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ABSTRACT

Offshoring to a Developing Nation with a Dual Labor Market*

We present a model of offshoring of tasks to a developing nation, which is characterized by a minimum wage formal sector and a flexible wage informal sector. Some offshored tasks are outsourced by the formal sector to the lower wage informal sector. An improvement in the productivity in performing offshored tasks in the developing country raises offshoring, but not necessarily formal-to-informal outsourcing, and, in response, the developed nation wage can fall. Productivity improvements in the informal sector expand both offshoring and outsourcing, and the developed nation wage must rise. When the minimum wage is reduced, the developed nation wage falls when most of the efficiency gains accrue to the informal sector.

JEL Classification: F1, F2, J4, J8

Keywords: offshoring, outsourcing, informal sector, dual labor markets

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1. Introduction

This paper analyzes developed-to-developing nation offshoring in the presence of a dual labor market structure in the developing nation. While the developed nation's labor market is assumed to feature flexible wages and full employment, the developing nation is characterized by a dual labor market where a formal and an informal sector coexist. While the formal sector is subject to a minimum wage regulation, the informal sector is assumed to be able to either circumvent that law (or the law does not apply to it) and pay a lower market-clearing wage. It is also possible that the formal sector circumvents the law by outsourcing to the informal sector or hiring informal or casual workers to perform certain tasks. Consideration of labor market duality leads to some important departures from the existing literature on trade-in-tasks which was pioneered by Grossman and Rossi-Hansberg (2008, GRH hereafter), among others.

As described in Bhagwati and Panagariya (2013), India has over 200 labor regulations that apply to firms in the formal sector. These make labor costs higher than what they should be and adversely affect the flexibility of firms in responding to shocks. In practice, firms find ways of getting around these labor regulations by incurring some costs. For example, Ramaswamy (2003) documents that formal-sector manufacturing firms in India are able to circumvent labor regulations by hiring temporary (casual) or contract workers to whom those regulations do not apply. Hasan and Jandoc (2013) show that even in large Indian manufacturing firms with employment over 200 workers, casual or contract workers constitute about 30 percent of total employment. Harris-White and Sinha (2007) provide anecdotal evidence supporting outsourcing of certain activities by formal-sector firms to informal-sector firms. Sundaram (2015) also provides evidence indicative of outsourcing of relatively labor-intensive activities by formal sector firms to informal sector firms in India. And, finally, Sundaram, Ahsan and Mitra (2013) provide evidence of "linkages between the formal and informal manufacturing sectors through outsourcing." In addition to the evidence on India, there is also evidence from Mexico showing that about 25 percent of employees of formal firms are informal workers. Thus, formal firms are able to avoid many of the labor regulations (Samaniega de la Parra, 2016).

We build a model that borrows from GRH and Bandyopadhyay et al. (2020). We extend these models to consider the presence of domestic outsourcing to the informal sector in the developing nation. Two nations, which are small in the output market, have a bilateral offshoring relationship in the production of a manufacturing good. As in GRH, competitive firms based in the developed nation produce this good by completing a range of tasks. Some of these tasks are relatively complex and require more labor to be completed in the developing nation. These tasks are cheaper to complete in the developed nation, while the rest are offshored. Among the offshored tasks, the least complex tasks are cheaper to complete in the developing country's lower wage informal sector compared to its minimum wage formal sector.[1] The rest of the offshored tasks, of intermediate complexity, are completed in the formal sector. This second layer of task allocation within the developing nation is what has been referred to as "domestic outsourcing," which allows formal sector firms to circumvent the minimum wage.[2]

Our general equilibrium model analyzes the interactions of three linked labor markets – the developed nation's labor market, the developing nation's formal sector, and the developing nation's informal sector. While a rigid wage characterizes the developing country's formal sector,

[1] The more complex tasks will also be more costly to domestically outsource, since greater skills might be required to perform them and skills cannot be fully transferred from the formal to the informal sector. Also, supervision by formal-firm managers of informal sector firms or of casual workers is more difficult. Informal workers, due to the temporary nature of their jobs, have little incentive to acquire skills on the job. For the same reason, their employers have virtually no incentive to invest in their human capital or productivity. Despite their low productivity, formal firms transfer some of the relatively simple tasks to them because of the lower informal sector wage.
[2] See for example Goldschmidt and Schmieder (2017), where "domestic outsourcing" in Germany is analyzed.

flexible wages characterize the developed nation's labor market, as well as the developing nation's informal sector. The residual labor supply to the flexible wage manufacturing sectors are absorbed by the respective alternate sectors of the two nations. The analysis of the equilibrium developed nation wage and the informal sector wage and how they respond to parametric changes in technologies of offshoring and outsourcing is a central focus of our analysis. In turn, these factor price and parametric changes affect other endogenous variables of interest, such as the levels of offshoring, outsourcing and the share of informal sector in the developing nation economy.

The comparative static analysis yields some results that depart from the existing literature. For example, while a rise in offshoring productivity raises offshoring, it may reduce the developed nation wage. This can happen because the informal sector wage may rise through offshoring demand effects, and also because of the accompanying shift of marginal tasks from the low wage informal sector to a higher wage formal sector. As a result, the degree of informality, given by the ratio of informal to formal manufacturing employment, may fall. Some other results are counterintuitive at first glance. For example, although increased informal sector productivity will raise formal to informal outsourcing, it may reduce both the informal sector wage as well as the degree of informality of the developing country's manufacturing sector. Similarly, while a cut in the minimum wage reduces informality, informal wage may actually increase.

Section 2 presents the model and the description of the equilibrium. Section 3 presents comparative static analyses. Section 4 concludes.

2. The Model and Equilibrium

2.1 The Basic Structure

Consider two countries, a developed country F and a developing country H. There are two goods, a numeraire manufactured good and food. We assume that the two nations are small in the output market, so the prices of both goods can be set at unity, without loss of generality.[3] The output levels of the manufactured good and food in nation F are denoted by x^* and y^*, respectively. Country H also produces food, whose output is given by y and this country's workers may also perform tasks offshored by country F's manufacturing sector. For simplicity, we assume that all of the manufacturing sector activity in H is completion of the tasks offshored by F.

Following GRH, we assume that production of a unit of x^* requires a continuum of labor tasks $i \in [0,1]$ to be performed either in H or in F. Labor is the only input used to perform the required tasks. While each task i requires a unit of labor in F, the same task requires $\beta t(i) > 1$ units of labor in H, where β is a general technology parameter and $t(i)$ is the part of technology specific to task i in nation H. Tasks that are more complex and require more labor to complete in the developing nation are indexed by higher values of i. Therefore, by construction $t'(i) > 0$.

Developing nations are often characterized by a dual labor-market environment, where a formal manufacturing sector coexists with an informal manufacturing sector and the food (agricultural) sector. The formal manufacturing sector features large and well-organized firms, bound by laws and regulations that they need to conform to, pay corporate income taxes, get import

[3] Extending the model to consider the large country case for the output market is straightforward, but the analysis becomes more opaque because of the interactions between the output market and factor market terms-of-trade.

licenses, have labor unions etc. The informal manufacturing sector and the agricultural sector are usually characterized by small firms or farmers in rural settings, respectively, where labor laws and regulations do not apply or are not enforceable (because of prohibitive monitoring costs). Accordingly, we first assume that there is a minimum wage in the formal manufacturing sector and a flexible wage in the informal manufacturing sector, the latter conducting the simplest of manufacturing tasks and characterized by perfect labor mobility with the agricultural sector. Secondly, we assume that completion of tasks in the informal sector involves some additional costs. This may arise due to a lack of infrastructure that allows such tasks to be transported to the informal sector combined with inferior production technology characterizing the informal sector. Furthermore, to the extent that the incidence of infrastructure constraints like unreliable electricity supply is worse for the informal sector, worker productivity in this sector suffers. Since higher values of i represent more complex tasks, labor required to outsource from the formal to the informal sector is assumed to be an increasing markup over the labor required to complete the task in the formal sector. This markup is $\tilde{\beta}\tau(i)$, where $\tilde{\beta}$ is a general informal-sector technology parameter and the fact that a technologically backward informal sector encounters increasing difficulty in completing more complex tasks is captured by the technology $\tau(i)$, $\tau'(i) > 0$. Thus, the labor required to complete task *i* in the informal sector is $\tilde{\beta}\tau(i)\beta t(i)$.

Denoting land and labor by *T* and *L*, respectively, the constant-returns-to-scale (CRS) production function for food in nation *H* is $y = G(L_y, T)$, where L_y is labor used in *H*'s food sector. Similarly, $y^* = G^*(L_y^*, T^*)$ represents nation *F*'s production function for food. Since land is specific to food production and its endowment in each nation is fixed, the CRS production functions for food in the two nations are characterized by diminishing returns to labor,

$$y = G\left(L_y, T\right),\ G_{L_y}\left(L_y, T\right) > 0,\ \ G_{L_y L_y}\left(L_y, T\right) < 0 \text{, and} \tag{1}$$

$$y^* = G^*\left(L_y^*, T^*\right),\ G_{L_y^*}^*\left(L_y^*, T^*\right) > 0,\ \ G_{L_y^* L_y^*}^*\left(L_y^*, T^*\right) < 0. \tag{2}$$

2.2 Labor Supply to the Manufacturing Sector

Let us denote the developed nation wage by w^* and the developing nation wage in the agricultural sector as *w*. Recalling that output prices are fixed at unity, competitive profit maximization conditions in the food sector in nations *H* and *F* are, respectively, $w = G_{L_y}\left(L_y, T\right)$ and $w^* = G_{L_y^*}^*\left(L_y^*, T^*\right)$. Inverting these functions, and suppressing T and T^* from the functional forms, we obtain the respective labor demand functions in *H* and *F* as:

$$L_y^d = L_y^d\left(w\right),\ L_y^{d\prime}\left(w\right) < 0 \text{, and} \tag{3}$$

$$L_y^{*d} = L_y^{*d}\left(w^*\right),\ L_y^{*d\prime}\left(w^*\right) < 0\,. \tag{4}$$

Given respective labor endowments $\overline{L}$ and $\overline{L}^*$ of nations *H* and *F*, the labor supply function to the manufacturing sector for each nation (*H* and *F* respectively) is given by:

$$L\left(w\right) = \overline{L} - L_y^d\left(w\right),\ L'\left(w\right) > 0 \text{ , and} \tag{5}$$

$$L^*\left(w^*\right) = \overline{L}^* - L_y^{*d}\left(w^*\right),\ L^{*\prime}\left(w^*\right) > 0\,. \tag{6}$$

2.3 Offshoring to the Developing Nation: The Formal-Informal Sector Task Allocation

We assume that technology in the food sector and endowments in the two nations are such that the developed nation wage w^* exceeds the minimum wage $\overline{w}$ in the developing nation's formal manufacturing sector. Labor mobility between the informal sector and the agricultural sector equalizes the wage between these sectors at w. Although w^* and w are endogenous, the labor allocation decisions are best explained for a given vector of wage rates $\left(w^*, \overline{w}, w\right)$. Any task i can be completed by a unit of labor in F at a cost of w^*. This same task can be completed in nation H's formal sector at a lower wage rate $\overline{w}$, albeit with a greater labor requirement $\beta t\left(i\right) > 1$. The cost of completing this task in H's formal sector is $\overline{w}\beta t\left(i\right)$. As i goes to zero, we have tasks that are less complex, and the labor cost of completing these tasks in the developing nation are small enough such that $\overline{w}\beta t\left(i\right) < w^*$, and hence these tasks are offshored by F. On the other hand, as i goes to one, we assume that the tasks require sufficiently more labor to complete in the developing nation such that $\overline{w}\beta t\left(i\right) > w^*$. These latter tasks are completed in nation F. Given continuity and monotonicity of the underlying functions, the marginal offshored task is denoted by I, where

$$\overline{w}\beta t\left(I\right) = w^* \Leftrightarrow t\left(I\right) = \rho_I \Rightarrow I = I\left(\rho_I\right), \; I'\left(\rho_I\right) = \frac{1}{t'\left(I\right)} > 0, \tag{7}$$

where $\rho_I = w^* / \left(\beta\overline{w}\right)$ is the effective relative factor price of completing a task in the developed nation. Thus, tasks in the range $i \in \left[0, I\right]$ are offshored, while the remaining tasks $i \in \left[I, 1\right]$ are completed in nation F. Next, notice that for the minimum wage to be binding, the informal sector of the developing nation has a lower wage w. The least complex tasks (i.e., as i goes to zero) can be performed at lower cost $w\tilde{\beta}\tau(i)\beta t(i)$ compared to the formal sector costs of $\overline{w}\beta t(i)$. This is true for all tasks where $w\tilde{\beta}\tau(i) < \overline{w}$. On the other hand, the most complex offshored task (i.e., $i = I$) is such that the high labor requirements dominate the wage advantage of the informal sector, such that $w\tilde{\beta}\tau(I) > \overline{w}$. Thus, task *I* and tasks in its immediate neighborhood are completed in the developing nation's formal sector. The marginal task that is outsourced from the formal to the informal sector is *J*, where:

$$w\tilde{\beta}\tau(J) = \overline{w} \Leftrightarrow \tau(J) = \rho_J \Rightarrow J = J(\rho_J),\ J'(\rho_J) = \frac{1}{\tau'(J)} > 0, \tag{8}$$

where $\rho_J = \overline{w}/(\tilde{\beta}w)$ is the effective relative factor price of completing an offshored task in the developing nation's formal sector (relative to the informal sector). Given the assumed continuity and monotonicity of the $\tau(i)$ function, (8) implies that out of the offshored tasks, $i \in [0, J]$ are done in the informal sector and the remainder $i \in [J, I]$ are completed in the formal sector.

2.4 Equilibrium

The labor-market equilibrium conditions in the two nations are given by

$$x^*(1-I) = L^*(w^*) \text{ , and} \tag{9}$$

$$x^*\beta\left[\tilde{\beta}\int_0^J t(i)\tau(i)di + \int_J^I t(i)di\right] = L(w), \tag{10}$$

where x^* is the output of the manufactured sector produced by completions of tasks in the two nations' manufacturing sectors. Using Eqs.(9) and (10), the relative labor demand of the two nations equal the relative labor supply when

$$\beta\left[\tilde{\beta}\mu(J,I)+\gamma(J,I)\right]=\frac{L(w)}{L^*(w^*)}, \tag{11}$$

where $\mu(J,I)=\left(\int_0^J t(i)\tau(i)di\right)/(1-I)$, and $\gamma(J,I)=\left(\int_J^I t(i)di\right)/(1-I)$.

The cost of producing a unit of x^* is the sum of the costs of completing all the tasks necessary to produce that unit. The cost of completing tasks $(1-I)$ in the developed nation is $w^*(1-I)$, while the cost of completing the offshored tasks in the formal and informal sectors are, respectively, $\overline{w}\beta\int_J^I t(i)di$ and $w\beta\tilde{\beta}\int_0^J t(i)\tau(i)di$. Noting that the price of good x^* is unity, the zero profit condition for the good is:

$$w^*(1-I)+\beta\left[w\tilde{\beta}\int_0^J t(i)\tau(i)di+\overline{w}\int_J^I t(i)di\right]=1 \ , \tag{12}$$

Eqs.(11) and (12) jointly determine the international equilibrium (w,w^*) at a given minimum wage $\overline{w}$ and for given technology parameters β and $\tilde{\beta}$.

3. Comparative Statics

Let us define the share of the informal sector employment in total manufacturing sector employment in the developing nation as $\delta = \dfrac{\tilde{\beta}\int_0^J t(i)\tau(i)di}{\tilde{\beta}\int_0^J t(i)\tau(i)di + \int_J^I t(i)di}$. Using the definitions of μ and γ above, this reduces to $\delta = \dfrac{\tilde{\beta}\mu}{\tilde{\beta}\mu+\gamma}$. Next, consider the elasticity of relative demand for labor with respect to change in the relative factor price ρ_I, given $(\beta, \tilde{\beta}, \rho_J)$. This elasticity is $\xi^I = \dfrac{d\ln\beta\left(\tilde{\beta}\mu+\gamma\right)}{d\ln\rho_I} = \delta\dfrac{\partial\ln\mu}{\partial\ln\rho_I} + (1-\delta)\dfrac{\partial\ln\gamma}{\partial\ln\rho_I} > 0$. The elasticity is positive because given ρ_J, J is fixed, and the rise in ρ_I raises *I*. Therefore, noting the expressions for μ and γ above, it is clear that $\tilde{\beta}\mu+\gamma$ must rise when ρ_I is raised. Similarly, the demand elasticity relevant to ρ_J is $\xi^J = \dfrac{d\ln\beta\left(\tilde{\beta}\mu+\gamma\right)}{d\ln\rho_J} = \delta\dfrac{\partial\ln\mu}{\partial\ln\rho_J} + (1-\delta)\dfrac{\partial\ln\gamma}{\partial\ln\rho_J} > 0$. This elasticity must also be positive, because given ρ_I, *I* is fixed, and the rise in ρ_J raises *J*, which must, in turn, raise $\tilde{\beta}\mu+\gamma$.[4] These elasticities work through impacts on the formal and the informal sector and each is a weighted average of the formal and informal sector's responses. Differentiating (11), we get

$$\left(\eta^* + \xi^I\right)\hat{w}^* - \left(\eta + \xi^J\right)\hat{w} = \left(\xi^I - 1\right)\hat{\beta} + \left(\xi^J - \delta\right)\hat{\tilde{\beta}} + \left(\xi^I - \xi^J\right)\hat{\bar{w}}. \quad (13)$$

[4] Notice that $\dfrac{\partial\left(\tilde{\beta}\mu+\gamma\right)}{\partial J} = \dfrac{t(J)\left[\tilde{\beta}\tau(J)-1\right]}{1-I} > 0$, because using Eq.(8), we have $\tilde{\beta}\tau(J) = \dfrac{\bar{w}}{w} > 1$.

Equation (13) yields an upward sloping locus in $\left(w, w^*\right)$ space because a higher w^* increases offshoring, raising labor demand in nation *H*, so that labor markets of the two nations clear after a suitable increase in the wage rate *w*. Differentiating (12) we get

$$\theta^* \hat{w}^* + \left(1-\theta-\theta^*\right)\hat{w} = -\left(1-\theta^*\right)\hat{\beta} - \left(1-\theta-\theta^*\right)\hat{\tilde{\beta}} - \theta\hat{\overline{w}}, \tag{14}$$

where θ^* is the cost share of *F* in the production of x^*, θ is the corresponding cost share of *H*'s formal sector, and the remainder $\left(1-\theta-\theta^*\right)$ is the share of *H*'s informal sector. This relationship yields a familiar negative relationship corresponding to the zero-profit condition in the factor price space $\left(w, w^*\right)$. Given output price, higher reward for labor in nation *F* can be consistent with zero profit only if the reward for nation *H*'s labor is lower.

3.1 Technological improvement in offshoring (fall in β):

Using equations (13) and (14) we consider the effects of a change in β (i.e., inverse of labor productivity of offshoring) on w and w^* for a given vector $\left(\tilde{\beta}, \overline{w}\right)$:

$$\frac{\hat{w}}{\hat{\beta}} = \frac{-\theta^*\left(\xi^I - 1\right) - \left(1-\theta^*\right)\left(\eta^* + \xi^I\right)}{\theta^*\left(\eta + \xi^J\right) + \left(1-\theta^*-\theta\right)\left(\eta^* + \xi^I\right)},$$

$$\text{and } \frac{\hat{w}^*}{\hat{\beta}} = \frac{\left(1-\theta^*-\theta\right)\left(\xi^I - 1\right) - \left(1-\theta^*\right)\left(\eta + \xi^J\right)}{\theta^*\left(\eta + \xi^J\right) + \left(1-\theta^*-\theta\right)\left(\eta^* + \xi^I\right)}. \tag{15}$$

Proposition 1[5] *A reduction in* β *leads to:*

(*a*). *an increase in the range of offshoring* $[0, I]$

(b). an increase in w and a fall in the range of formal-informal outsourcing $[0, J]$ *if and only if* $\xi^I > \theta^* - \eta^*(1-\theta^*)$,

(c). an increase in w^* *if and only if* $\xi^I < 1 + \frac{(1-\theta^*)(\eta + \xi^J)}{(1-\theta^* - \theta)}$, and

(d). a decrease in δ *if* $\xi^I \geq \theta^* - \eta^*(1-\theta^*)$.

Comment:

The decrease in β has the following effects on the initial equilibrium. First, it raises the relative factor price $\rho_I \left(= \frac{w^*}{\overline{w}\beta} \right)$ of completing a task in the developed nation, leading to more tasks being offshored. Second, less labor is required to complete each offshored task which dampens labor demand. Finally, lower labor costs initially drives down unit costs, and competitive equilibrium is restored through expansion of scale and higher labor demand on that count. This last effect is the familiar productivity effect, where technology improvement allows all factors to (potentially) get higher rewards. When $\xi^I > \theta^* - \eta^*(1-\theta^*)$, there is a relatively strong response of offshored labor demand to the change in the effective factor price ρ_I. In this case, the expansionary effects on labor demand dominate. Since the minimum wage is fixed, the labor market clears through an increase in the informal sector wage *w*. When *w* rises, the effective relative factor price for the formal sector $\rho_J = \overline{w}/(\tilde{\beta}w)$ must fall. This reduces formal to informal outsourcing *J*. Turning to the effect on the foreign wage, notice that if ξ^I is relatively small, the labor demand shift effect

[5] Proofs of all the propositions are provided in an appendix at the end.

(towards the developing nation) is relatively small and is dominated by the scale effect and hence w^* rises. Finally, the relative size of the informal sector δ must fall in when $\xi^I \geq \theta^* - \eta^*\left(1-\theta^*\right)$. This is because the relative size is independent of scale, and hence all that matters is the range of tasks that are outsourced from the formal to the informal sector. Since, J falls when $\xi^I > \theta^* - \eta^*\left(1-\theta^*\right)$, a smaller range of tasks are done in the informal sector. Even when $\xi^I = \theta^* - \eta^*\left(1-\theta^*\right)$, the relative size of the informal sector must fall because J remains unchanged but I rises, which means that a higher fraction of offshored tasks are now being done in the formal sector. ■

3.2 Technological improvement in the informal sector (fall in $\tilde{\beta}$):

The effect of a rise in informal sector productivity (i.e., fall in $\tilde{\beta}$) can be obtained by using Eqs.(12) and (14):

$$\frac{\hat{w}}{\hat{\tilde{\beta}}} = \frac{-\theta^*\left(\xi^J-\delta\right)-\left(1-\theta^*-\theta\right)\left(\eta^*+\xi^I\right)}{\theta^*\left(\eta+\xi^J\right)+\left(1-\theta^*-\theta\right)\left(\eta^*+\xi^I\right)},$$

$$\text{and } \frac{\hat{w}^*}{\hat{\tilde{\beta}}} = \frac{-\left(1-\theta^*-\theta\right)\left(\delta+\eta\right)}{\theta^*\left(\eta+\xi^J\right)+\left(1-\theta^*-\theta\right)\left(\eta^*+\xi^I\right)}. \tag{16}$$

Proposition 2 *A reduction in $\tilde{\beta}$ leads to:*

(a). an increase in the range of offshoring $\left[0,I\right]$ and also an increase in the range of formal-informal outsourcing $\left[0,J\right]$.

(b). an increase in w if and only if $\xi^J > \delta - \dfrac{\left(1-\theta^*-\theta\right)\left(\eta^*+\xi^I\right)}{\theta^*}$,

(c*). an increase in* w^**,* and

(d). a decrease in δ *if the* $\tau(i)$ *schedule is relatively steep at* $i = J$.

Comment:

At the initial *w*, the fall in $\tilde{\beta}$ raises the effective factor price $\rho_J = \overline{w}/(\tilde{\beta}w)$ of completing the tasks in the formal sector compared to the informal sector. This shifts some more tasks to the informal sector (i.e., *J* rises). However, because of the decline in $\tilde{\beta}$, each informal sector task needs less labor. This cost reduction at the initial equilibrium leads to reallocations that increase scale. The scale expansion drives up labor demand in the developed nation raising w^* and hence $\rho_I = w^*/(\beta\overline{w})$. Thus, more tasks are offshored. There are different opposing effects on demand in the informal sector. First, there is the demand reduction due to greater efficiency arising out of a lower $\tilde{\beta}$. On the other hand, increased offshoring of tasks, increased outsourcing of task to the informal sector, and scale expansion, all suggest an expansion of the manufacturing sector's labor demand in the developing country. When the offshoring and outsourcing elasticities (ξ^I, ξ^J) are relatively large, the inequality in part (b) of the proposition above is more likely to be satisfied, and the expansionary effects dominate the contractionary effect of labor saving technology change. In this case, manufacturing-sector labor demand in the developing country rises and the market clear at a higher informal wage *w*. Finally, consider the ratio of formal to informal sector labor employment. Suppose $\tau(i)$ is very steep at the initial equilibrium. As $\tilde{\beta}$ falls, there is not much of a change in J because τ rises rapidly to equal the new factor price ρ_J. Without much of a change in *J*, there are two effects of a fall in $\tilde{\beta}$, both of which reduce the ratio δ. First, each informal sector task requires less labor, which shrinks its relative employment through the labor-saving effect. Second, as I rises in response to a higher w^*, a rigid J means a greater range of tasks $[J, I]$ being done in the formal sector. This effect also shrinks δ. In other words, unless the $\tau(i)$ schedule is sufficiently flat to allow for an elastic response of J to a rise in ρ_J, share of informal sector employment in inversely related to informal sector productivity. ■

3.3 The Effects of a Change in the Minimum Wage:

If the developing nation's government decides to change the minimum wage, the effects can be analyzed using Eqs.(12) and (14) as:

$$\frac{\hat{w}}{\hat{\bar{w}}} = \frac{-\theta^*\left(\xi^I - \xi^J\right) - \theta\left(\eta^* + \xi^I\right)}{\theta^*\left(\eta + \xi^J\right) + \left(1 - \theta^* - \theta\right)\left(\eta^* + \xi^I\right)},$$

$$\frac{\hat{w}^*}{\hat{\bar{w}}} = \frac{\left(1 - \theta^*\right)\left(\xi^I - \xi^J\right) - \theta\left(\eta + \xi^I\right)}{\theta^*\left(\eta + \xi^J\right) + \left(1 - \theta^* - \theta\right)\left(\eta^* + \xi^I\right)}. \tag{17}$$

Proposition 3 *A reduction in $\bar{w}$ leads to:*

(a). an increase in the range of offshoring $[0, I]$ and a decrease in the range of formal-informal outsourcing $[0, J]$.

(b). an increase in w if and only if $\xi^I > \dfrac{\theta^*\xi^J - \theta\eta^*}{\theta^* + \theta}$,

(c). an increase in w^* if and only if $\xi^I < \dfrac{\left(1 - \theta^*\right)\xi^J + \eta\theta}{1 - \theta^* - \theta}$, and

(d). a decrease in δ.

Comment:

A cut in the minimum wage raises the relative price of doing tasks in the developed nation (i.e., ρ_I) and reduces the relative price ρ_J of doing tasks in the developing nation's formal sector (*vis a vis* the informal sector). This expands the offshoring margin *I* and shrinks outsourcing margin *J*. There are three effects on the informal wage *w* from these reallocations. First, as the marginal offshored task *I* rises, demand shifts from the developed to the developing nation tightening the latter's labor market and exerting an upward pressure on *w*. Second, at a lower minimum wage more tasks are done in the formal sector, reducing demand for informal sector labor, and this has a negative impact on the informal wage. Finally, the lowering of the unit cost at the initial equilibrium leads to scale expansion, which raises demand in all the labor markets, exerting an upward push on all the flexible factor prices. If ξ^I is large relative to ξ^J, the formal-informal reallocation effect (i.e., the second effect) is small, and the expansionary effects dominate. The net increase in the manufacturing sector's demand for labor in the developing country drives up the informal wage *w*. Finally, the comparative static effect on w^* is best understood by focusing on how the factor rewards $\left(w^*, \bar{w}, w\right)$ in the unit cost function may change *vis a vis* each other. When $\bar{w}$ falls, given the technology and output price, zero-profit requires that at least one of the factor rewards $\left(w^*, w\right)$ rises. When ξ^J is large relative to ξ^I, demand shifts disproportionately from the informal to the formal sector in response to the minimum wage cut. In this situation, there may be a net reduction in the developing country's manufacturing sector's labor demand which requires *w* to fall to clear the market. When *w* falls, the only possible outcome consistent with a zero-profit equilibrium is a higher w^*. Put differently, if ξ^J is relatively small, then it is possible that the informal wage *w* rises (as explained above), and it rises to such an extent that even at a lower $\bar{w}$

zero-profit can only be reestablished through a fall in w^*. It is easy to check that

$\frac{\theta^*\xi^J - \theta\eta^*}{\theta^* + \theta} < \frac{(1-\theta^*)\xi^J + \eta\theta}{1-\theta^* - \theta}$. Using this fact and part (c) of proposition 3, we have that if w^* falls, it must be that $\xi^I > \frac{(1-\theta^*)\xi^J + \eta\theta}{1-\theta^* - \theta} \Rightarrow \xi^I > \frac{\theta^*\xi^J - \theta\eta^*}{\theta^* + \theta}$. In turn, using part (b) of the proposition and the last inequality in the previous sentence, it must be that a necessary (but not sufficient) condition for w^* to fall is a rise in *w*. In other words, a rising factor reward in the informal sector is what allows developed nation wage to fall in spite of the fall in the developing nation's minimum wage. Finally, notice that a larger *I* and a smaller *J* in response to a cut in the minimum wage imply that fewer tasks $[0, J]$ are done in the informal sector and a greater range of tasks $[J, I]$ are done in the formal sector. Thus, the ratio of informal sector employment δ, must decline. ■

4. Conclusion

We consider the implications of having a formal-informal duality in a developing nation which receives offshored tasks from a developed nation. An important message underlying the findings is that results that are associated with traditional models may not necessarily extend to models with an informal sector. A prime example is the possibility of a decline in the developed nation wage in the face of an offshoring technology improvement, although this possibility is ruled out when the improvement in technology is specific to outsourcing to the informal sector. The reason, among other facts, is that while improvement in offshoring technology can raise effective costs of operating in the informal sector, improvement in the outsourcing technology must reduce the effective informal sector cost. On the policy front, we considered changes in the minimum wage. As one would expect, a cut in the minimum wage shrinks the relative size of the informal sector. However, the informal wage can actually rise because of expansionary effects on the scale of production of the manufactured good.

Our agenda for future work on this topic of dual labor markets include the analysis of effect of different types of labor standards (including the minimum wage) after allowing for imperfect monitoring of these standards in the formal sector. It is also relevant to look at competing offshoring destinations and how labor standards or degree of informality in one nation affects other offshoring recipients and possibly their labor standards. Finally, we have abstracted in this paper from considerations arising out of terms-of-trade changes in the output market. Interactions between output market terms-of-trade and factor market terms-of-trade in the presence of informality is another possible avenue for our future work.

Appendix

(A). Proof of Proposition 1:

Given $\overline{w}$, the definition of ρ_I in (7), and also (15) above, we get

$$\frac{\hat{\rho}_I}{\hat{\beta}} = \frac{\hat{w}^*}{\hat{\beta}} - 1 = \frac{-\left(1-\theta^*-\theta\right)\left(1+\eta^*\right)-\left(\eta+\xi^J\right)}{\theta^*\left(\eta+\xi^J\right)+\left(1-\theta^*-\theta\right)\left(\eta^*+\xi^I\right)} < 0. \tag{A1}$$

Equation (A1) implies that a fall in β must raise ρ_I. Therefore, using (7) we have that *I* must rise when β falls $\left(\frac{dI}{d\beta} < 0\right)$. The first relationship in (15) establishes that $\frac{\hat{w}}{\hat{\beta}} < 0 \Leftrightarrow \xi^I > \theta^* - \eta^*\left(1-\theta^*\right)$. Notice from the definition of ρ_J that given $\left(\tilde{\beta}, \overline{w}\right)$, $\hat{\rho}_J = -\hat{w}$.

Thus, $\frac{\hat{\rho}_J}{\hat{\beta}} = -\frac{\hat{w}}{\hat{\beta}} > 0 \Leftrightarrow \xi^I > \theta^* - \eta^*\left(1-\theta^*\right)$. In turn, from (8) we get $\frac{\hat{J}}{\hat{\beta}} > 0 \Leftrightarrow \xi^I > \theta^* - \eta^*\left(1-\theta^*\right)$.

Now, the second relationship in (15) shows that $\frac{\hat{w}^*}{\hat{\beta}} < 0 \Leftrightarrow \xi^I < 1 + \frac{\left(1-\theta^*\right)\left(\eta+\xi^J\right)}{\left(1-\theta^*-\theta\right)}$.

Finally, notice that $\delta = \frac{\tilde{\beta}\mu}{\tilde{\beta}\mu+\gamma} = \frac{\tilde{\beta}}{\tilde{\beta}+\lambda(J,I)}$, where $\lambda(J,I) \equiv \frac{\gamma}{\mu} = \frac{\int_J^I t(i)di}{\int_0^J t(i)\tau(i)di}$. As shown above, when $\xi^I \geq \theta^* - \eta^*\left(1-\theta^*\right)$, *w* will either rise or be constant when β falls. Thus, the marginal task *J* will either fall or remain constant. The increase in *I* without any increase in *J* means that the numerator of the expression for $\lambda(J,I)$ rises but the denominator remains constant or falls. Thus, $\lambda(J,I)$ must rise, implying that δ must fall when $\xi^I \geq \theta^* - \eta^*\left(1-\theta^*\right)$. ■

(B). Proof of Proposition 2:

The second relationship in (16) shows that the developed nation wage w^* must always rise when $\tilde{\beta}$ falls. In turn, this means that $\rho_I = w^* / (\beta \overline{w})$ must rise, which implies that *I* must rise.

Using the first relationship in (16) we get

$\frac{\hat{w}}{\hat{\tilde{\beta}}} + 1 = \frac{\theta^* (\eta + \delta)}{\theta^* (\eta + \xi^J) + (1 - \theta^* - \theta)(\eta^* + \xi^I)} > 0 \Leftrightarrow \frac{d(w\tilde{\beta})}{d\tilde{\beta}} > 0$. Thus, $\rho_J = \overline{w} / (\tilde{\beta} w)$ must rise when $\tilde{\beta}$ falls, which implies that *J* must rise. Using the first relationship in (16) we find that

$\xi^J > \delta - \frac{(1 - \theta^* - \theta)(\eta^* + \xi^I)}{\theta^*}$ is a necessary and sufficient condition for the informal wage *w* to rise with a fall in $\tilde{\beta}$. Turning to the relative size of the informal sector, recall that

$\delta = \frac{\tilde{\beta}}{\tilde{\beta} + \lambda(J, I)}$. where $\frac{\gamma}{\mu} = \frac{\int_J^I t(i) di}{\int_0^J t(i) \tau(i) di} \equiv \lambda(J, I)$. Fall in $\tilde{\beta}$ for a given λ reduces δ.

However, since *I* and *J* both rise, the direction of change of λ is, in general, ambiguous. If the $\tau(i)$ schedule is steep at $i = J$, the comparative static change in *J* will be small. In this event, the denominator for the expression for λ does not change much, but the numerator rises because of a rise in *I*. Thus, λ rises (assuming that $t(i)$ is not too steep at $i = I$). Therefore, in this case, a reduction in $\tilde{\beta}$ and an increase in λ both reduce δ. If both schedules $t(i)$ and $\tau(i)$ are steep, the offshoring and outsourcing margins do not change much, and λ does not change much. However, the fall in $\tilde{\beta}$ reduces δ. Therefore, as long as $\tau(i)$ is sufficiently steep at $i = J$, the informal share δ must fall with a fall in $\tilde{\beta}$. ■

(C). Proof of Proposition 3:

Using Eqs. (7), (8) and (17) for a given β and $\tilde{\beta}$, we get $\frac{\hat{\rho}_I}{\hat{\bar{w}}} = \frac{\hat{w}^*}{\hat{\bar{w}}} - 1 < 0$, and $\frac{\hat{\rho}_J}{\hat{\bar{w}}} = 1 - \frac{\hat{w}}{\hat{\bar{w}}} > 0$. These imply that a cut in the minimum wage must raise ρ_I and reduce ρ_J. In turn, Eqs.(7) and (8) show that *I* must rise and *J* must fall. The two inequalities in (17) yield $\frac{\hat{w}}{\hat{\bar{w}}} > 0$ if and only if $\xi^I < \frac{\theta^* \xi^J - \theta\eta^*}{\theta^* + \theta}$, and $\frac{\hat{w}^*}{\hat{\bar{w}}} < 0$ if and only if $\xi^I < \frac{(1-\theta^*)\xi^J + \eta\theta}{1 - \theta^* - \theta}$. Finally, recall that $\delta = \frac{\tilde{\beta}}{\tilde{\beta} + \lambda(J,I)}$, where $\lambda(J,I) = \frac{\int_J^I t(i)di}{\int_0^J t(i)\tau(i)di}$. As *I* rises and *J* falls, the numerator of the expression for λ rises and the denominator shrinks. Thus, λ rises as the minimum wage falls, and this means that δ must fall. ■

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