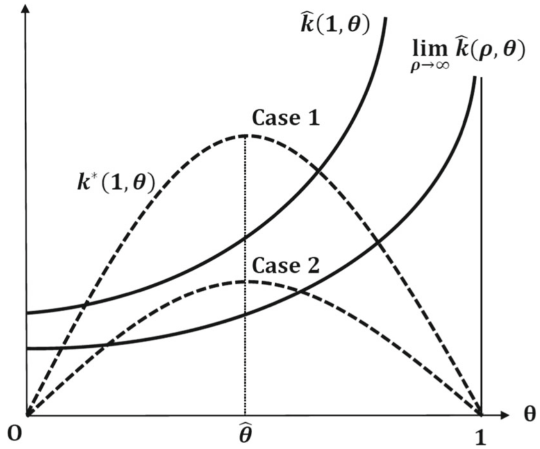


Fig. 3 $\hat{k}(1,\theta)$, $\lim_{\rho\to\infty}\hat{k}(\rho,\theta)$, and $k^*(1,\theta)$

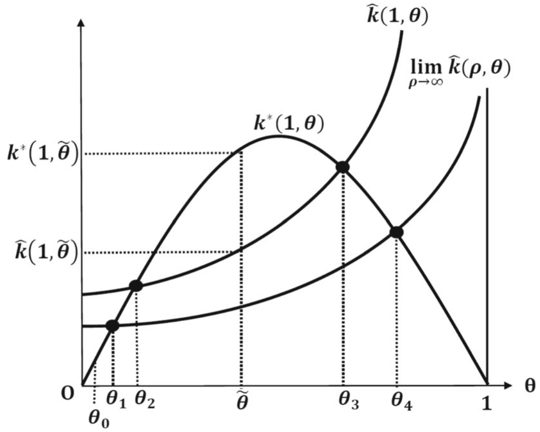


Fig. 4 First case, in which $k^*(1,\theta)$ intersects with both $\hat{k}(1,\theta)$ and $\lim_{\rho\to\infty}\hat{k}(\rho,\theta)$

equation k^C_{t+1} shifts upward, and then the steady state level of per capita capital increases from $k^*(1,\theta_0)$ to $k^*(1,\tilde{\theta})$. However, increasing public spending offers greater incentives for bureaucrats to engage in corruption. Hence, the threshold also increases from $\hat{k}(1,\theta_0)$ to $\hat{k}(1,\tilde{\theta})$. Thus, the economy converges to the new steady state, $\tilde{E}$. The economy still suffers from the poverty trap at $\tilde{E}$ since $k^*(1,\tilde{\theta}) < \hat{k}(1,\tilde{\theta})$ holds. In this case, even if the economy increases public spending to improve the mortality rate, a large portion of that spending is not translated into public services. Thus, to heighten the effectiveness of translating public spending into public services, a policy to reduce corruption must be conducted. We show that there is $\hat{\rho}$ that satisfies $\hat{k}(\hat{\rho},\tilde{\theta}) = k^*(1,\tilde{\theta})$ in Fig. 5. This indicates that by increasing ρ from one to $\tilde{\rho} \in [\hat{\rho},\infty)$, $\hat{k}(\tilde{\rho},\tilde{\theta}) \leq k^*(1,\tilde{\theta})$ holds, and then the economy can escape from the trap. As shown in Fig. 7, increasing ρ from one to $\tilde{\rho}$ decreases bureaucrats' incentives; that is, $\hat{k}(1,\tilde{\theta})$ decreases to $\hat{k}(\tilde{\rho},\tilde{\theta})$. Then, the high public sector wage

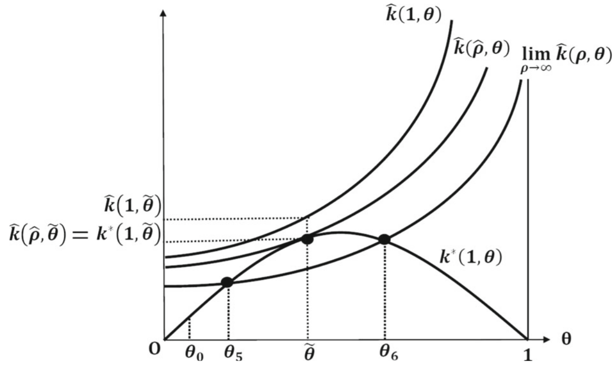


Fig. 5 Second case, in which $k^*(1,\theta)$ intersects with $\lim_{\rho\to\infty}\hat{k}(\rho,\theta)$ but not with $\hat{k}(1,\theta)$

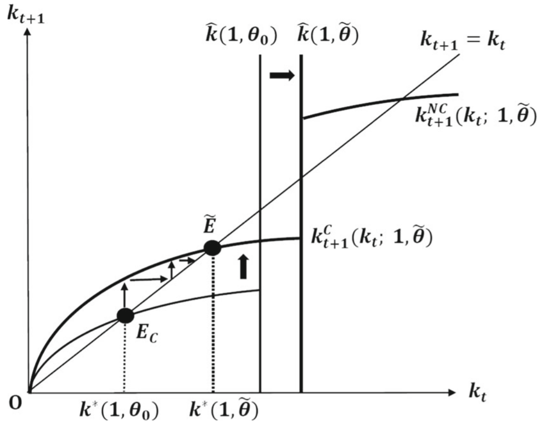


Fig. 6 The transition when the government only increases public health spending

deters corruptible bureaucrats from engaging in corruption. Accordingly, the economy jumps from $\tilde{E}$ to E', and the process of capital accumulation follows the dynamic equation k^{NC}_{t+1}. Finally, the economy converges to the steady state, E_{NC}, at which the economy achieves no corruption, low mortality and fertility rates, and high development[15].

The preceding results can be summarized in the following proposition.

Proposition 2 *Suppose that an economy is at initial steady state E_C with $\rho = 1$ and a sufficiently small θ. Then, the following policies are effective in helping the economy escape from the poverty trap.*

1. *If $k^*(1,\theta)$ intersects with both $\hat{k}(1,\theta)$ and $\lim_{\rho\to\infty}\hat{k}(\rho,\theta)$, there is a range of θ that satisfies $\hat{k}(1,\theta) \leq k^*(1,\theta)$; that is, the economy can escape from the trap only by increasing public spending.*

15 We note that this result occurs in the first case when the government increases θ_0 to $\tilde{\theta} \in [\theta_1, \theta_2)$ or $\tilde{\theta} \in (\theta_3, \theta_4]$.

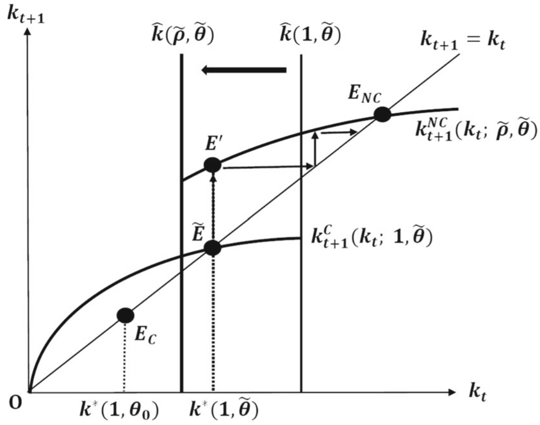


Fig. 7 The transition when the government increases both public health spending and public sector wages

2. *If* $k^*(1, \theta)$ *intersects with* $\lim_{\rho \to \infty} \hat{k}(\rho, \theta)$ *but not with* $\hat{k}(1, \theta)$, $k^*(1, \theta) < \hat{k}(1, \theta)$ *holds for all* $\theta \in (0, 1)$; *that is, the economy cannot escape from the trap only by increasing public spending. However, there is a range of* ρ *and* θ *that satisfies* $\hat{k}(\rho, \theta) \leq k^*(1, \theta)$; *that is, the economy can escape from the trap by not only increasing public spending but also raising the public sector wage.*

We discuss when the first or second case occurs. The first (second) case is likely to occur when $\hat{k}(1, \theta)$ is lower (higher) or $k^*(1, \theta)$ is higher (lower) or both. We focus on three parameters: δ, χ, and b. The parameters, δ and χ affect $\hat{k}(1, \theta)$, while b affects $k^*(1, \theta)$. A higher δ decreases $\hat{k}(1, \theta)$; that is, $\partial \hat{k}(1, \theta)/\partial \delta < 0$. A higher δ indicates that the amount of illegal income is small since dishonest bureaucrats obtain $1 - \delta$ proportion of illegal income of public funds provided by the government. The small benefits obtained by engaging in corruption diminish the incentives to be corrupt. Similarly, as χ rises, $\hat{k}(1, \theta)$ decreases; that is, $\partial \hat{k}(1, \theta)/\partial \chi < 0$. Dishonest bureaucrats lose χ proportion of their utility as costs of engaging in corruption. When χ is high and the costs are high, corruptible bureaucrats are reluctant to engage in corruption. As indicated earlier, χ can be broadly interpreted, such as the probability of being caught by the government or psychological distress stemming from cultural norms against corruption. If the probability or distress is high, engaging in corruption is not attractive for bureaucrats. b is the share of corruptible bureaucrats. A higher b decreases $k^*(1, \theta)$, through which it causes a fall in the survival rate. In an economy at steady state E_C, all corruptible bureaucrats actually become dishonest. In other words, bN^B_t number of bureaucrats engage in corruption. As b is high, public health spending does not contribute to improvement in the quality of public health since a large portion of the spending is stolen by the dishonest bureaucrats. This decreases the survival rate; that is, $d\underline{\pi}/db < 0$. Households who face a low survival rate decrease their level of saving. Thus, a high b decreases the stock of per capita capital at the steady state; that is, $\partial k^*(1, \theta)/\partial b < 0$. Therefore, the first case can occur if δ or χ is high or b is low, or if both conditions are true, and the second case can occur if δ or χ is low or b is high, or both.

Last, we consider which case can be applied to developing countries. To do so, we regard χ as the degree of psychological distress (e.g., cultural norms against corruption, social stigma, and peer reputation) and explore it in developing countries. The reason why we focus on χ is that there are a large number of studies investigating the relationships between psychological costs and illegal activities (e.g., corruption, tax evasion, and crime). Barr and Serra (2010) find that in their experiment, individuals who grew up in countries in which corruption is prevalent are likely to engage in bribery. They state that social norms internalized during childhood determine individuals' decisions about bribery. Moreover, Dong et al. (2012) and Lee and Guven (2013) use micro data sets and show that the higher the frequency of corruption, the higher the justifiability of corruption. Hence, according to their findings, if the public tolerates corruption, corruption is likely to occur; and, if corruption is rampant, the public are likely to accept corruption. As we confirmed in the introduction (Fig. 1), developing countries suffer from sever corruption. Thus, corrupt bureaucrats may feel lower psychological distress when they engage in corruption; that is, χ is low in our model. Therefore, the second case shown in Fig. 5 can be applied to developing countries. As summarized in Proposition 2, conducting a policy to prevent corruption is essential for these countries to increase the effectiveness of expanding public spending, and thereby achieving economic development.

5 Concluding remarks

This paper builds an overlapping generations model by taking into account endogenous corruption, mortality and fertility rates, and economic development. We consider a less developed economy suffering from corruption as well as high mortality and fertility rates in a poverty trap. Our analysis examines how the economy can escape from the trap and achieve economic development. In the analysis, we focus on two policies, raising public sector wages as a way to reduce corruption and increasing public health spending to improve the mortality rate. We show that two cases exist. In the first case, increasing public spending is sufficient. In the second, both policies must be implemented simultaneously. For developing countries, the second case can be applied; it may be essential to increase both public spending and public sector wages. In particular, raising public sector wages plays an important role in heightening the effectiveness of transforming public spending into public services. Thus, we can theoretically confirm the necessity of a policy to prevent corruption, which is implied by the empirical finding of Rajkumar and Swaroop (2008) and the arguments of World Bank (2003).

Finally, we must note that our analysis stands on the assumption that bureaucrats die at the end of adulthood, whereas households only have a probability of surviving to old age. Hence, we focus on only some of the many effects that the policies have on the economy. However, this study does contribute to the literature on corruption, demography, and economic development in that the effects and their mechanisms are analytically clarified using the dynamic general equilibrium model. Another point we must state is that our analysis concentrates on raising public sector wages as a method of preventing corruption. This is because there are no theoretical studies that examine the effects of this policy on the macroeconomy by constructing a dynamic general equilibrium model. However, we could also consider other methods such as imposing severe punishments or improving monitoring systems. In particular, in our model, we could analyze a case in which the government pays out a bonus to bureaucrats for successful execution of a Type-1 project. It would be interesting to conduct future research examining whether a public sector wage and bonus scheme could explain differences in corruption among countries.

The case of bureaucrats who also give birth and face a mortality rate

To ensure concreteness, we confirm that our results about the relationships between corruption, mortality and fertility rates, and development as well as the dynamics of an economy and multiple steady states hold in a scenario in which both households and bureaucrats give birth and face the mortality rate.

The utility of bureaucrats is

$$a \ln n_t^i + (1-a) \ln[\ln c_{a,t}^i + \beta\pi_t \ln c_{o,t+1}^i], \qquad i \in \{CB, NB\}. \tag{32}$$

First, we derive the optimal choices of non-corruptible bureaucrats ($i = NB$). Non-corruptible bureaucrats maximize (32) subject to $c_{a,t}^{NB} + s_t^{NB} = \omega_t - en_t^{NB}\omega_t$ and $c_{o,t+1}^{NB} = R_{t+1}s_t^{NB}/\pi_t$. Then, we obtain

$$c_{a,t}^{NB} = \frac{1-a}{1+(1-a)\beta\pi_t}\omega_t, \qquad c_{o,t+1}^{NB} = \frac{(1-a)\beta R_{t+1}}{1+(1-a)\beta\pi_t}\omega_t,$$
$$s_t^{NB} = \frac{(1-a)\beta\pi_t}{1+(1-a)\beta\pi_t}\omega_t, \qquad n_t^{NB} = \frac{a}{e[1+(1-a)\beta\pi_t]}.$$

Second, we derive the optimal choices of corruptible bureaucrats ($i = CB$). The choices of corruptible bureaucrats who do not engage in corruption (i.e., honest bureaucrats) are the same as those of non-corruptible bureaucrats. In addition, corruptible bureaucrats who engage in corruption (i.e., dishonest bureaucrats) behave in a similar way as honest bureaucrats. If the government finds a bureaucrat behaving differently, such as larger savings, it can detect his/her corruption. Thus, to avoid being caught, dishonest bureaucrats must match their decisions regarding consumption in adulthood, savings, and number of children to those of honest bureaucrats. Furthermore, they invest illegal income in a foreign market (e.g., an offshore bank) where it is difficult for the government to observe their investment[16]. The return of the foreign market is μR_{t+1}. $\mu \in (0,1)$ represents the costs and risk of investing illegal income in the foreign market. The optimal choices of honest and dishonest bureaucrats are summarized as follows.

[16] This idea is similar to Varvarigos (2017). In the model of Varvarigos (2017), tax evaders use a storage technology, such as offshore bank accounts, to conceal their unreported income.

$$c_{a,t}^{CB(honest)} = c_{a,t}^{CB(dishonest)} = c_{a,t}^{NB},$$
$$s_{a,t}^{CB(honest)} = s_{a,t}^{CB(dishonest)} = s_{a,t}^{NB},$$
$$n_{a,t}^{CB(honest)} = n_{a,t}^{CB(dishonest)} = n_{a,t}^{NB},$$

and

$$c_{o,t+1}^{i} = \begin{cases} \dfrac{(1-a)\beta R_{t+1}}{1+(1-a)\beta\pi_t}\omega_t = c_{o,t+1}^{NB} & \text{if} \quad i = CB(honest), \\ \dfrac{(1-a)\beta R_{t+1}}{1+(1-a)\beta\pi_t}\omega_t + \dfrac{\mu(1-\delta)R_{t+1}G_t}{N_t^B} & \text{if} \quad i = CB(dishonest). \end{cases}$$

This leads to the following indirect utility for each type of corruptible bureaucrat:

$$U_t^{CB(honest)} = a\ln n_{a,t}^{CB(honest)} + (1-a)\left[\ln c_{a,t}^{CB(honest)} + \beta\pi_t \ln c_{o,t+1}^{CB(honest)}\right], \tag{33}$$

$$\begin{aligned} U_t^{CB(dishonest)} &= a\ln n_{a,t}^{CB(dishonest)} + (1-a)\Big[(1-\chi)\ln c_{a,t}^{CB(dishonest)} \\ &\quad + \beta\pi_t \ln c_{o,t+1}^{CB(dishonest)}\Big]. \end{aligned} \tag{34}$$

As in the basic model, dishonest bureaucrats face the cost of engaging in corruption, and this cost is proportional to their utility from consumption in adulthood. Since corruption occurs in adulthood, they lose a part of the utility from consumption in adulthood. We note that $U_t^{CB(honest)}$ and $U_t^{CB(dishonest)}$ depend on the stock of per capita capital, k_t, and the share of dishonest bureaucrats among the corruptible bureaucrats, σ_t, since ω_t, R_{t+1}, and G_t are a function of k_t, and π_t is a function of σ_t.

A corruptible bureaucrat j chooses the probability of engaging in corruption, $\sigma_{jt} \in [0,1]$, to maximize $U(\sigma_{jt}, \sigma_t, k_t) = \sigma_{jt}U_t^{CB(dishonest)} + (1-\sigma_{jt})U_t^{CB(honest)}$ given k_t and σ_t. Since $U(\sigma_{jt}, \sigma_t, k_t)$ is affected by the strategies of other corruptible bureaucrats, we consider a Nash equilibrium.

Definition 1 σ_{jt}^* is a Nash equilibrium if σ_{jt}^* is the best response to σ_t^* under the given k_t, for all corruptible bureaucrats. That is, $U(\sigma_{jt}^*, \sigma_t^*, k_t) \geq U(\sigma_{jt}', \sigma_t^*, k_t)$ for all $\sigma_{jt}' \in [0,1]$ and all corruptible bureaucrats.

In the Nash equilibrium, $\sigma_{jt}^* = \sigma_{-jt}^*$ so that $\sigma_{jt}^* = \sigma_t^*$.

When $\partial U(\sigma_{jt}, \sigma_t, k_t)/\partial\sigma_{jt} > 0$, $\sigma_{jt} = 1$ becomes optimal, from (33) and (34), $\partial U(\sigma_{jt}, \sigma_t, k_t)/\partial\sigma_{jt} > 0$ is rewritten as $k_t < \tilde{k}(\sigma_t)$, where

$$\tilde{k}(\sigma_t) \equiv \left\{\frac{\kappa(\sigma_t)l^\alpha}{A}\left[1 + \frac{\kappa(\sigma_t)\mu\theta l(1-\delta)}{\beta\lambda}\right]^{\frac{\beta\pi(\sigma_t)}{\chi}}\right\}^{\frac{1}{\alpha}}.$$

We note $\kappa(\sigma_t) \equiv [1+(1-a)\beta\pi(\sigma_t)]/[\rho(1-a)(1-\tau)(1-\alpha)]$. If $k_t < \tilde{k}(\sigma_t)$, a corruptible bureaucrat j takes $\sigma_{jt} = 1$. Thus, $\sigma_t = 1$ is realized since all the other corruptible bureaucrats choose the same strategy. This leads to $k_t < \tilde{k}(1)$. Then, the strategy $\sigma_{jt} = 1$ if $k_t < \tilde{k}(1)$ is the Nash equilibrium. When $\partial U(\sigma_{jt}, \sigma_t, k_t)/\partial \sigma_{jt} < 0$, we obtain $k_t > \tilde{k}(\sigma_t)$. $\sigma_{jt} = 0$ is optimal if $k_t > \tilde{k}(\sigma_t)$ holds; then, $\sigma_t = 0$ is realized. Thus, the strategy $\sigma_{jt} = 0$ if $k_t > \tilde{k}(0)$ is the Nash equilibrium. We note that $d\pi(\sigma_t)/d\sigma_t < 0$; the degree of corruption, σ_t, affects the survival rate, π_t, through which it determines the amount of public services. Then, we can prove that $\tilde{k}(1) < \tilde{k}(0)$ holds by using $d\tilde{k}(\sigma_t)/d\pi(\sigma_t) > 0$. A similar discussion can be applied to the case of $\partial U(\sigma_{jt}, \sigma_t, k_t)/\partial \sigma_{jt} = 0$. $\partial U(\sigma_{jt}, \sigma_t, k_t)/\partial \sigma_{jt} = 0$ yields $k_t = \tilde{k}(\sigma_t)$. In this case, $\sigma_{jt} \in [0, 1]$ becomes optimal. However, there is a unique σ_{jt} that satisfies $\sigma_{jt} = \tilde{\sigma}_t$ and $k_t = \tilde{k}(\tilde{\sigma}_t)$ in the interval $\tilde{k}(1) \le k_t \le \tilde{k}(0)$ since $\tilde{k}(\sigma_t)$ is a decreasing function of its argument. Its inverse function, $\tilde{\sigma}_j(k_t)$, becomes the unique strategy. In addition, since $\tilde{k}(\sigma_t)$ is a decreasing function, $\tilde{\sigma}_j(k_t)$ must decrease with k_t; that is, $d\tilde{\sigma}_j(k_t)/dk_t < 0$. Thus, the strategy $\tilde{\sigma}_j(k_t)$ if $\tilde{k}(1) \le k_t \le \tilde{k}(0)$ is the Nash equilibrium.

By summarizing the above discussion, we obtain a strategy of a corruptible bureaucrat:

$$\sigma(k_t) = \begin{cases} 1 & \text{for} \quad k_t < \tilde{k}(1), \\ \tilde{\sigma}(k_t) & \text{for} \quad \tilde{k}(1) \le k_t \le \tilde{k}(0), \\ 0 & \text{for} \quad \tilde{k}(0) < k_t. \end{cases} \tag{35}$$

This correspond to Eq. (22) in the basic model. The difference between the two equations is whether corruptible bureaucrats take a mixed strategy in the middle stages of development. In the extended model, some corruptible bureaucrats engage in corruption, while the others do not. The mixed strategy becomes optimal since a corruptible bureaucrat faces a mortality rate that is affected by strategies of other corruptible bureaucrats. The difference slightly changes the per capita public services, f_t; the quality of public health, h_t; the survival rate, π_t; and fertility rates, n_t, n_t^{NB}, $n_t^{CB(honest)}$, and $n_t^{CB(dishonest)}$. However, the intuition and mechanism behind the relationships between corruption, mortality and fertility rates, and economic development hold. That is, as economic development proceeds, the degree of corruption decreases, amount of public services increases, quality of public health improves, and mortality and fertility rates decrease.

Next, we consider the dynamics of per capita capital. The capital market clearing condition is $K_{t+1} = s_t N_t^H + s_t^{NB}(1-b)N_t^B + s_t^{CB(honest)}[1-\sigma(k_t)]bN_t^B + s_t^{CB(dishonest)}\sigma(k_t)bN_t^B$. From $N_{t+1} = n_t N_t^H + n_t^{NB}(1-b)N_t^B + n_t^{CB(honest)}[1-\sigma(k_t)]bN_t^B + n_t^{CB(dishonest)}\sigma(k_t)bN_t^B$, the condition is rewritten as follows:

$$k_{t+1} = \frac{1-a}{a} e\beta(1-\tau)(1-\alpha)Al^{-\alpha}[(1-\lambda) + \rho\lambda]\pi(\sigma(k_t))k_t^{\alpha}. \tag{36}$$

Subsequently, taking into account (35), we obtain the following three dynamic equations:

$$k_{t+1}^{C} = \frac{1-a}{a} e\beta(1-\tau)(1-\alpha)Al^{-\alpha}[(1-\lambda)+\rho\lambda]\underline{\pi}k_t^{\alpha}$$
$$k_{t+1}^{M} = \frac{1-a}{a} e\beta(1-\tau)(1-\alpha)Al^{-\alpha}[(1-\lambda)+\rho\lambda]\pi(\tilde{\sigma}(k_t))k_t^{\alpha}$$
$$k_{t+1}^{NC} = \frac{1-a}{a} e\beta(1-\tau)(1-\alpha)Al^{-\alpha}[(1-\lambda)+\rho\lambda]\bar{\pi}k_t^{\alpha}$$

where $\underline{\pi} = \Pi([1-b(1-\gamma)]\theta)$, $\pi(\tilde{\sigma}(k_t)) = \Pi([1-\tilde{\sigma}(k_t)b(1-\gamma)]\theta)$, $\bar{\pi} = \Pi(\theta)$, and $\underline{\pi} \leq \pi(\tilde{\sigma}(k_t)) \leq \bar{\pi}$. As in the basic model, two stable steady states can exist[17]: E_C and E_{NC}. E_C is characterized by severe corruption, high mortality and fertility rates, and low development, while E_{NC} is characterized by no corruption, low mortality and fertility rates, and high development. This result is the same as that in the basic model. However, we should note that it would be complicated in the extended model to consider the effective policy for a less developed country caught in a poverty trap since there are three dynamic equations (k_{t+1}^{C}, k_{t+1}^{M}, and k_{t+1}^{NC}) and two thresholds ($\tilde{k}(1)$ and $\tilde{k}(0)$).

Proof of Lemma 1

By taking the partial derivatives of $\hat{k}(\rho,\theta)$, represented by (30) with respect to ρ and θ, respectively, we obtain

$$\frac{\partial\hat{k}(\rho,\theta)}{\partial\rho} = -\frac{\hat{k}(\rho,\theta)}{\alpha\rho}\frac{1-\lambda}{1-\lambda+\rho\lambda(1-\alpha)}\left\{1+\frac{1-\chi}{\chi}\frac{1}{1+\frac{\rho\lambda(1-\theta)(1-\alpha)}{\theta(1-\delta)[(1-\lambda)+\rho\lambda(1-\alpha)]}}\right\}<0$$

and

$$\frac{\partial\hat{k}(\rho,\theta)}{\partial\theta} = \frac{\hat{k}(\rho,\theta)}{\alpha(1-\theta)}\left\{1+\frac{1-\chi}{\chi}\frac{1}{\theta+\frac{\rho\lambda(1-\theta)(1-\alpha)}{(1-\delta)[(1-\lambda)+\rho\lambda(1-\alpha)]}}\right\} > 0.$$

In addition, we obtain

$$\lim_{\rho\to\infty}\hat{k}(\rho,\theta) = \left\{\frac{\lambda}{(1-\theta)(1-\lambda)^{1-\alpha}A}\left[1+\frac{\theta(1-\delta)}{1-\theta}\right]^{\frac{1-\chi}{\chi}}\right\}^{\frac{1}{\alpha}} < \infty.$$

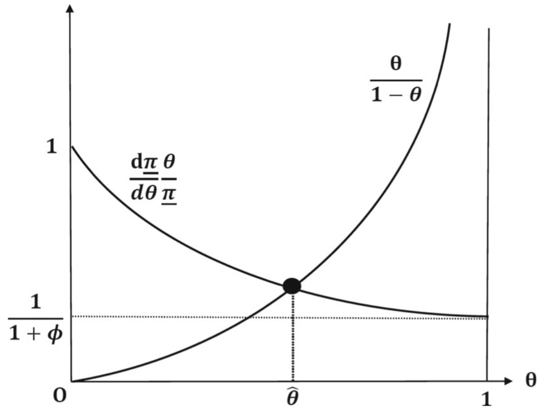
Thus, $\hat{k}(\rho,\theta)$ decreases with ρ and increases with θ. As ρ approaches infinity, $\hat{k}(\rho,\theta)$ converges to a finite value.

Proof of Lemma 2

By taking the partial derivative of $k^*(\rho,\theta)$, represented by (29) with respect to ρ, we obtain

[17] The steady state at which the 45-degree line intersects with k_{t+1}^{M} is unstable.

Fig. 8 $(d\underline{\pi}/\underline{\pi})/(d\theta/\theta)$ and $\theta/(1-\theta)$



$$\frac{\partial k^*(\rho,\theta)}{\partial \rho} = -\frac{k^*(\rho,\theta)\lambda}{(1-\lambda)+\rho\lambda(1-\alpha)} < 0.$$

That is, $k^*(\rho,\theta)$ decreases with ρ. Similarly, by taking the partial derivative of $k^*(\rho,\theta)$ with respect to θ, we obtain

$$\frac{\partial k^*(\rho,\theta)}{\partial \theta} = \frac{k^*(\rho,\theta)}{\theta(1-\alpha)}\left(\frac{d\underline{\pi}}{d\theta}\frac{\theta}{\underline{\pi}} - \frac{\theta}{1-\theta}\right).$$

$(d\underline{\pi}/\underline{\pi})/(d\theta/\theta)$ represents the degree to which a change in θ leads to a change in the survival rate, $\underline{\pi}$. Since the survival rate is given by (31), it has the following characteristics:

$$\frac{d}{d\theta}\left(\frac{d\underline{\pi}}{d\theta}\frac{\theta}{\underline{\pi}}\right) < 0, \quad \frac{d^2}{d\theta^2}\left(\frac{d\underline{\pi}}{d\theta}\frac{\theta}{\underline{\pi}}\right) > 0, \quad \left.\frac{d\underline{\pi}}{d\theta}\frac{\theta}{\underline{\pi}}\right|_{\theta=0} = 1, \quad \left.\frac{d\underline{\pi}}{d\theta}\frac{\theta}{\underline{\pi}}\right|_{\theta=1} = \frac{1}{1+\phi}.$$

On the other hand, we can show that

$$\frac{d}{d\theta}\left(\frac{\theta}{1-\theta}\right) > 0, \quad \frac{d^2}{d\theta^2}\left(\frac{\theta}{1-\theta}\right) > 0, \quad \lim_{\theta\to 0}\frac{\theta}{1-\theta} = 0, \quad \lim_{\theta\to 1}\frac{\theta}{1-\theta} = \infty.$$

Thus, there is a threshold, $\hat{\theta} = [-1+(1+\phi)^{\frac{1}{2}}]/\phi$, that satisfies $(d\underline{\pi}/\underline{\pi})/(d\theta/\theta)|_{\theta=\hat{\theta}} = \hat{\theta}/(1-\hat{\theta})$. We also confirm $\hat{\theta}$ in Fig. 8. If $\theta \in (0,\hat{\theta})$, $(d\underline{\pi}/\underline{\pi})/(d\theta/\theta) > \theta/(1-\theta)$ holds. On the contrary, if $\theta \in [\hat{\theta},1)$, $(d\underline{\pi}/\underline{\pi})/(d\theta/\theta) \leq \theta/(1-\theta)$ holds. Thus, we obtain

$$\frac{\partial k^*(\rho,\theta)}{\partial \theta}\begin{cases} > 0 & \text{if} \quad \theta \in (0,\hat{\theta}), \\ \leq 0 & \text{if} \quad \theta \in [\hat{\theta},1). \end{cases}$$

That is, $k^*(\rho,\theta)$ is hump-shaped in θ.

References

Acemoglu D, Verdier T (1998) Property rights, corruption and the allocation of talent: a general equilibrium approach. Econ J 108(450):1381–1403

Agénor PR (2015) Public capital, health persistence and poverty traps. J Econ 115(2):103–131

Aisa R, Pueyo F (2006) Government health spending and growth in a model of endogenous longevity. Econ Lett 90(2):249–253

Alesina A, Angeletos GM (2005) Corruption, inequality, and fairness. J Monet Econ 52(7):1227–1244

Barr A, Serra D (2010) Corruption and culture: an experimental analysis. J Public Econ 94(11–12):862–869

Becker GS, Stigler GJ (1974) Law enforcement, malfeasance, and compensation of enforcers. J Legal Stud 3(1):1–18

Besley T, McLaren J (1993) Taxes and bribery: the role of wage incentives. Econ J 103(416):119–141

Bhattacharya J, Qiao X (2007) Public and private expenditures on health in a growth model. J Econ Dyn Control 31(8):2519–2535

Blackburn K (2012) Corruption and development: explaining the evidence. Manch School 80(4):401–428

Blackburn K, Cipriani GP (1998) Endogenous fertility, mortality and growth. J Popul Econ 11(4):517–534

Blackburn K, Cipriani GP (2002) A model of longevity, fertility and growth. J Econ Dyn Control 26(2):187–204

Blackburn K, Forgues-Puccio GF (2007) Distribution and development in a model of misgovernance. Eur Econ Rev 51(6):1534–1563

Blackburn K, Forgues-Puccio GF (2009) Why is corruption less harmful in some countries than in others? J Econ Behav Org 72(3):797–810

Blackburn K, Sarmah R (2008) Corruption, development and demography. Econ Gov 9(4):341–362

Blackburn K, Bose N, Haque ME (2006) The incidence and persistence of corruption in economic development. J Econ Dyn Control 30(12):2447–2467

Blackburn K, Bose N, Haque ME (2011) Public expenditures, bureaucratic corruption and economic development. Manch School 79(3):405–428

Cervellati M, Sunde U (2007) Human capital, mortality and fertility: a unified theory of the economic and demographic transition. IZA Discussion Paper (2905)

Chakraborty S (2004) Endogenous lifetime and economic growth. J Econ Theory 116(1):119–137

Chong A, Calderon C (2000) Causality and feedback between institutional measures and economic growth. Econ Politics 12(1):69–81

Cigno A (1998) Fertility decisions when infant survival is endogenous. J Popul Econ 11(1):21–28

Di Tella R, Schargrodsky E (2003) The role of wages and auditing during a crackdown on corruption in the city of buenos aires. J Law Econ 46(1):269–292

Dioikitopoulos EV (2014) Aging, growth and the allocation of public expenditures on health and education. Canadian Journal of Economics/Revue Canadienne d'économique 47(4):1173–1194

Dong B, Dulleck U, Torgler B (2012) Conditional corruption. J Econ Psychol 33(3):609–627

Dzhumashev R (2014a) Corruption and growth: The role of governance, public spending, and economic development. Econ Modell 37:202–215

Dzhumashev R (2014b) The two-way relationship between government spending and corruption and its effects on economic growth. Contemp Econ Policy 32(2):403–419

Ehrlich I, Lui FT (1999) Bureaucratic corruption and endogenous economic growth. J Polit Econ 107(S6):S270–S293

Eicher T, García-Peñalosa C, Van Ypersele T (2009) Education, corruption, and the distribution of income. J Econ Growth 14(3):205–231

Fanti L, Gori L (2014) Endogenous fertility, endogenous lifetime and economic growth: the role of child policies. J Popul Econ 27(2):529–564

Fioroni T (2010) Child mortality and fertility: public vs private education. J Popul Econ 23(1):73–97

Futagami K, Konishi K (2019) Rising longevity, fertility dynamics, and R&D-based growth. J Popul Econ 32(2):591–620

Galor O, Moav O (2005) Natural selection and the evolution of life expectancy. CEPR Discussion Paper (5373)

Goel RK, Nelson MA (1998) Corruption and government size: A disaggregated analysis. Public Choice 97(1–2):107–120

Hazan M, Zoabi H (2006) Does longevity cause growth? a theoretical critique. J Econ Growth 11(4):363–376

Kalemli-Ozcan S (2002) Does the mortality decline promote economic growth? J Econ Growth 7(4):411–439

Ki H, Tabata K (2005) Health infrastructure, demographic transition and growth. Rev Develop Econ 9(4):549–562

Lagerlöf NP (2003) From malthus to modern growth: can epidemics explain the three regimes? Int Econ Rev 44(2):755–777

Lee WS, Guven C (2013) Engaging in corruption: The influence of cultural values and contagion effects at the microlevel. J Econ Psychol 39:287–300

Lorentzen P, McMillan J, Wacziarg R (2008) Death and development. J Econ Growth 13(2):81–124

Mauro P (1995) Corruption and growth. Q J Econ 110(3):681–712

Okada K (2020) Dynamic analysis of demographic change and human capital accumulation in an R&D-based growth model. J Econ 130:225–248

Osang T, Sarkar J (2008) Endogenous mortality, human capital and economic growth. J Macroecon 30(4):1423–1445

Rajkumar AS, Swaroop V (2008) Public spending and outcomes: does governance matter? J Develop Econ 86(1):96–111

Sarte PDG (2001) Rent-seeking bureaucracies and oversight in a simple growth model. J Econ Dyn Control 25(9):1345–1365

Spinesi L (2009) Rent-seeking bureaucracies, inequality, and growth. J Develop Econ 90(2):244–257

Treisman D (2000) The causes of corruption: a cross-national study. J Public Econ 76(3):399–457

Van Rijckeghem C, Weder B (2001) Bureaucratic corruption and the rate of temptation: do wages in the civil service affect corruption, and by how much? J Develop Econ 65(2):307–331

Varvarigos D (2017) Cultural norms, the persistence of tax evasion, and economic growth. Econ Theory 63(4):961–995

Varvarigos D, Arsenis P (2015) Corruption, fertility, and human capital. J Econ Behav Org 109:145–162

Wadho WA (2016) Corruption, tax evasion and the role of wage incentives with endogenous monitoring technology. Econ Inquiry 54(1):391–407

World Bank (2003) World development report 2004: making services work for poor people. World Development Report