Public-Private Wage Gap and Corruption in a Macroeconomic Model*

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Abstract

In developing countries, large public wage premiums are confirmed. On the other hand, in developed countries, small public wage premiums exist but they are close to zero. According to seminal theoretical works on corruption, offering public workers a higher wage than they can get elsewhere reduces corruption. However, data on corruption indicates that developing countries suffer more severe corruption. Thus, the observed evidence that larger public wage premiums and higher levels of corruption coexist in developing countries, while smaller or zero premiums and lower levels of corruption coexist in developed countries is puzzling. To the best of our knowledge, no theoretical study explains this puzzle. The aim of this paper is to provide an explanation for the aforementioned puzzle by analyzing the relationships among public wages, corruption, and economic development.

Keywords: Bureaucratic corruption; Public sector wage; Economic development

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1 Introduction

Much attention has been given to the question of whether a public-private wage gap exists. Some studies identify positive public-private wage gaps (i.e., public wage premiums) whereas others identify negative gaps (i.e., public wage penalties). However, the main results obtained in the empirical literature are as follows. Significantly large public wage premiums are confirmed in developing countries. On the other hand, in developed countries, small public wage premiums exist but they are close to zero (Lausev (2014)).

In literature on corruption, it is recognized that public wage premiums can deter corruption. The seminal work by Becker and Stigler (1974) shows that offering public workers a higher wage than they can get elsewhere (i.e., an opportunity or reservation wage) reduces corruption. Moreover, empirical studies provide evidence on the negative effects of high public wages on corruption (for example, see Goel and Nelson (1998), Van Rijckeghem and Weder (2001), and Di Tella and Schargrodsky (2003)). In fact, international organizations recommend a policy of raising public workers' wages as a means of fighting corruption.

Studies on public wage and corruption predict that the degree of corruption will be lower in developing countries with substantial public wage premiums than in developed countries with small or near-zero premiums. However, data on corruption indicates that developing countries suffer more severe corruption[1]. In addition, a negative correlation between corruption and economic development has been well established by empirical studies such as Knack and Keefer (1995), Mauro (1995), Keefer and Knack (1997), Li et al. (2000), Gyimah-Brempong (2002), and Aidt (2009).

The observed evidence that larger public wage premiums and higher levels of corruption coexist in developing countries, while smaller or zero premiums and lower levels

[1]One of the indexes of corruption is the Corruption Perception Index published by Transparency International. It uses a scale of 0 to 100, in which a high score indicates a low degree of corruption, and vice versa. According to the index, in 2017 low-income or lower-middle-income countries had lower scores: 22 for Haiti, 33 for Bolivia, and 35 for Vietnam. On the other hand, high-income countries had higher scores: 73 for Japan, 75 for the United States, and 81 for Germany. New Zealand ranks the highest with 89.

of corruption coexist in developed countries is puzzling. To the best of our knowledge, no theoretical study explains this puzzle. This is because studies about public-private wage gaps do not consider corruption, whereas studies about the effects of higher public wages on corruption do not consider economic development[2]. The aim of this paper is to provide an explanation for the aforementioned puzzle by analyzing the relationships among public wages, corruption, and economic development.

We construct a two-period overlapping-generation model in which bureaucrats can engage in corruption. The model has two features. Firstly, a government chooses the public wage rate for bureaucrats to maximize the welfare of households. The welfare maximization is achieved by minimizing the degree of corruption. As in Besley and McLaren (1993), three types of public wages exist: a reservation wage, an efficiency wage, and a capitulation wage. The reservation wage is equal to the private wage. Since bureaucrats can work in the private sector, the private wage is an outside option for them. The efficiency wage is higher than the reservation wage, while the capitulation wage is lower. Secondly, educated households are able to monitor the corrupt behavior of bureaucrats. Thus, the probability of detecting corruption depends on the number of educated households determined endogenously. This idea is in agreement with Glaeser et al. (2007), who analyze the relationship between education and democracy. They show that education increases all forms of social and political participation.

Our results replicate empirical facts on the public-private wage gap and corruption. When a stock of capital is small, a government offers efficiency wages, and most bureaucrats engage in corruption. On the other hand, when a stock of capital is large, a government offers reservation wages, and no bureaucrat engages in corruption. That is, public wage premiums are large and the degree of corruption is high in developing countries, whereas public wage premiums and corruption are non-existent in developed countries. However, when a stock of capital is very low, a government offers a capitulation wage and all bureaucrats engage in corruption. This is supported by Gorodnichenko

[2]A few seminal works that explain the wage gaps between public and private sectors are Gunderson (1979), Holmlund (1993), and Burdett (2012). Starting from Becker and Stigler (1974), many studies construct static models to examine the effects of public wages on corruption. For example, see Besley and McLaren (1993), Mookherjee and Png (1995), Acemoglu and Verdier (1998), and Wadho (2016).

and Peter (2007) and Saha et al. (2014). Gorodnichenko and Peter (2007) find that, in the Ukraine, public workers receive public wage penalties while they have identical levels of consumer expenditure and asset holdings. This implies the existence of unreported income (e.g., bribery) in the public sector. In addition, Saha et al. (2014) obtain similar evidence in India.

This model can provide one explanation for the puzzle. In an economy with a very small stock of capital, only a small number of households monitor the corrupt behavior of bureaucrats. It follows that efficiency wages are too high for the government to reduce corruption by offering a higher public wage. Then, the government has no choice but to accept corruption by offering a lower wage. As capital accumulates and more households obtain education, the efficiency wage becomes lower. Then, offering the efficiency wage becomes feasible and optimal. However, the feasible efficiency wage level is not sufficiently high to deter some bureaucrats who have higher abilities from engaging in corruption. Thus, much of the corruption remains. At last, in an economy with a large stock of capital, offering the reservation wage is enough to reduce corruption because all or most households receive education, and the probability of detecting corruption is thus, high. In this case, no bureaucrat engages in corruption.

Moreover, we show that an economy that always offers reservation wages can fall into a poverty trap. It can suffer from a lower level of economic development and a higher level of corruption in a steady state. However, our results suggest that offering efficiency wages that are higher than reservation wages can help an economy escape the trap. A policy that ensures a higher public wage is effective for reducing corruption and promoting capital accumulation. Thus, by adopting this policy, an economy can converge to new steady state and achieve a higher level of development with minimal corruption.

The rest of this article is organized as follows. Section 2 constructs the model. Section 3 derives equilibrium conditions and examines relationships among public-private wage gaps, corruption, and economic development. Section 4 shows the dynamics of an economy and describes a poverty trap. Section 5 concludes the paper.

2 Model

We consider a two-period overlapping-generation model. At birth, individuals are divided into two groups: households and bureaucrats. Households receive education, work in the private sector, pay tax, save in the first period, and consume goods in the second period. Size is normalized to one. On the other hand, for simplicity, bureaucrats live for one period; they work in the public sector and consume goods[3]. The size is $\lambda \in (0, 1)$. Then, the population's size is constant over time; that is, $1 + \lambda$. The private sector is perfectly competitive. Firms produce final goods by using labor and capital. A government employs bureaucrats to transfer public funds to households. In the course of doing their jobs, bureaucrats can engage in corruption.

2.1 Households

At the beginning of the first period of life, a household decides whether to obtain education. To obtain education, it has to pay e units of final goods. If it does obtain education, it supplies labor as a skilled worker and earns the wage for skilled workers, $w_{s,t}$. On the other hand, if it does not, it supplies labor as an unskilled worker and earns the wage for unskilled workers, $w_{u,t}$. Then, its consumption level in the next period is as follows:

$$\begin{cases} (1 + r_{t+1})(w_{s,t} - e + b_t - \tau) & \text{if being educated,} \\ (1 + r_{t+1})(w_{u,t} + b_t - \tau) & \text{if being not educated,} \end{cases} \tag{1}$$

where r_{t+1}, τ, and b_t are the interest rate in period $t+1$, the constant tax rate, and the income transfer from the government in period t. From (1), it becomes a skilled worker

[3]We can confirm that our results still hold, even if we construct a model where bureaucrats live two periods and save their labor income in the first period as households do. While the dynamics would change quantitatively, our implications hold true.

if $(1+r_{t+1})(w_{s,t}-e+b_t-\tau) \geq (1+r_{t+1})(w_{u,t}+b_t-\tau)$ holds. That is,

$$w_{s,t} \geq w_{u,t} + e. \tag{2}$$

This says that the net return of education, $w_{s,t} - w_{u,t} - e$ is non-negative.

2.2 Bureaucrats

Bureaucrats live for only one period and have the ability to obtain education without incurring costs. In addition, they are exempt from taxes and do not receive a portion of the income transfer. These assumptions clarify our analysis. Instead, we consider heterogeneity among bureaucrats. A bureaucrat i has the ability $h_i \in [\underline{h}, \bar{h}]$ that is drawn from a continuous distribution. $f(h_i)$ and $F(h_i)$ denote its probability density function and its cumulative distribution function, respectively. Each bureaucrat knows its own ability. However, the ability is publicly unobservable and the government only knows the distribution.

The government delegates the job of transferring public funds to bureaucrats. Each bureaucrat is provided with g/λ units of funds that should be transferred to households. A bureaucrat i can obtain a portion of the funds as illegal income, $\gamma g/\lambda$, and distribute $(1-\gamma)g/\lambda$ units of funds to households, where $\gamma \in (0,1)$. This represents corruption in this model. If the bureaucrat engages in corruption, its total income is $\omega_t + \gamma g/\lambda - c/h_i$ where ω_t is the public wage and c/h_i is the cost of concealing corrupt behavior. A corrupt bureaucrat with higher ability incurs lower costs. However, since the monitoring system works in the economy, it gets caught and loses all its income with the probability π_t. Thus, if the bureaucrat engages in corruption, the expected income is as follows:

$$(1-\pi_t)\left(\omega_t + \frac{\gamma g}{\lambda} - \frac{c}{h_i}\right). \tag{3}$$

On the other hand, if the bureaucrat is honest, it gets ω_t. Then, if $\omega_t < (1-\pi_t)(\omega_t + \gamma g/\lambda - c/h_i)$ holds, it engages in corruption. Let σ_t denote the share of corrupt bureau-

crats; that is, $\sigma_t \lambda$ is the number of corrupt bureaucrats.

2.3 Firms

Final goods are produced from two complementary production processes. One uses skilled workers and capital and has a Cobb-Douglas production technology. The other uses unskilled workers and has a linear production technology. The productivity level of skilled workers, A_s, is higher than that of unskilled workers, A_u. That is, $A_s > A_u > 0$ is assumed. The total amount of final goods is represented by the following:

$$y_t = A_s l_{s,t}^{\alpha} k_t^{1-\alpha} + A_u l_{u,t}, \tag{4}$$

where k_t, $l_{s,t}$, and $l_{u,t}$ are the capital stock, the labor force of skilled workers, and the labor force of unskilled workers, respectively. The capital stock is assumed to be fully depreciated. The first order conditions are as follows:

$$r_t = (1-\alpha) A_s l_{s,t}^{\alpha} k_t^{-\alpha}, \tag{5}$$

$$w_{s,t} = \alpha A_s l_{s,t}^{\alpha-1} k_t^{1-\alpha}, \tag{6}$$

$$w_{u,t} = A_u \equiv w_u. \tag{7}$$

The wage for skilled workers depends on the stock of capital, while the wage for unskilled workers is constant.

2.4 Government

The government collects lump-sum taxes from households and uses the tax revenue for the income transfer and for wage payments for bureaucrats. The λ number of bureaucrats should be hired in order to transfer public funds to households. Since the government cannot observe the ability of each bureaucrat, it offers identical public

wages. Thus, the budget constraint is as follows[4]:

$$\tau \geq g + \lambda\omega_t. \tag{8}$$

Under the constraint (8), the government sets the public wage, ω_t, to maximize the welfare of households. Since in this model, a decrease in corruption increases the income transfer from the government, reducing corruption increases the total income and consumption of households in (1). Thus, welfare-maximization is achieved by minimizing the degree of corruption[5].

The government can offer three types of public wages: a reservation wage, an efficiency wage, and a capitulation wage. A reservation wage is equal to a private wage for a skilled worker, $w_{s,t}$. We assume that bureaucrats can work in the private sector as skilled workers. Then, $w_{s,t}$ is an outside option for bureaucrats. An efficiency wage is defined as a wage rate above which a bureaucrat i does not engage in corruption. We can derive the efficiency wage for a bureaucrat i with ability h_i by solving the equation $\omega_t = (1-\pi_t)(\omega_t + \gamma g/\lambda - c/h_i)$ for ω_t: that is,

$$\omega_t = \frac{1-\pi_t}{\pi_t}\left(\frac{\gamma g}{\lambda} - \frac{c}{h_i}\right) \equiv \omega^{ef}(\pi_t; h_i). \tag{9}$$

[4]When the government recognizes corrupt bureaucrats, it dispossesses them of their whole income, and the budget constraint can be written in the following form: $\tau + \int_{\hat{h}_t}^{\bar{h}} \pi_t\sigma_t\lambda\left(\omega_t + \frac{\gamma g}{\lambda} - \frac{c}{h_i}\right)dh_i \geq g + \lambda\omega_t$ where bureaucrats with ability $h_i \in (\hat{h}_t, \bar{h}]$ engage in corruption. However, it seems reasonable to assume that the government does not take into account the revenue from the penalty when it decides the wage level. Then, we consider optimal public wages by using the budget constraint given by (8). If the net revenue is positive, $\tau + \int_{\hat{h}_t}^{\bar{h}} \pi_t\sigma_t\lambda\left(\omega_t + \frac{\gamma g}{\lambda} - \frac{c}{h_i}\right)dh_i - (g + \lambda\omega_t) > 0$, the government consumes it.

[5]This objective of the government is different from that assumed in other theoretical studies on corruption. Governments maximize a net tax revenue in studies based on microeconomic models such as Glaeser et al. (2007) and Wadho (2016). However, if the net tax revenue is transferred to households, this objective would accomplish the welfare maximization of households. In this case, the governments in previous models and in our model achieve the same goal. In macroeconomic models such as Blackburn et al. (2006) and Varvarigos and Arsenis (2015), governments minimize wage payments while they hire the necessary number of bureaucrats. This assumption clarifies their focus on a two-way causal relationship between corruption and development and its channels. On the other hand, our focus is on the public wage strategies of the government.

If the public wage is not lower than its efficiency wage, $\omega_t \geq \omega^{ef}(\pi_t; h_i)$, a bureaucrat i does not engage in corruption. On the other hand, if the public wage is lower than its efficiency wage, $\omega_t < \omega^{ef}(\pi_t; h_i)$, the bureaucrat engages in corruption. Efficiency wages for bureaucrats have the following properties. For a bureaucrat with higher ability, a higher public wage is required to deter it from corruption; that is, $\partial\omega^{ef}(\pi_t; h_i)/\partial h_i > 0$. In addition, when the monitoring system works well, efficiency wages become lower, that is, $\partial\omega^{ef}(\pi_t; h_i)/\partial\pi_t < 0$. A capitulation wage is the rate at which a reservation wage is equal to the expected income a bureaucrat i obtains when it engages in corruption; that is, $w_{s,t} = (1-\pi_t)(\omega_t + \gamma g/\lambda - c/h_i)$. Offering the capitulation wage implies that the government accepts corrupt behavior. Solving this equation yields a capitulation wage for bureaucrat i as follows:

$$\omega_t = \frac{w_{s,t}}{1-\pi_t} - \frac{\gamma g}{\lambda} + \frac{c}{h_i} \equiv \omega^{ca}(\pi_t, w_{s,t}; h_i). \tag{10}$$

As the probability of detecting corruption increases, the capitulation wage also increases, that is, $\partial\omega^{ca}(\pi_t, w_{s,t}; h_i)/\partial\pi_t > 0$. In addition, since $\partial\omega^{ca}(\pi_t, w_{s,t}; h_i)/\partial h_i < 0$, if the government offers $\omega_t = \omega^{ca}(\pi_t, w_{s,t}; h_i)$ bureaucrats whose ability satisfies $h_j \in [\underline{h}, h_i)$ move to the private sector.

3 Equilibrium

Firstly, we consider the educational choices by households. From (2), (6), and (7), the number of households who receive education is $l_{s,t} = [\alpha A_s/(A_u + e)]^{\frac{1}{1-\alpha}} k_t$. Since the size of households is unity, $l_{s,t}$ should be in the interval $0 \leq l_{s,t} \leq 1$. Then, we can rewrite the number of skilled households as follows:

$$l_{s,t} = \begin{cases} \phi k_t & \text{if} \quad k_t \in [0, k^s), \\ 1 & \text{if} \quad k_t \in [k^s, \infty), \end{cases} \tag{11}$$

where $\phi \equiv [\alpha A_s/(A_u + e)]^{\frac{1}{1-\alpha}}$ and k^s is defined by

$$k^s \equiv \phi^{-1}. \tag{12}$$

k_s is the threshold above which all households receive education and work as skilled workers. By substituting (11) into (6), the private wage for a skilled worker becomes the following:

$$w_{s,t} = \begin{cases} A_u + e & \text{if} \quad k_t \in [0, k^s), \\ \alpha A_s k_t^{1-\alpha} & \text{if} \quad k_t \in [k^s, \infty). \end{cases} \tag{13}$$

In an equilibrium, households are indifferent about whether to receive education for $k_t \in [0, k^s)$, since $w_{s,t} = A_u + e$ and $w_{u,t} = A_u$.

3.1 Three types of public wages

This paper considers an economy in which educated households monitor bureaucrats' behavior. We assume that the probability of detecting corruption is equal to the number of skilled households, that is, $\pi_t = l_{s,t}$. This assumption captures the idea that educated individuals are better able to access and understand information about policies and corruption. This idea is supported by empirical findings. Glaeser and Saks (2006) find that US states with larger populations of educated individuals have a lower degree of corruption. By using cross-country and dynamic panel data, Fortunato and Panizza (2015) show that education increases the quality of governments. Glaeser et al. (2007) explain the correlation between education and democracy. Based on empirical facts, they construct a model in which education increases political participation. Moreover, Eicher et al. (2009) apply the empirical evidence to their study. In their model, the probability that a corrupt political party will be found increases with the number of educated individuals. We follow these strands of studies.

The efficiency wage for a bureaucrat i with ability h_i is rewritten as follows: from

(9) and (11),

$$\omega^{ef}(k_t; h_i) = \begin{cases} \frac{1-\phi k_t}{\phi k_t}\left(\frac{\gamma g}{\lambda} - \frac{c}{h_i}\right) & \text{if} \quad k_t \in [0, k^s), \\ 0 & \text{if} \quad k_t = k^s. \end{cases} \tag{14}$$

$\omega^{ef}(k_t; h_i)$ has the following characteristics; $\partial\omega^{ef}(k_t; h_i)/\partial k_t < 0$, $\partial^2\omega^{ef}(k_t; h_i)/\partial k_t^2 > 0$, and $\partial\omega^{ef}(k_t; h_i)/\partial h_i > 0$. As capital accumulates, the number of skilled households increases, and then the efficiency wage decreases. It follows that capital accumulation makes it easier for a government to offer an efficiency wage. Then, we derive the threshold of k_t, above which a government can offer the public wage $\omega_t = \omega^{ef}(k_t; h_i)$; from the budget constraint $\tau - g = \lambda\omega^{ef}(k_t; h_i)$,

$$k_t = \frac{\lambda\left(\frac{\gamma g}{\lambda} - \frac{c}{h_i}\right)\phi^{-1}}{\tau - g + \lambda\left(\frac{\gamma g}{\lambda} - \frac{c}{h_i}\right)} \equiv k^{ef}(h_i). \tag{15}$$

Since $dk^{ef}(h_i)/dh_i > 0$, at $k_t = k^{ef}(h_i)$, the government can offer the efficiency wage $\omega^{ef}(k_t; h_j)$ for $h_j \in [\underline{h}, h_i]$. Let us denote $\hat{h}(k_t)$ the ability that satisfies $k_t = k^{ef}(\hat{h}(k_t))$. $\hat{h}(k_t)$ is represented by $\hat{h}(k_t) = (k^{ef})^{-1}(k_t)$ where $(k^{ef})^{-1}(\cdot)$ is the inverse function of $k^{ef}(\cdot)$. Then, when the public wage is $\omega_t = \omega^{ef}(k_t; \hat{h}(k_t))$, the government can deter bureaucrats whose ability is $h_i \in [\underline{h}, \hat{h}(k_t)]$ from engaging in corruption. It yields the share of corruption as follows:

$$\sigma_t = 1 - F(\hat{h}(k_t)). \tag{16}$$

As educated households increase and the probability of detecting corruption increases, the efficiency wage becomes lower than the reservation wage. Then, as capital accumulates, a bureaucrat i behaves honestly even if the public wage is equal to the reservation wage. Since, for $k_t \in [0, k^s)$, $w_{s,t} = A_u + e$ and $\omega^{ef}(k_t; h_i)$ is positive and decreases in k_t, there exists the threshold of k_t that satisfies $\omega^{ef}(k_t; h_i) = w_{s,t}$. The

threshold is represented by:

$$k_t = \frac{\left(\frac{\gamma g}{\lambda} - \frac{c}{h_i}\right)\phi^{-1}}{A_u + e + \frac{\gamma g}{\lambda} - \frac{c}{h_i}} \equiv k^{re}(h_i). \tag{17}$$

This threshold increases in h_i; that is, $dk^{re}(h_i)/dh_i > 0$. When $k^{re}(h_i) \leq k_t$, offering the reservation wage can deter bureaucrats whose ability is $h_j \in [\underline{h}, h_i]$ from engaging in corruption.

The capitulation wage for a bureaucrat i with ability h_i is rewritten as follows: from (10), (11), and (13), it becomes

$$\omega^{ca}(k_t; h_i) = \frac{A_u + e}{1 - \phi k_t} - \frac{\gamma g}{\lambda} + \frac{c}{h_i}. \tag{18}$$

At $k_t = k^{re}(h_i)$, a bureaucrat i stops engaging in corrupt behavior. Thus, $\omega^{ca}(k_t; h_i)$ is defined in the interval $k_t \in [0, k^{re}(h_i)]$. The capitulation wages have the following properties: $\partial\omega^{ca}(k_t; h_i)/\partial k_t > 0$, $\partial^2\omega^{ca}(k_t; h_i)/\partial k_t^2 > 0$, and $\omega^{ca}(k^{re}(h_i); h_i) = A_u + e$ for all $h_i \in [\underline{h}, \bar{h}]$. In addition, $\partial\omega^{ca}(k_t; h_i)/\partial h_i < 0$. It follows that when the government decides to offer a capitulation wage, ω_t should be $\omega^{ca}(k_t; \underline{h})$ to attract all bureaucrats. If the government offers $\omega_t = \omega^{ca}(k_t; h_i)$, bureaucrats whose ability is $h_j \in [\underline{h}, h_i)$ move to the private sector.

When $k_t < k^s$, the reservation wage is $\omega_t = A_u + e$. We assume that the government has enough budget to pay the reservation wage for all bureaucrats, that is,

$$\tau - g > \lambda(A_u + e). \tag{19}$$

When $k_t \geq k^s$, the reservation wage increases with the stock of capital, $\omega_t = \alpha A_s k_t^{1-\alpha}$. Since τ and g are constant, there is an upper limit of k_t, above which the government cannot pay the reservation wage. $\bar{k}$ denotes the upper limit and satisfies

$\tau - g = \lambda\alpha A_s k_t^{1-\alpha}$. It is defined by the following:

$$\bar{k} \equiv \left(\frac{\tau - g}{\lambda\alpha A_s}\right)^{\frac{1}{1-\alpha}}. \tag{20}$$

Then, from (12), (15), (17), (19), and (20),

$$0 < k^{ef}(h_i) < k^{re}(h_i) < k^s < \bar{k}$$

holds for all bureaucrats. Furthermore, since $dk^{ef}(h_i)/dh_i > 0$ and $dk^{re}(h_i)/dh_i > 0$, we obtain $k^{ef}(\underline{h}) < k^{ef}(\bar{h})$ and $k^{re}(\underline{h}) < k^{re}(\bar{h})$. The relationship between $k^{re}(\underline{h})$ and $k^{ef}(\bar{h})$ is ambiguous since it depends on the following parameters:

$$k^{re}(\underline{h}) \begin{array}{c} \geq \\ < \end{array} k^{ef}(\bar{h}) \quad \Leftrightarrow \quad \frac{\frac{\tau-g}{\lambda}}{A_u + e} \begin{array}{c} \geq \\ < \end{array} \frac{\frac{\gamma g}{\lambda} - \frac{c}{\underline{h}}}{\frac{\gamma g}{\lambda} - \frac{c}{\bar{h}}} \tag{21}$$

The following analysis assumes $k^{re}(\underline{h}) < k^{ef}(\bar{h})$, and then the following relationships hold among thresholds[6]:

$$0 < k^{ef}(\underline{h}) < k^{re}(\underline{h}) < k^{ef}(\bar{h}) < k^{re}(\bar{h}) < k^s < \bar{k}. \tag{22}$$

3.2 Optimal public wage

A government determines the public wage to maximize the welfare of households. Since decreases in corruption increase the level of consumption of households, a government can achieve welfare-maximization by minimizing the degree of corruption. We consider optimal public wages in five ranges of the stock of capital, respectively.

The first case is that the stock of capital is in the interval $k_t \in \left[0, k^{ef}(\underline{h})\right)$. At this stage, since the probability of detecting of corruption is low, efficiency wages are

[6]The relationship between $k^{re}(\underline{h})$ and $k^{ef}(\bar{h})$ does not affect our main results. That is, the model replicates empirical facts on public wage premiums and corruption discussed in the introduction, if we assume $k^{re}(\underline{h}) > k^{ef}(\bar{h})$.

high. Thus, the government cannot reduce corruption by paying efficiency wages, and all bureaucrats engage in corruption; that is, $\sigma_t = 1$. Then, to hire the λ number of bureaucrats by minimizing wage payments, offering the capitulation wage is rational; that is, the public wage is $\omega_t = \omega^{ca}(k_t; \underline{h})$ in the interval $k_t \in \big[0, k^{ef}(\underline{h})\big)$.

The second case is that the stock of capital is in the interval $k_t \in \big[k^{ef}(\underline{h}), k^{ef}(\bar{h})\big)$. Some bureaucrats who have lower abilities stop engaging in corruption if they obtain a wage higher than their efficiency wage. Then, by offering the efficiency wage, the government can reduce corruption. Note that the government can afford to offer efficiency wages to bureaucrats with ability $h_i \in [\underline{h}, \hat{h}(k_t)]$ at k_t. To minimize the degree of corruption, it is optimal to raise the public wage as much as possible. It yields the optimal public wage $\omega_t = \omega^{ef}(k_t; \hat{h}(k_t))$ for $k_t \in \big[k^{ef}(\underline{h}), k^{ef}(\bar{h})\big)$ that satisfies $\tau - g = \lambda\omega^{ef}(k_t; \hat{h}(k_t))$. Thus, the public wage is represented by $\omega_t = (\tau - g)/\lambda$ for $k_t \in \big[k^{ef}(\underline{h}), k^{ef}(\bar{h})\big)$. The share of corrupt bureaucrats is given by $\sigma_t = 1 - F(\hat{h}(k_t))$ and decreases in k_t.

The third case is that the stock of capital is in the interval $k_t \in \big[k^{ef}(\bar{h}), k^{re}(\bar{h})\big)$. Since many households now become educated, the efficiency wages are sufficiently low for the government to offer $\omega^{ef}(k_t; h_i)$ for $h_i \in [\underline{h}, \bar{h}]$. Then, the government can eradicate corruption completely by offering the maximum efficiency wage, $\omega(k_t; \bar{h})$. Thus, the optimal public wage is $\omega(k_t; \bar{h})$ for $k_t \in \big[k^{ef}(\bar{h}), k^{re}(\bar{h})\big)$. The share of corrupt bureaucrats becomes zero, that is, $\sigma_t = 0$.

The fourth case is that the stock of capital is in the interval $k_t \in \big[k^{re}(\bar{h}), k^{s}\big)$. Regardless of the public wage level, no bureaucrats find corruption attractive because corrupt behavior is recognized and punished with a high probability. The government offers the reservation wage $\omega_t = A_u + e$ and $\sigma_t = 0$.

The fifth case is that the stock of capital is in the interval $k_t \in \big[k^{s}, \bar{k}\big]$. At this stage, all households obtain education. Thus, the optimal wage is the reservation wage, that is, $\omega_t = \alpha A_s k_t^{1-\alpha}$ for $k_t \in \big[k^{s}, \bar{k}\big]$ and $\sigma_t = 0$.

The optimal public wage is summarized as follows:

$$\omega_t = \begin{cases} \omega^{ca}(k_t; \underline{h}) & \text{for} \quad k_t \in \left[0, k^{ef}(\underline{h})\right), \\ \frac{\tau - g}{\lambda} & \text{for} \quad k_t \in \left[k^{ef}(\underline{h}), k^{ef}(\bar{h})\right), \\ \omega^{ef}(k_t; \bar{h}) & \text{for} \quad k_t \in \left[k^{ef}(\bar{h}), k^{re}(\bar{h})\right), \\ A_u + e & \text{for} \quad k_t \in \left[k^{re}(\bar{h}), k^{s}\right), \\ \alpha A_s k_t^{1-\alpha} & \text{for} \quad k_t \in \left[k^{s}, \bar{k}\right], \end{cases} \tag{23}$$

and the share of corrupt bureaucrats becomes the following:

$$\sigma_t = \begin{cases} 1 & \text{for} \quad k_t \in \left[0, k^{ef}(\underline{h})\right), \\ 1 - F(\hat{h}(k_t)) & \text{for} \quad k_t \in \left[k^{ef}(\underline{h}), k^{ef}(\bar{h})\right), \\ 0 & \text{for} \quad k_t \in \left[k^{ef}(\bar{h}), \bar{k}\right]. \end{cases} \tag{24}$$

We illustrate optimal public wages in Figure 1. The solid line represents the optimal public wages given by (23). In addition, we add the reservation wage given by (13); the dashed line represents it in Figure 1.

The differences between the optimal public wage and the reservation wage are interpreted as public-private wage gaps since the reservation wage is equal to the public wage. In $k_t \in \left[0, k^{ef}(\underline{h})\right)$, the capitulation wage is optimal, and the share of corrupt bureaucrats is one. Thus, all bureaucrats receive the public wage penalty and engage in corruption. This concurs with the empirical findings obtained by Gorodnichenko and Peter (2007). In the Ukraine, public workers earn a lower public wage but have identical consumer expenditures and asset holdings. In $k_t \in \left[k^{ef}(\underline{h}), k^{re}(\bar{h})\right)$, the public wage premium exists since the government offers an efficiency wage that is higher than the reservation wage. Although the government succeeds in reducing corruption by offering an efficiency wage, some corruption remains. In $k_t \in \left[k^{re}(\bar{h}), \bar{k}\right]$, the public wage is

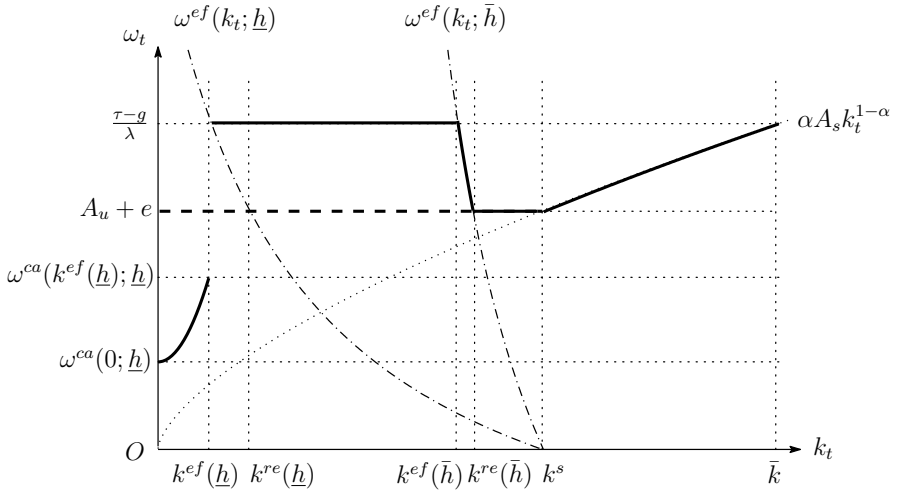

Figure 1: The optimal public wages. The solid and dashed lines represent the optimal public wages and the reservation wages, respectively. The gaps between the optimal public wages and the reservation wages are the public wage premiums/penalties.

equal to the private wage, and bureaucrats do not engage in corruption.

This theoretical result can explain the puzzle in which developing countries have a high degree of corruption despite substantial wage premiums, whereas developed countries have a small degree of corruption despite small or near-zero premiums. The mechanism for this puzzle is as follows. In developing countries with a smaller stock of capital, $k_t \in \left[k^{ef}(\underline{h}), k^{re}(\bar{h})\right)$, only a small number of educated individuals are able to monitor the corrupt behavior of bureaucrats. Since the probability of detecting corruption is low, the expected benefit of corruption is high. Then, higher public wages must be offered to decrease the incentives of bureaucrats to engage in corruption. However, under the budget constraint, the government cannot afford to offer the high wages to deter all bureaucrats from engaging in corruption. Thus, corruption remains, even if the government can eliminate some of it by raising the public wage as much as possible. On the other hand, in developed countries with a larger stock of capital, $k_t \in \left[k^{re}(\bar{h}), \bar{k}\right]$, many or all individuals obtain education and are able to monitor bureaucrats' behavior. Then, no bureaucrats engage in corruption, because corrupt behaviors are recognized with high probability. Thus, the government only offers the

reservation wage to employ a sufficient number of bureaucrats.

4 Dynamics

This section considers the effects of optimal public wages (in other words, effects of public wage premiums/penalties) on economic development. To do so, we compare two economies. One economy adopts the optimal public wage policy. The other economy always offers reservation wages.

4.1 An economy offering optimal wages

Firstly, we derive the dynamics of an economy offering optimal public wages. The equilibrium condition of the asset market is $k_{t+1} = s_t$, where s_t represents the total savings of households. Since households invest their all income, the dynamic equation of capital stock is as follows:

$$k_{t+1} = \pi_t(w_{s,t} - e + b_t - \tau) + (1 - \pi_t)(w_{u,t} + b_t - \tau). \tag{25}$$

The first term is the savings of skilled workers and the second term is that of unskilled workers. The share of skilled workers, π_t, and the private wages for unskilled and skilled workers, $w_{u,t}$ and $w_{s,t}$, are given by (11), (7), and (13), respectively.

From (24), the transfer from the government, $b_t = g/\lambda(1 - \sigma_t)\lambda + (1 - \gamma)g/\lambda\sigma_t\lambda$, is calculated. If $k_t \in \big[0, k^{ef}(\underline{h})\big)$, each bureaucrat steals γ share of public funds and transfers $(1 - \gamma)g/\lambda$ units. Total public funds transferred to households is $(1 - \gamma)g$. If $k_t \in \big[k^{ef}(\underline{h}), k^{ef}(\bar{h})\big)$, honest bureaucrats transfer $gF(\hat{h}(k_t))$ units of public funds while dishonest bureaucrats transfer $(1 - \gamma)g[1 - F(\hat{h}(k_t))]$ units. If $k_t \in \big[k^{ef}(\bar{h}), \bar{k}\big]$, no corruption happens. Then, the transfer to households, b_t, is represented by the

following:

$$b_t = \begin{cases} (1-\gamma)g & \text{for} \quad k_t \in \left[0, k^{ef}(\underline{h})\right), \\ \left\{1-\gamma\left[1-F(\hat{h}(k_t))\right]\right\} g & \text{for} \quad k_t \in \left[k^{ef}(\underline{h}), k^{ef}(\bar{h})\right), \\ g & \text{for} \quad k_t \in \left[k^{ef}(\bar{h}), \bar{k}\right]. \end{cases} \tag{26}$$

We obtain the dynamics as follows:

$$k_{t+1} = \begin{cases} A_u + (1-\gamma)g - \tau & \text{for} \quad k_t \in \left[0, k^{ef}(\underline{h})\right), \\ A_u + \left\{1-\gamma\left[1-F(\hat{h}(k_t))\right]\right\} g - \tau & \text{for} \quad k_t \in \left[k^{ef}(\underline{h}), k^{ef}(\bar{h})\right), \\ A_u + g - \tau & \text{for} \quad k_t \in \left[k^{ef}(\bar{h}), k^{s}\right), \\ \alpha A_s k_t^{1-\alpha} - e + g - \tau & \text{for} \quad k_t \in \left[k^{s}, \bar{k}\right]. \end{cases} \tag{27}$$

To ensure a positive income level, we make the following assumption:

$$A_u > \tau - (1-\gamma)g. \tag{28}$$

4.2 An economy offering reservation wages

Secondly, we derive the dynamics of an economy always offering reservation wages. As in the economy offering optimal public wages, the equilibrium condition of the asset market, the share of skilled workers, π_t, and the private wages for unskilled and skilled workers, $w_{u,t}$ and $w_{s,t}$, are given by (25), (11), (7), and (13), respectively. Let $\tilde{k}_t$, $\tilde{\omega}_t$, $\tilde{\sigma}_t$, and $\tilde{b}_t$ denote the stock of capital, the public wage, the share of corrupt bureaucrats, and the income transfer in this economy. The public wage is $\tilde{\omega}_t = w_{s,t}$ given by (13).

The difference in public wages yields different shares of corrupt bureaucrats in the

two economies. $\tilde{\sigma}_t$ is as follows:

$$\tilde{\sigma}_t = \begin{cases} 1 & \text{for} \quad k_t \in [0, k^{re}(\underline{h}))\,, \\ 1 - F(\tilde{h}(k_t)) & \text{for} \quad k_t \in \left[k^{re}(\underline{h}), k^{re}(\bar{h})\right)\,, \\ 0 & \text{for} \quad k_t \in \left[k^{re}(\bar{h}), \bar{k}\right]\,. \end{cases} \tag{29}$$

$\tilde{h}(k_t)$ is the ability that satisfies $k_t = k^{re}(\tilde{h}(k_t))$. This implies that when the reservation wage is offered at $k_t \in \left[k^{re}(\underline{h}, k^{re}(\bar{h})\right]$, bureaucrats whose ability is $h_i \in [\underline{h}, \tilde{h}(k_t)]$ stop engaging in corruption. Since $\partial \omega^{ef}(k_t; h_i)/\partial k_t < 0$, $\sigma_t = 1 - F(\hat{h}(k_t)) < 1 - F(\tilde{h}(k_t)) = \tilde{\sigma}_t$ holds for $k_t \in \left[k^{re}(\underline{h}), k^{ef}(\bar{h})\right]$.

Substituting (29) into $\tilde{b}_t = g(1 - \tilde{\sigma}_t) + (1 - \gamma) g \tilde{\sigma}_t$, the income transfer is as follows:

$$\tilde{b}_t = \begin{cases} (1-\gamma)g & \text{for} \quad k_t \in [0, k^{re}(\underline{h}))\,, \\ \left\{1 - \gamma\left[1 - F(\tilde{h}(k_t))\right]\right\} g & \text{for} \quad k_t \in \left[k^{re}(\underline{h}), k^{re}(\bar{h})\right)\,, \\ g & \text{for} \quad k_t \in \left[k^{re}(\bar{h}), \bar{k}\right]\,. \end{cases} \tag{30}$$

Then, the dynamics of capital in this economy, $\tilde{k}_{t+1}$, is given by the following:

$$\tilde{k}_{t+1} = \begin{cases} A_u + (1-\gamma)g - \tau & \text{for} \quad k_t \in [0, k^{re}(\underline{h}))\,, \\ A_u + \left\{1 - \gamma\left[1 - F(\tilde{h}(k_t))\right]\right\} g - \tau & \text{for} \quad k_t \in \left[k^{re}(\underline{h}), k^{re}(\bar{h})\right)\,, \\ A_u + g - \tau & \text{for} \quad k_t \in \left[k^{re}(\bar{h}), k^{s}\right)\,, \\ \alpha A_s k_t^{1-\alpha} - e + g - \tau & \text{for} \quad k_t \in \left[k^{s}, \bar{k}\right]\,. \end{cases} \tag{31}$$

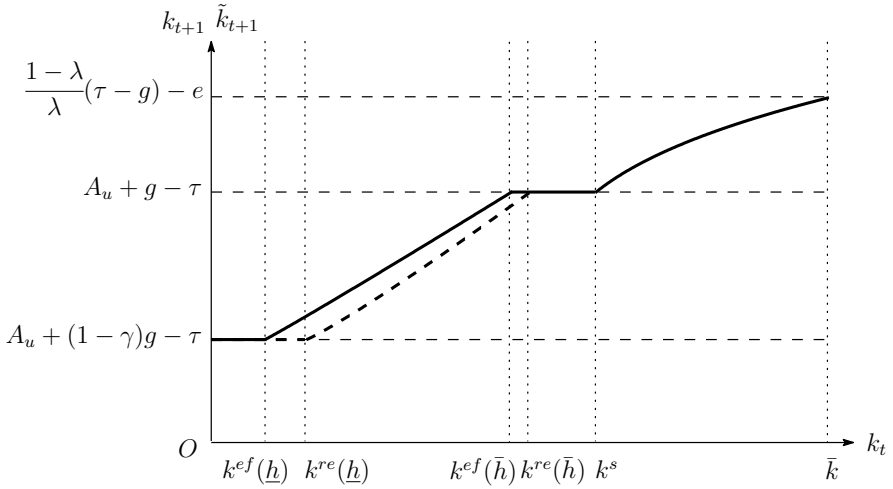

Figure 2: The dynamics of an economy. The solid line represents an economy offering optimal public wages while the dashed line represents an economy always offering reservation wages.

4.3 Effects of an optimal public wage

Let us draw the phase diagram of two dynamic equations, (27) and (31). Figure 2 represents the phase diagram[7]. The solid line shows the economy offering an optimal wage while the dashed line shows the economy offering a reservation wage.

From (27) and (31), we can confirm that corruption negatively affects economic development. The incidence of corruption disturbs income transfer from the government to households. This decreases households' investments and hinders the capital accumulation process. Since optimal public wages have been determined to minimize corruption, offering optimal wages can reduce the share of corrupt bureaucrats and increase income transfer, that is, $\sigma_t \geq \tilde{\sigma}_t$ and $b_t \geq \tilde{b}_t$ hold. It follows that $k_{t+1} \geq \tilde{k}_{t+1}$. Therefore, an optimal public wage policy has positive effects on economic development by reducing corruption.

Moreover, from (26) and (30), we obtain the negative effects of economic development on corruption. As economic development proceeds, the degree of corruption

[7]To draw the dynamic equations, we assume that $f(h_i)$ is given by the uniform distribution in the interval $h_i \in [\underline{h}, \bar{h}]$. Then, $dk_{t+1}/dk_t > 0$ and $d^2k_{t+1}/dk_t^2 > 0$ for $k_t \in \left[k^{ef}(\underline{h}), k^{ef}(\bar{h})\right)$. In addition, $d\tilde{k}_{t+1}/dk_t > 0$ and $d^2\tilde{k}_{t+1}/dk_t^2 > 0$ for $k_t \in \left[k^{re}(\underline{h}), k^{re}(\bar{h})\right)$. We apply the assumption for Figure 3.

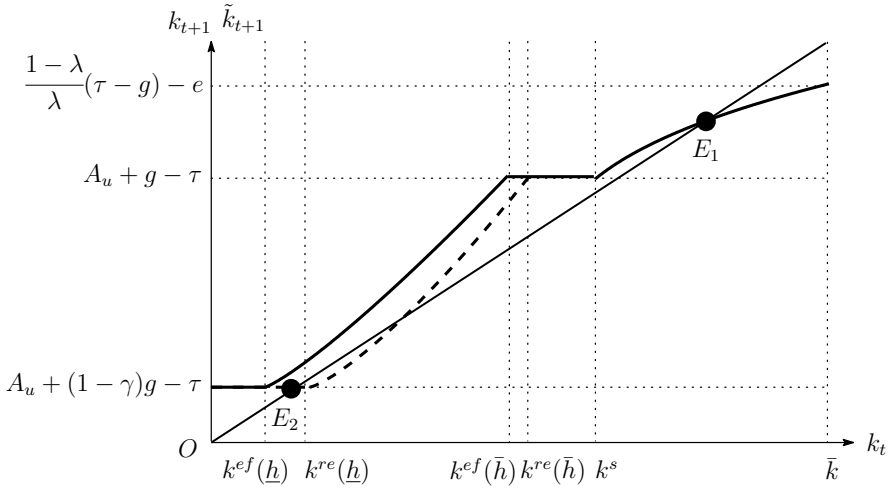

Figure 3: Multiple steady states and a poverty trap. The solid line represents an economy offering optimal public wages while the dashed line represents an economy always offering reservation wages.

decreases. This stems from the effects of education on monitoring. A large number of households obtain education and are able to monitor bureaucrats' behavior as capital accumulates. This leads to higher probability of detecting corruption. Subsequently, the share of corrupt bureaucrats decreases. Therefore, there exists a two-way causal relationship between corruption and economic development in this model; more corruption impedes development and low development induces corruption. This can yield a multiple steady state.

We pick up one possible case depicted in Figure 3 to discuss multiple steady states and the poverty trap. The economy offering optimal public wages has a unique, stable steady state, E_1, in $k_t \in \left[k^s, \bar{k}\right]$. On the other hand, the economy offering reservation wages has two stable steady states: E_2 in $k_t \in \left[k^{ef}(\underline{h}), k^{re}(\underline{h})\right]$ and E_1 in $k_t \in \left[k^s, \bar{k}\right]$. Two economies can converge to the same steady state E_1 if the latter economy starts with a large stock of capital. In this steady state, high economic development and no corruption are realized. However, if an economy starts with a small stock of capital and does not adopt an optimal wage policy, it converges to a steady state E_2. Then, it falls into a poverty trap and suffers from low economic development and a high degree of

corruption. This paper suggests that the economy can escape from the poverty trap by using an optimal public wage policy. If the government adopts this policy, the degree of corruption decreases and the stock of capital accumulates. Then, the dynamics of the economy is described by k_{t+1} given by (27). Thus, at last, the economy arrives at the steady state E_1 in $k_t \in \left[k^s, \bar{k}\right]$ and achieves a high level of development without corruption.

5 Conclusion

We provide a model to explain empirical evidence on public-private wage gaps and corruption. The evidence shows that large public wage premiums and a high degree of corruption exist in developing countries, whereas small or near-zero premiums and a low degree of corruption exist in developed countries. This poses a puzzle, since theoretical models that examine public wages and corruption suggest that corruption is reduced when public wages are higher than private ones. The mechanism for this puzzle is as follows. In an economy with a small stock of capital, the probability of detecting corruption is low since there are fewer educated households who are able to monitor the corrupt behavior of bureaucrats. Although higher public wages are needed to deter bureaucrats from engaging in corruption, the public budget constraint does not allow the government to pay high wages. Thus, corruption remains, despite the government offering efficiency wages that are higher than private wages. On the other hand, in developed countries, a large number of educated households exist; thus, the probability of detecting corruption is high. In this case, the government can eliminate corruption even if it offers reservation wages that are equal to private wages. To the best of our knowledge, this is the first study to provide an explanation for this puzzle, because previous models do not consider relationships among public wage, corruption, and economic development simultaneously.

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