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The impacts of corruption on wage inequality and rural–urban migration in developing countries

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Abstract This paper establishes three-sector general equilibrium models and separately investigates how sector-biased corruption influences the wage rates of skilled and unskilled workers, the wage inequality, and the amount of unskilled rural–urban migrants in developing countries. Corrupt activities are introduced in our theoretical models as transaction costs. We find that the reductions in different sector-biased corrupt behaviors exert different impacts through various economic mechanisms. In addition, the change in urban unskilled unemployment due to the decrease in the degree of sector-biased corruption is also taken into account.

JEL Classification D73 · J31 · R23

1 Introduction

Corrupt activities are prevalent in developing countries. However, the impacts of corruption are various in different developing countries. For example, empirical evidence shows that in some developing countries, corruption is less harmful, while in others, corruption does greater harm to economic development (Rock and Bonnet 2004; Campos and Pradhan 2007; Blackburna and Forgues-Puccio 2009; Meon and Weill

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2010; Wang and You 2012). In fact, corruption is a hot point and always attracts much attention of both empirical and theoretical economists. Different studies investigate the impacts of corruption from various viewpoints, which have been sketchily reviewed by Bardhan (1997), Jain (2001), Aidt (2003), Olken and Pande (2012) and others. However, the existing literature largely ignores the impacts of corruption on skilled–unskilled wage inequality and rural–urban migration, while both of them are particularly important phenomena in developing countries.

On the one hand, development economists have paid lots of attention to the increased skilled–unskilled wage inequality in developing countries. They address such an issue by establishing theoretical models, and the relevant explanations can be roughly divided into two main strands. The first strand of the literature (e.g., Liang and Mai 2003; Marjit et al. 2004; Marjit and Kar 2005; Anwar 2006; Sayek and Sener 2006; Oladi and Beladi 2007; Anwar 2008; Chaudhuri and Yabuuchi 2007; Beladi et al. 2008, 2010, 2011; Oladi et al. 2011; Pan and Zhou 2013; Pi et al. 2013; Pi and Zhou 2015) tries to analyze the widening skilled–unskilled wage gap via trade liberalization, international factor mobility and global production fragmentation, which contends that the aforementioned channels will unconditionally or conditionally increase the skilled–unskilled wage gap in developing countries. The second strand of the literature (e.g., Ethier 2005; Moore and Ranjan 2005; Avalos and Sawides 2006; Fang et al. 2008; Wang et al. 2009) uses technological progress and its spillover effects to explain the widening wage inequality, which argues that the above-mentioned factors will lead to wage disparity in both developed and developing countries. However, the role that corrupt behaviors play in determining the skilled–unskilled wage inequality is largely neglected by the existing theoretical explanations. The empirical literature (e.g., Gyimah-Brempong 2002; Dobson and Ramlogan-Dobson 2010, 2012) supports that corrupt activities are positively or negatively correlated with wage inequality in developing countries, as there exist different trade-offs between corruption and inequality. Therefore, it is necessary for us to investigate the impacts of corruption on skilled–unskilled wage inequality.

On the other hand, when we address the issues concerning developing countries, rural–urban migration and urban unemployment should be taken into consideration. Basu (1997), Ray (1998) and Beladi et al. (2010) point out that one of the most typical structural features of developing countries is rural–urban migration in the presence of urban unemployment. The mainstream theoretical studies related to rural–urban migration in developing countries are mostly conducted in the framework of the Harris–Todaro model, which has been an evergreen research area since the publication of Harris and Todaro's path-breaking paper (see Harris and Todaro 1970). The existing studies of the Harris–Todaro model can be divided into two main directions. The first strand of the literature (e.g., Grinols 1991; Chandra and Khan 1993; Gupta 1997) investigates how the growing economic endowments in developing countries influence rural–urban migration, urban unemployment, industrial development and other economic variables. Here, the increased economic endowments come from the accumulation of domestic production factors or the inflow of international factors. Some scholars establish two-sector, three-sector or even four-sector models under different conditions to address such issues. The second strand of the literature (e.g.,

Gupta 1993; Krichel and Levine 1999; Beladi and Chao 2006; Zenou 2011) discusses how development policies carried out by the governments produce their economic effects, where development policies can be industrial ones, environmental ones and so on. Unfortunately, the discussion of corrupt behaviors is ignored by the existing Harris–Todaro studies. As mentioned before, corruption can generate significant impacts on economic and social activities in developing countries. Thus, it is crucial for us to introduce corruption into the framework of Harris–Todaro model and investigate their impacts on rural–urban migration, urban unemployment and other economic variables.

In order to fill the aforementioned theoretical research gap, this paper establishes three-sector general equilibrium models to separately investigate how sector-biased corruption (i.e., urban high-skill sector-biased corruption, urban low-skill sector-biased corruption and agricultural sector-biased corruption) influences the wage rates of skilled and unskilled workers, the skilled–unskilled wage inequality and the amount of unskilled rural–urban migrants. Corrupt behaviors discussed here are viewed as directly unproductive profit-seeking (DUP) activities in Bhagwati's (1982) sense, which are introduced in our theoretical models as transaction costs, just as Mandal and Marjit (2010) do. Such a treatment method is greatly different from Pi and Zhou (2013), who take corrupt behaviors directly as an erosion of economic resources. We find that a reduction in urban high-skilled sector-biased corruption will increase the wage rate of skilled labor and decrease the wage rate of unskilled labor, resulting in the increased skilled–unskilled wage inequality and the decreased amount of rural–urban migrants. A reduction in urban low-skill sector-biased corruption will decrease the wage rate of skilled labor, but the wage rate of unskilled labor, the skilled–unskilled wage inequality and the amount of rural–urban migrants will conditionally rise or fall. A reduction in agricultural sector-biased corruption generates no impact on the wage rates of skilled and unskilled labor, but the skilled–unskilled wage inequality and the amount of the rural–urban migrants will also conditionally rise or fall. In sum, a reduction in different sector-biased corrupt behaviors exerts impacts on the wage rates of skilled and unskilled workers, the skilled–unskilled wage inequality and the amount of unskilled rural–urban migrants through various economic mechanisms. In addition, the change in urban unskilled unemployment due to the decrease in the degree of sector-biased corruption is also taken into account.

It is worth noting that corrupt activities discussed in our paper are sector biased, which are also in accord with the current empirical literature (see Campos and Pradhan 2007). By working with other development economists, Campos and Pradhan, two World Bank economists, conduct their survey of the sector-level corrupt activities appearing in developing countries. In their book, they argue that these corrupt activities exert great socioeconomic impacts. However, just as Campos and Pradhan (2007) argue, most of the existing empirical studies concerning corrupt activities usually use macro-level data. It is more important to investigate corruption by collecting micro-level data, especially at the sector level. Studying corruption from the sector level will help us acquire more detailed knowledge of corruption. Different from the macro-level econometric approach, we can know corrupt activities in depth from sector-level data. In the real world, economic resources are limited, so policy makers and reformers should know which sector is more prone to corrupt activities and which sector faces the

most serious corruption. What is more, the measures aimed at preventing the corruption should be tractable and have a clear focus on a special sector. Thus, studying sector-biased corruption is of both theoretical and practical importance.

This paper contributes to the current theoretical studies in two aspects. First, for the theoretical research concerning the growing skilled–unskilled wage inequality in developing countries, we try to address such an issue from the perspective of sector-biased corrupt activities, which is ignored by the existing literature in this field. Second, this paper introduces corrupt activities into Harris–Todaro model, which is seldom considered by the existing literature.

The remaining parts are organized as follows. In Sect. 2, we establish three models to separately investigate how urban high-skill sector-biased corruption, urban low-skill sector-biased corruption and agricultural sector-biased corruption exert their impacts on the wage rates of skilled and unskilled workers, the skilled–unskilled wage gap and the amount of unskilled rural–urban migrants. In addition, the change in urban unskilled unemployment is also considered. In Sect. 3, some concluding remarks are provided.

2 Theoretical model

Consider a small open economy consisting of three sectors: the urban high-skill sector, the urban low-skill sector and the rural agricultural sector. The urban high-skill sector uses skilled labor and capital as factors of production to produce an exportable good. The urban low-skill sector uses unskilled labor and capital to produce an import-competing good. The agricultural sector uses unskilled labor and land to produce an exportable good. Skilled labor and land are sector specific to the urban high-skill sector and the agricultural sector, respectively. Capital can move freely between the urban high-skill and low-skill sectors. Unskilled labor moves imperfectly between the agricultural sector and the urban low-skill sector. All the factor prices are flexible, except for the wage rate of the urban low-skill sector, which is protected by the minimum wage law. Urban unemployment only exists among unskilled workers, who migrate from rural areas to urban areas satisfying the Harris–Todaro equilibrium condition (see Harris and Todaro 1970). Such denotations of the unskilled labor market in developing countries prevail in the existing theoretical literature (e.g., Beladi et al. 2008; Beladi et al. 2010). All the goods and factor markets are perfectly competitive.

As previously mentioned, corrupt behaviors discussed in this paper are viewed as directly unproductive profit-seeking (DUP) activities (see Bhagwati 1982). Such kinds of corruption behaviors shift some labor from productive activities to corrupt activities, leading to a reduction in the amount of labor available for production. In accord with Mandal and Marjit (2010), DUP activities are also introduced in our theoretical framework as transaction costs, and the sector involved in DUP activities will lose part of its product value due to transaction costs. It is hypothesized that such corrupt activities are competitive. People engaging in DUP activities are treated as intermediaries or middlemen, and their payments are equal to transaction costs, namely the lost part of the product value.

2.1 Urban high-skill sector-biased corruption

In this part, corrupt activities only take place in the urban high-skill sector, where the urban high-skill sector loses part of its output value. The cost minimization conditions for three production sectors are described as:

$$(1-\alpha_X)p_X = a_{SX}w_S + a_{KX}r, \tag{1}$$

$$p_Y = a_{LY}\bar{w} + a_{KY}r, \tag{2}$$

$$p_Z = a_{LZ}w_U + a_{TZ}t, \tag{3}$$

where p_X, p_Y and p_Z are the prices of the urban high-skill sector, the urban low-skill sector and the agricultural sector, respectively. w_S is the wage rate of skilled labor. r is the interest rate of capital. $\bar{w}$ and w_U are the wage rates of unskilled labor used by the urban low-skill sector and the agricultural sector, respectively. t is the return rate of land. a_{SX} and a_{KX} are the amount of skilled labor and capital usage to produce one unit of urban high-skill product. a_{LY} and a_{KY} are the amount of unskilled labor and capital usage to produce one unit of urban low-skill product. a_{LZ} and a_{TZ} are the amount of unskilled labor and land usage to produce one unit of agricultural product.

Furthermore, competitive corrupt activities of skilled labor are depicted by:

$$\alpha_X p_X X = L_{CX} w_S, \tag{4}$$

where $\alpha_X \in (0, 1)$ denotes the appropriation rate of the product value in the urban high-skill sector. The lower the value of α_X, the better the quality of the institution. X is the output of the urban high-skill sector, and L_{CX} is the amount of skilled labor engaging in DUP activities. The left-hand side of Eq. (4) is transaction costs, and the right-hand side is the total payment for intermediaries or middlemen.

The market-clearing conditions for factor markets are given by:

$$a_{SX}X + L_{CX} = \bar{L}_S, \tag{5}$$

$$a_{KX}X + a_{KY}Y = \bar{K}, \tag{6}$$

$$a_{LY}Y(1+\lambda) + a_{LZ}Z = \bar{L}_U, \tag{7}$$

$$a_{TZ}Z = \bar{T}, \tag{8}$$

where Y and Z are the outputs of the urban low-skill and rural agricultural sectors, respectively. $\bar{L}_S$, $\bar{K}$, $\bar{L}_U$ and $\bar{T}$ are the economic endowments of skilled labor, capital, unskilled labor and land, respectively. λ is the Harris–Todaro-type urban unemployment rate of unskilled labor.

The Harris–Todaro rural–urban migration equilibrium condition of unskilled labor is:

$$\bar{w} = (1+\lambda)w_U. \tag{9}$$

So far, the theoretical model of the urban skill-biased corruption has been built, from Eqs. (1) to (9). Nine equations determine nine endogenous variables, namely

w_S, r, w_U, t, L_{CX}, X, Y, Z and λ. The policy variable is α_X, and other variables are exogenous parameters.

In accordance with the denotation of skilled–unskilled wage inequality in Chaudhuri and Yabuuchi (2007), Beladi et al. (2008), Beladi et al. (2010) and Pi and Zhou (2012, 2014), our paper also uses the wage rate of skilled labor and the average wage rate of unskilled labor, as well as their relative change to address the issue concerning the skilled–unskilled wage gap. From Eqs. (7) and (9), it is not hard to verify that the average wage rate of unskilled labor is w_U.

Now, under the framework of urban high-skill sector-biased corruption, we will investigate the impacts of urban high-skill sector-biased corruption on the wage rates of skilled and unskilled workers, the skilled–unskilled wage inequality and the unskilled rural–urban migrants, which can be summarized by Proposition 1.

Proposition 1 *If the urban high-skill sector-biased corruption is reduced, then (i) the wage rate of skilled labor will increase and that of unskilled labor will decrease; (ii) the skilled–unskilled wage inequality will be widened; and (iii) the amount of unskilled rural–urban migrants will decrease.*

Proof Before we begin to prove Proposition 1, the following denotations are necessary to be provided. The superscript "$\wedge$" represents the relative rate of the change in the variable (e.g., $\hat{X} = \frac{dX}{X}$). σ_i $(i = X, Y, Z)$ is the factor substitution elasticity for the production of goods X, Y and Z. θ_{ij} is the distributive share (e.g., $\theta_{LY} = \frac{a_{LY}\bar{w}}{p_Y}$). λ_{ij} is the allocative shares (e.g., $\lambda_{KX} = \frac{a_{KX}X}{\bar{K}}$, $\lambda_{PX} = \frac{a_{SX}X}{L_S}$ and $\lambda_{CX} = \frac{L_{CS}}{L_S}$). λ_U and λ_R are shares of unskilled labor in urban and rural areas, respectively. Similar terminology can be referred to Chaudhuri and Yabuuchi (2007), Beladi et al. (2008), and Mandal and Marjit (2010) and others.

By totally differentiating Eqs. (1) and (2), we can obtain:

$$\frac{\hat{w}_S}{\hat{\alpha}_X} = -\frac{\alpha_X}{\theta_{SX}(1-\alpha_X)} < 0.$$

By totally differentiating Eqs. (4) and (5) and combining with the result of $\frac{\hat{w}_S}{\hat{\alpha}_X}$, we can get:

$$\frac{\hat{X}}{\hat{\alpha}_X} = -\frac{\lambda_{PX}\sigma_X\theta_{KX}\alpha_X}{\theta_{SX}(1-\alpha_X)} - \lambda_{CX}\left[1 + \frac{\alpha_X}{\theta_{SX}(1-\alpha_X)}\right] < 0,$$

$$\frac{\hat{L}_{CX}}{\hat{\alpha}_X} = \lambda_{PX}\left[1 + \frac{\alpha_X}{\theta_{SX}(1-\alpha_X)}\right] - \frac{\lambda_{CX}\lambda_{PX}\sigma_X\theta_{KX}\alpha_X}{\theta_{SX}(1-\alpha_X)}.$$

By totally differentiating Eq. (6) and combining with the results of $\frac{\hat{w}_S}{\hat{\alpha}_X}$ and $\frac{\hat{X}}{\hat{\alpha}_X}$, we can obtain:

$$\hat{Y} = -\frac{\lambda_{KX}\theta_{SX}\sigma_X}{\lambda_{KY}}\hat{w}_S - \frac{\lambda_{KX}}{\lambda_{KY}}\hat{X}.$$

Furthermore, we can get:

$$\frac{\hat{Y}}{\hat{\alpha}_X} = \frac{\lambda_{KX}\sigma_X\alpha_X}{\lambda_{KY}(1-\alpha_X)} + \frac{\lambda_{KX}}{\lambda_{KY}}\left\{\frac{\lambda_{PX}\sigma_X\theta_{KX}\alpha_X}{\theta_{SX}(1-\alpha_X)} + \lambda_{CX}\left[1+\frac{\alpha_X}{\theta_{SX}(1-\alpha_X)}\right]\right\} > 0.$$

By totally differentiating Eqs. (3), (7) and (8), we can obtain:

$$\frac{\hat{w}_U}{\hat{\alpha}_X} = \frac{\lambda_U}{\lambda_U + \lambda_R\frac{\sigma_Z}{\theta_{TZ}}}\frac{\hat{Y}}{\hat{\alpha}_X} > 0.$$

Denote L_Z as the amount of unskilled labor working for the agricultural sector, and it is easy to know that $L_Z = a_{LZ}Z$. The change in L_Z can express the change in the amount of unskilled rural–urban migrants. More unskilled workers engaging in the agricultural sector means that less unskilled people migrate to urban areas. From Eq. (8), we can get:

$$\frac{\hat{L}_Z}{\hat{\alpha}_X} = \hat{a}_{LZ} - \hat{a}_{TZ} = -\frac{\sigma_Z}{\theta_{TZ}}\frac{\hat{w}_U}{\hat{\alpha}_X} < 0.$$

□

The economic explanation for Proposition 1 is as follows. From Eq. (2), we know that given the price of the urban low-skill sector's product, the interest rate of capital is fixed. Thus, from Eq. (1), it is easy to verify that a reduction in degree of corruption will obviously raise the wage rate of skilled labor. At the same time, a reduction in the degree of corruption will also raise the real price of the urban high-skill sector's product ($(1-\alpha_X)p_X$), which stimulates that sector to raise the output. The growing wage rate and product's price will encourage the urban high-skill sector to use more capital to produce, which inversely decreases the amount of capital available for the urban low-skill sector. Since the urban low-skill sector is protected by the minimum wage law, a reduction in capital usage in that sector will lessen the marginal productivity of unskilled labor, resulting in a reduction in unskilled employment. Therefore, the amount of unskilled urban migrants will be reduced, that is, more unskilled people will work for the agricultural sector, reducing the wage rate of unskilled labor. As a result, the skilled–unskilled wage gap will be widened.

From the above analyses, it is easy to establish Corollary 1 to state the effect exerted by a reduction in the degree of corruption on the urban unskilled unemployment rate.

Corollary 1 *If the urban high-skill sector-biased corruption is reduced, the urban unskilled unemployment rate will rise.*

Proof Recall that the Harris–Todaro urban unemployment rate λ is just the ratio of the amount of unemployed urban unskilled labor to that of employed urban unskilled labor. Thus, the urban unskilled unemployment rate is $\frac{\lambda}{1+\lambda}$, and the change in the urban unskilled unemployment rate is $\frac{1}{\lambda}\overset{\wedge}{(1+\lambda)}$. From Eq. (9) and the results achieved by the proof of Proposition 1, we know that $\frac{\overset{\wedge}{(1+\lambda)}}{\lambda\hat{\alpha}_X} = -\frac{\hat{w}_U}{\lambda\hat{\alpha}_X} < 0$. □

From the analyses of Proposition 1, we know that a reduction in urban high-skill-biased corruption will lead to the shrink of the urban low-skill sector, which means that less unskilled workers in urban areas can be absorbed by the urban low-skill sector. Thus, the urban unskilled unemployment rate will rise.

2.2 Urban low-skill sector-biased corruption

In this situation, corrupt activities merely happen in the urban low-skilled sector, where part of the output value of the urban low-skilled sector is eroded. Eqs. (1), (2), (4), (5) and (7) will be changed to:

$$p_X = a_{SX} w_S + a_{KX} r, \tag{10}$$

$$(1 - \alpha_Y) p_Y = a_{LY} \bar{w} + a_{KY} r, \tag{11}$$

$$\alpha_Y p_Y Y = L_{CY} \bar{w}, \tag{12}$$

$$a_{SX} X = \bar{L}_S, \tag{13}$$

$$(a_{LY} Y + L_{CY})(1 + \lambda) + a_{LZ} Z = \bar{L}_U, \tag{14}$$

where $\alpha_Y \in (0, 1)$ denotes the appropriation rate of the product value in the urban low-skill sector. The lower the value of α_Y, the better the quality of institution. The new theoretical model has been established, which consists of Eqs. (10), (11), (3), (12), (13), (6), (14), (8) and (9). Nine endogenous variables are determined, namely w_S, r, w_U, t, L_{CY}, X, Y, Z and λ. The policy variable is α_Y, and other variables are exogenous parameters.

Now, we will build Proposition 2 to analyze the effects of urban low-skill sector-biased corruption.

Proposition 2 *If the urban low-skill sector-biased corruption is reduced, then (i) the wage rate of skilled labor will decrease and that of unskilled labor will rise (resp. fall) if the effect exerted by the change in unskilled employment in the urban low-skilled sector dominates (resp. is dominated by) that produced by the change in the amount of unskilled labor engaging in DUP activities; (ii) the skilled–unskilled wage inequality will be reduced if the effect exerted by the change in unskilled employment in the urban low-skilled sector dominates that produced by the change in the amount of unskilled labor engaging in DUP activities. Otherwise, the change in skilled–unskilled wage gap will be ambiguous; and (iii) the amount of unskilled rural–urban migrants will increase (resp. decrease) if the effect exerted by the change in unskilled employment in the urban low-skilled sector dominates (resp. is dominated by) that produced by the change in the amount of unskilled labor engaging in DUP activities.*

Proof By totally differentiating Eqs. (10) and (11), we can get:

$$\frac{\hat{w}_S}{\hat{\alpha}_Y} = \frac{\theta_{KX} \alpha_Y}{\theta_{SX} \theta_{KY} (1 - \alpha_Y)} > 0.$$

Taking total differentiation of Eqs. (6) and (12) and combining with the help of the above result yield:

$$\hat{Y} = -A\hat{\alpha}_Y,\ \hat{L}_{CY} = (1-A)\hat{\alpha}_Y,$$

where $A = \frac{\lambda_{KX}\sigma_X\alpha_Y}{\lambda_{KY}\theta_{SX}\theta_{KY}(1-\alpha_Y)} + \frac{\sigma_Y\theta_{LY}\alpha_Y}{\theta_{KY}(1-\alpha_Y)} > 0$.

Denote L_Y as the amount of unskilled labor employed by the urban low-skill sector, and we have:

$$\frac{\hat{L}_Y}{\hat{\alpha}_Y} = \hat{a}_{LY} + \hat{Y} = -\left(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y} + A\right) < 0.$$

By totally differentiating Eqs. (11), (12), and (14), we can get:

$$\begin{aligned}\frac{\hat{w}_U}{\hat{\alpha}_Y} &= \frac{\theta_{TZ}\lambda_U}{\theta_{TZ}\lambda_U + \lambda_R\sigma_Z}\left(\lambda_{PY}\frac{\hat{L}_Y}{\hat{\alpha}_Y} + \lambda_{CY}\frac{\hat{L}_{CY}}{\hat{\alpha}_Y}\right)\\ &= \frac{\theta_{TZ}[-\lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y} + A) + \lambda_U\lambda_{CY}(1-A)]}{\lambda_U\theta_{TZ} + \lambda_R\sigma_Z}.\end{aligned}$$

Thus, we can obtain: if $\lambda_U\lambda_{CY}(1-A) < \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y} + A)$, then $\frac{\hat{w}_U}{\hat{\alpha}_Y} < 0$; if $\lambda_U\lambda_{CY}(1-A) > \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y} + A)$, then $\frac{\hat{w}_U}{\hat{\alpha}_Y} > 0$.

Besides, we can also know that $\frac{\hat{L}_Z}{\hat{\alpha}_Z} = \hat{a}_{LZ} - \hat{a}_{TZ} = -\sigma_Z\frac{\hat{w}_U}{\theta_{TZ}}$.

Furthermore, we have: if $\lambda_U\lambda_{CY}(1-A) < \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y} + A)$, then $\frac{\hat{L}_Z}{\hat{\alpha}_Z} > 0$; if $\lambda_U\lambda_{CY}(1-A) > \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y} + A)$, then $\frac{\hat{L}_Z}{\hat{\alpha}_Z} < 0$. □

The economic intuition behind Proposition 2 can be described as follows. From Eq. (2), we know that a reduction in the degree of corruption will raise the real price of the urban low-skill sector's product (i.e., $(1-\alpha_Y)p_Y$), and thus the interest rate of capital in that sector will increase. Because capital moves freely between the two urban sectors, the interest rate of capital used by the urban high-skill sector will also rise, resulting in a reduction in the wage rate of skilled labor when the price of the product produced by that sector is given. An increase in the real price of the urban low-skill sector's product will also incentivize that sector to produce more goods, which obviously leads to an increase in demand for unskilled labor, that is to say, $\frac{\hat{L}_Y}{\hat{\alpha}_Y} < 0$. However, although the degree of corruption is reduced and the output of the urban low-skill sector increases, the total change in transaction costs is undetermined. Therefore, the change in the amount of unskilled labor engaging in DUP activities is also ambiguous. When $\lambda_U\lambda_{CY}(1-A) < \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y} + A)$, which means that the effect exerted by the change in unskilled employment in the urban low-skilled sector dominates that produced by the change in the amount of unskilled labor engaging in DUP activities, the total demand for unskilled labor in urban areas will increase. More unskilled labor will transfer from rural areas to urban areas, the consequences of which

are that the wage rate of unskilled labor increases and that the skilled–unskilled wage gap is narrowed down. However, when $\lambda_U\lambda_{CY}(1-A) > \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y}+A)$, the opposite occurs. In this case, an increase in demand for unskilled labor in the urban low-skilled sector is less than the decrease in the amount of unskilled labor engaging in DUP activities. At this time, the total demand for unskilled labor in urban areas will fall. Thus, the amount of unskilled rural–urban migrants will decrease, the wage rates of skilled and unskilled workers will fall, and the change in skilled–unskilled wage gap will be indefinable.

Corollary 2 is built to show how a reduction in the degree of corruption affects the urban unskilled unemployment rate.

Corollary 2 *When the urban low-skill sector-biased corruption is reduced, the urban unskilled unemployment rate will fall (resp. rise) if the effect exerted by the change in unskilled employment in the urban low-skilled sector dominates (resp. is dominated by) that produced by the change in the amount of unskilled labor engaging in DUP activities.*

Proof From Eq. (9) and the proof of Proposition 2, we have the following results: if $\lambda_U\lambda_{CY}(1-A) < \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y}+A)$, then $\frac{\hat{(1+\lambda)}}{\lambda\hat{\alpha}_Z} > 0$; if $\lambda_U\lambda_{CY}(1-A) > \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y}+A)$, then $\frac{\hat{(1+\lambda)}}{\lambda\hat{\alpha}_Z} < 0$. □

The change in the urban unskilled unemployment rate is determined by whether the demand for unskilled labor in urban areas increases or not. From the explanation for Proposition 2, we know that when $\lambda_U\lambda_{CY}(1-A) < \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y}+A)$, the total demand for unskilled labor will increase, resulting in a reduction in urban unskilled unemployment. The opposite occurs when $\lambda_U\lambda_{CY}(1-A) > \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y}+A)$, that is, the urban unskilled unemployment will rise.

2.3 Agricultural sector-biased corruption

In this case, corruption only appears in the rural agricultural sector, which suffers from a loss of its product value. Eqs. (3), (4), and (7) will be rewritten as:

$$(1-\alpha_Z)p_Z = a_{LZ}w_U + a_{TZ}t, \tag{15}$$

$$\alpha_Z p_Z Z = L_{CZ}w_U, \tag{16}$$

$$a_{LY}Y(1+\lambda) + a_{LZ}Z + L_{CZ} = \bar{L}_U, \tag{17}$$

where $\alpha_Z \in (0,1)$ expresses the appropriation rate of the product value in the agricultural sector. The lower the value of α_Z, the better the quality of institution. L_{CZ} is the amount of unskilled labor in rural areas engaging in DUP activities. So far, the establishment of new theoretical model has been completed. Nine Eqs. (10), (2), (15), (16), (13), (6), (17), (8) and (9) determine nine endogenous variables, namely w_S, r, w_U, t, L_{CZ}, X, Y, Z and λ. The policy variable is α_Z, and other variables are exogenous parameters.

Now, we will turn our attention to the effects of agricultural sector-biased corruption, which can be given by Proposition 3.

Proposition 3 *If the degree of agricultural sector-biased corruption decreases, then (i) the wage rate of skilled labor will not change, and the wage rate of unskilled labor will rise (resp. fall) if the effect of the growing price dominates (resp. is dominated by) that of the increased return rate of land; (ii) the skilled–unskilled wage inequality will be narrowed down (resp. widened) if the effect of the growing price dominates (resp. is dominated by) that of the increased return rate of land; and (iii) the amount of unskilled rural–urban migrants will increase (resp. decrease) if the effect of the growing price dominates (resp. is dominated by) that of the increased return rate of land.*

Proof By totally differentiating Eqs. (15), (16), (8) and (17) and substituting Eq. (8) into Eqs. (16) and (17), we can get the following equations system:

$$\begin{pmatrix} -(\lambda_U+\sigma_Z\lambda_{PZ}) & \sigma_Z\lambda_{PZ} & \lambda_{CZ} \\ 1+\theta_{LZ}\sigma_Z & -\theta_{LZ}\sigma_Z & 1 \\ \theta_{LZ} & \theta_{TZ} & 0 \end{pmatrix} \begin{pmatrix} \hat{w}_U \\ \hat{t} \\ \hat{L}_{CZ} \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \\ -\frac{\alpha_Z}{1-\alpha_Z} \end{pmatrix} \hat{\alpha}_Z.$$

Denote the coefficient matrix of the above equations system as Δ, and we can get:

$$\Delta = (\lambda_U+\sigma_Z\lambda_{PZ})\theta_{TZ} + \sigma_Z\lambda_{PZ}\theta_{LZ} + \lambda_{CZ}[(1+\theta_{LZ}\sigma_Z)\theta_{TZ} + \theta_{LZ}\theta_{LZ}\sigma_Z] > 0.$$

Using the Cramer's rule to solve the above equations systems yields:

$$\begin{aligned}
\frac{\hat{w}_U}{\hat{\alpha}_Z} &= \frac{1}{\Delta}\left[-\frac{\alpha_Z\sigma_Z\lambda_{PZ}}{1-\alpha_Z} + \lambda_{CZ}\left(\theta_{TZ} - \frac{\theta_{LZ}\sigma_Z\alpha_Z}{1-\alpha_Z}\right)\right], \\
\frac{\hat{t}}{\hat{\alpha}_Z} &= \frac{1}{\Delta}\left\{-\frac{(\lambda_U+\sigma_Z\lambda_{PZ})\alpha_Z}{1-\alpha_Z} - \lambda_{CZ}\left[\theta_{LZ} + \frac{\alpha_Z(1+\theta_{LZ}\sigma_Z)}{1-\alpha_Z}\right]\right\} < 0, \\
\frac{\hat{L}_{CZ}}{\hat{\alpha}_Z} &= \frac{1}{\Delta}\left\{-(\lambda_U+\sigma_Z\lambda_{PZ})\left(\frac{\alpha_Z\theta_{LZ}\sigma_Z}{1-\alpha_Z} - \theta_{TZ}\right)\right. \\
&\quad \left. + \sigma_Z\lambda_{PZ}\left[\theta_{LZ} + \frac{\alpha_Z(1+\theta_{LZ}\sigma_Z)}{1-\alpha_Z}\right]\right\}.
\end{aligned}$$

Unfortunately, the sign of $\frac{\hat{w}_U}{\hat{\alpha}_Z}$ is indefinable. From Eq. (15), we can get:

$$\hat{w}_U = \frac{1}{\theta_{LZ}}\left(-\frac{\alpha_Z}{1-\alpha_Z}\hat{\alpha}_Z - \theta_{TZ}\hat{t}\right), \text{ or } \frac{\hat{w}_U}{\hat{\alpha}_Z} = \frac{1}{\theta_{LZ}}\left(-\frac{\alpha_Z}{1-\alpha_Z} - \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}\right).$$

It is not hard to know that if $-\frac{\alpha_Z}{1-\alpha_Z} > \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$, then $\frac{\hat{w}_U}{\hat{\alpha}_Z} > 0$ and that if $-\frac{\alpha_Z}{1-\alpha_Z} < \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$, then $\frac{\hat{w}_U}{\hat{\alpha}_Z} < 0$.

In addition, we can also know that $\frac{\hat{L}_Z}{\hat{\alpha}_Z} = \hat{a}_{LZ} - \hat{a}_{TZ} = -\sigma_Z(\hat{w}_U - \hat{t}) < 0$. However, in the situation of agricultural sector-biased DUP activities, the change in

the amount of unskilled rural–urban migrants should be measured by the change in the amount of unskilled labor in urban areas. Therefore, the change in the amount of unskilled rural–urban migrants is depicted by $L_Y\,(1 \overset{\wedge}{+} \lambda)$. Furthermore, we have $\frac{L_Y\,(1\overset{\wedge}{+}\lambda)}{\hat{\alpha}_Z} = \frac{(1\overset{\wedge}{+}\lambda)}{\hat{\alpha}_Z}$. Thus, if $-\frac{\alpha_Z}{1-\alpha_Z} > \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$, then $\frac{L_Y\,(1\overset{\wedge}{+}\lambda)}{\hat{\alpha}_Z} < 0$; if $-\frac{\alpha_Z}{1-\alpha_Z} < \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$, then $\frac{L_Y\,(1\overset{\wedge}{+}\lambda)}{\hat{\alpha}_Z} > 0$. □

From Eqs. (10) and (2), given the prices of the products produced by the urban high-skill and low-skill sectors and the wage rate of the unskilled labor employed by the urban low-skill sector, the interest rate of capital and the wage rate of skilled labor are determined, which are irrelevant to the reduction in the degree of corruption. Furthermore, from Eqs. (13) and (6), we can get the equilibrium value of the output of the urban high-skill sector and thus that of the urban low-skill sector is also determined. It is not hard to verify that an improvement in the quality of institution exerts no effects on urban outputs, factor prices and factor usages, which suggests that DUP activities happening in rural areas does no harm to urban production. However, from Eq. (15), we know that the reduction in the degree of corruption will raise the real price of the agricultural product (i.e., $(1-\alpha_Z)p_Z$). From the viewpoint of the supply side, this becomes a positive signal for the agricultural sector to produce more outputs. Given the amount of land available for the production, more unskilled workers will be needed as the factors of production and the output of the agricultural sector will eventually increase, just as suggested by the proof of Proposition 3. An increase in the employment of unskilled labor will raise the marginal productivity of land, leading to a rise of the return rate of land. From Eq. (15), we know that the change in the wage rate of unskilled labor is determined by the interaction between the growing price of the agricultural product and the increased return rate of land. When $-\frac{\alpha_Z}{1-\alpha_Z} > \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$, the effect of the increased price of the agricultural product dominates that of the increased return rate of land, the unskilled wage rate will increase, resulting in the reduced skilled–unskilled wage gap. When $-\frac{\alpha_Z}{1-\alpha_Z} < \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$, the opposite occurs, that is to say, the unskilled wage rate will be reduced and the skilled–unskilled wage gap will be widened.

Here, the change in the urban unskilled unemployment rate due to a reduction in the degree of corruption is summarized by Corollary 3.

Corollary 3 *When the degree of agricultural-biased corruption decreases, the urban unskilled unemployment rate will fall (resp. rise) if the effect of the growing price dominates (resp. is dominated by) that of the increased return rate of land.*

Proof From Eq. (9) and the proof of Proposition 3, we have the following results: if $-\frac{\alpha_Z}{1-\alpha_Z} < \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$, then $\frac{(1\overset{\wedge}{+}\lambda)}{\lambda\hat{\alpha}_Z} > 0$; if $-\frac{\alpha_Z}{1-\alpha_Z} > \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$, then $\frac{(1\overset{\wedge}{+}\lambda)}{\lambda\hat{\alpha}_Z} < 0$. □

In the situation that the wage rate of unskilled labor increases, combining with the results obtained by Proposition 3, it is easy for us to know from Eq. (9) that the urban unskilled unemployment rate will decrease, resulting from less workers migrating from rural areas to urban areas. If the wage rate of unskilled labor decreases, also from Eq. (9), more unskilled labor will transfer to the urban areas and the urban unskilled

Table 1 Impacts of reduction in sector-biased corruption

	Skilled wage	Unskilled wage	Wage inequality	Rural–urban migration
A reduction in α_X	Increase	Decrease	Widened	Decrease
A reduction in α_Y	Decrease	Increase, if $\lambda_U\lambda_{CY}(1-A) < \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y}+A)$; Decrease, if $\lambda_U\lambda_{CY}(1-A) > \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y}+A)$	Narrowed down, if $\lambda_U\lambda_{CY}(1-A) < \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y}+A)$; Ambiguous, if $\lambda_U\lambda_{CY}(1-A) > \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y}+A)$	Increase, if $\lambda_U\lambda_{CY}(1-A) > \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y}+A)$; Decrease, if $\lambda_U\lambda_{CY}(1-A) < \lambda_U\lambda_{PY}(\frac{\sigma_Y\alpha_Y}{1-\alpha_Y}+A)$
A reduction in α_Z	No impact	Increase, if $-\frac{\alpha_Z}{1-\alpha_Z} < \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$; Decrease, if $-\frac{\alpha_Z}{1-\alpha_Z} > \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$	Narrowed down, if $-\frac{\alpha_Z}{1-\alpha_Z} < \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$; Widened if $-\frac{\alpha_Z}{1-\alpha_Z} > \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$	Increase, if $-\frac{\alpha_Z}{1-\alpha_Z} > \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$; Decrease, if $-\frac{\alpha_Z}{1-\alpha_Z} < \theta_{TZ}\frac{\hat{t}}{\hat{\alpha}_Z}$

unemployment rate will rise due to the fixed employment of unskilled labor in the urban low-skill sector.

Now, we use Table 1 to summarize the main results obtained in this paper and to make a sector-based comparison. Different developing countries have different pillar industries and thus have different kinds of sector-biased corruption. Different sector-biased corruption generates different impacts through different economic mechanisms.[1]

Here, it is necessary to make some comparisons between Mandal and Marjit (2010) and our paper. Mandal and Marjit (2010) establish a two production sector general equilibrium model and treat DUP activities as transaction costs that exist in both skilled and unskilled sectors. In their paper, skilled and unskilled workers are simultaneously involved in competitive corrupt behaviors. Mandal and Marjit (2010) show that the comparisons of distributive shares of labor (or capital) in the skilled and unskilled sectors play a crucial role in the determination of the changes in the skilled and unskilled wage rates and their disparity. However, in our paper, this is not the case. When we consider an economy consisting of three production sectors featured with the characteristics of developing countries, a reduction in sector-biased corrupt activities will result in a more complex situation of the change in the factor prices and thus the factor redistribution. Therefore, the mechanisms of changes in the skilled and unskilled wage rates and their gap are more complicated here and could not be simply analyzed by the comparisons of distributive shares. In addition, Mandal and Marjit (2010) also contend that a reduction in DUP activities leads to the shrink of corrupt activities, because at this time, more skilled and unskilled workers are needed for production. However, in our paper, from the proofs of Proposition 1, 2 and 3, we know that a decrease in sector-biased DUP activities does not necessarily lead to a reduction in the amount of labor engaging in corrupt activities, for the reason that a decrease in the

[1] We would like to express our thanks to a reviewer who encourages us to make such a sector-based comparison.

degree of DUP activities raises the output of the sector involved in DUP activities, but labor needed for the increased output can be absorbed from other production sectors (or the urban unemployment), and at the same time, the total change in the amount of transaction costs is ambiguous, resulting in an indefinable change in corrupt activities.

3 Concluding remarks

Although corruption prevails in developing countries, the existing literature largely ignores the impacts of corruption on the skilled–unskilled wage inequality and the rural–urban migration. On the one hand, most of the theoretical explanations of the increased skilled–unskilled wage inequality neglect to take corruption into consideration. On the other hand, the existing literature focusing on rural–urban migration in the context of the Harris–Todaro model fails to pay attention to the role of corruption. Thus, we need to unify wage inequality and rural–urban migration in an integrated framework on the basis of corruption in developing countries.

In order to fill the existing theoretical research gap, this paper establishes three-sector general equilibrium models to separately investigate how urban high-skill sector-biased corruption, urban low-skill sector-biased corruption and agricultural sector-biased corruption influence the wage rates of skilled and unskilled workers, the skilled–unskilled wage inequality and the amount of unskilled rural–urban migrants in developing countries. Corrupt behaviors discussed here are regarded as DUP activities and introduced in our theoretical models as transaction costs. We find that the reductions in different sector-biased corrupt behaviors exert different impacts through various economic mechanisms. In addition, the change in urban unskilled unemployment due to the decrease in the degree of sector-biased corruption is also considered.

There are several potential extensions for future research. Firstly, introductions of more typical structural features of developing countries (e.g., the informal sector and the informal credit market) are good directions for future studies. Secondly, corrupt activities discussed in this paper can be embedded in a two-country model, and the related issues can be explored on the basis of two countries' comparative advantage. Thirdly, it is also valuable to analyze the economic and social impacts generated by international factor mobility (e.g., illegal migration) in the presence of corrupt activities.

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