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Disentangling the Wage Impacts of Offshoring on a Developing Country: Theory and Policy

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Offshoring in Developing Countries: Labor Market Outcomes, Welfare, and Policy*

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Abstract: Does a reduction in offshoring cost benefit workers in the world's factories in developing countries? Using a parsimonious two-country model of offshoring we find very nuanced results. These include cases where wages monotonically improve, worsen, as well as where wages exhibit an inverted U-shaped relationship with the offshoring cost. We identify qualitative conditions under which these relationships hold. Since global welfare always rises with an improvement in offshoring technology, we find that there is a role for a wage tax or a minimum wage in the developing country. We derive the optimal levels of such policies.

JEL Classification: F11, F13, F16, F66, O19, O24
Keywords: Wages, International Offshoring, Wage Tax, Minimum Wage

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1 Introduction

Changes in communication and transportation technology have spurred international trade. It has also led to increased international fragmentation of production through offshoring. The latter makes it easier for nations to trade in productive factors without actually moving people across international borders. Recently, key offshoring locations, such as China, have turned to automation to increase productivity and reduce labor requirements in production. By 2013, thanks in part to direct local government subsidies, China was poised to become the world's biggest user of manufacturing robots, with the explicit goal of replacing jobs with machines and to attract foreign investors (New York Times 2017; Bloomberg View 2015, 2016; CKGSB 2016).[1]

For firms hoping to offshore tasks to developing countries, technological improvements in offshoring locations such as automation is tantamount to a reduction in the cost of offshoring (Grossman and Rossi-Hansberg 2008, henceforth GRH). The purpose of this paper is to study the effects on developing nations of technological improvements that reduce the cost of offshoring from developed to developing nations. While such technological improvements surely spur offshoring to developing nations, and also raise global income, it is unclear to what extent developing nations can share this income gain.[2] This is because technological change, such as automation and the widespread use of robots is explicitly labor saving, and therefore there are, ex ante, conflicting effects on a developing nation's labor demand. The interplay of an exogenous technological improvement and consequent endogenous adjustments in factor allocations across and

[1]See also Knight (2017), who reports that China's latest Five Year Plan will allocate billions of yuan worth of central government funds to industrial upgrading using robots and machines. In addition, provincial government funds are also being allocated towards the same objective, e.g., Guangdong province has proposed to spend $150 billion to equip its factories with robots.

[2]It is worth mentioning that the effect of offshoring on developed nation wages and income distribution is a subject of much recent research. In particular, although it is natural for developed nations to gain from offshoring technology improvements, their effect on wages are less clear. For example, there is concern that offshoring has contributed to "hollowing out" of the middle of the US income distribution (see Autor et al. 2006). This can happen when middle income earners do routine tasks that are more easily offshorable, compared to advanced tasks at the top that are harder to replicate abroad, or more manual tasks at the bottom that require physical presence in the developed nation (like lawn mowing, janitorial services etc.).

within nations determine the final outcome in complicated ways. While the literature on offshoring has developed rapidly, many of these issues have not yet been addressed. This paper attempts to fill some of this gap.

We build a model that borrows insights developed in GRH. In particular, we use their trade in tasks technology, where some tasks are more easily offshored to developing nations than other tasks. The tasks that are harder to be offshored require more labor to be completed in the developing nation. GRH assumed that the developing nation wage is exogenously given, and therefore they do not model the supply side of the offshoring labor market. In contrast, our main focus is the developing nation's labor market, and how it is impacted by changes in offshoring technology. However, in general international equilibrium, the source and destination (of offshoring) nations' labor markets are linked, and one of the novelties of the paper is to qualitatively disentangle the wage effects in the two nations. While the positive productivity effects of GRH is present in our framework and tends to lift all boats, a potential adverse movement in the developing nation's factor market terms of trade can hurt it.

We present a two good competitive trade model where firms from a developed nation producing one of the goods offshore some tasks to be completed in the developing nation. To focus on factor market trade, and for greater analytical clarity, we start out by assuming that the nations are "small" in the output market.[3] For example, these nations can have a purely bilateral offshoring relationship, while they trade in goods with all nations. Laborers in the developing nation work either in the offshoring sector, or in the sector producing the other good. Improvements in offshoring technology allow all wages to rise through increased productivity, but interlinked labor market effects of the two nations can pull wages in different directions. We identify qualitative conditions that determine when the wages move together or when they diverge. We show that under free trade, with improvements in offshoring technology, while the developing nation wage can fall under certain conditions, the developed nation wage must always rise. Furthermore, we find that if an optimal wage tax is placed in the developing nation's offshoring sector,

[3]Section 7 of the paper considers the implications of relaxing this assumption.

then wage and welfare reductions can be ruled out.[4] We also show that a sector specific minimum wage in the offshoring sector achieves the same outcome, although an economy-wide minimum wage does not. Some of our findings are reminiscent of Bhagwati's (1958) immiserizing growth contribution and also his work on the theory of distortions. It should be noted, however, that the conditions under which Bhagwati's paradox can happen are quite demanding. In contrast, we identify a simple and plausible condition pertaining to elasticity of labor demand in the offshoring sector that enables welfare reductions for the developing nation. We also extend the analysis to the case where the developing nation can tax wages in the offshoring sector.[5]

Finally, we also fully analyze the implications of relaxing the "small country" assumption in the final goods market. In this case, we still have the possibility of the developing country real wage and welfare going down with a fall in the cost of offshoring, even though the price of the final good, whose production faces offshoring, can fall. This fall in welfare is more likely to happen with a relatively small share of this good in consumption. In other words, there is another channel that works through the final good price, which also comes into play in evaluating the impact of the wage tax. In the context of the wage tax, the original channel, which still exists, is the impact of this tax on the developing country wage at given final good price. The new channel works through the impact of the wage tax on the world price of the good whose production process involves offshoring. This price increases with the tax, which has a consumption cost associated

[4]We assume that the developed country government is passive in that it does not try to formulate policies to move the factoral terms of trade toward itself. We believe this is a reasonable assumption, given that no developed country would like to be seen as reacting to labor market policies enacted by a developing nation. Furthermore, our wage tax policy relies on the assumption that wage increases in the developing nation do not drive offshoring to alternate destination nations. This is reasonable for sizable destination countries like India or China. In manufacturing, China has a lion's share of the world's input processing, while India is a major destination of service offshoring, especially in information technology and information technology enabled services. These countries, therefore, have considerable market power in "tasks". However, as they specialize in tasks offshored in different sectors (manufacturing in China and services in India) due to differences in infrastructure and skill availability, they are not viewed as substitute destinations for offshoring.

[5]Specifically, we show that if the wage tax is exogenously given, the welfare paradox cannot be ruled out. However, if the tax is set at an unilaterally optimal level, the equilibrium must occur on the elastic range of the labor demand curve. See Bhagwati (1968) for an analogous result in a somewhat different context of export-biased growth.

with it. But the price increase also increases the developing country wage. Thus, when this good is not an important component of the consumption basket, the net impact of this price increase on welfare is positive, and adds to the original direct positive impact, leading to the implication that the optimal wage tax is likely to be larger in the large country case.

One could question the importance of the possibility of real wage and welfare reducing impacts of improvements in offshoring technology in our model, given that countries like India and China, that have been recipients of significant amounts of offshoring, have, in fact, seen significant real income growth accompanying this offshoring. Our results caution us about making generalizations based on the experiences of these two countries (i.e., applying them to other countries). More importantly, in many developing countries, minimum wage laws are probably much more strictly enforced in the case of multinational firms, resulting in the differential application of these instruments within such economies (which is consistent with what we do in our model).[6] Under these conditions, in our model offshoring cost reductions are more likely to result in welfare increases in the developing country, a result consistent with the observed income growth accompanying offshoring. As Heineman (2012) notes, global corporations are "subject to exacting scrutiny" about their motives behind offshoring to developing countries related to avoiding "environmental, health and safety regulations" in developed countries. As a result, he argues for the adoption of certain "global standards" by these corporations, which have to be a part of "responsible offshoring", irrespective of local regulations. These standards include policies to be set (or already set) by multinationals to assure "decent working conditions", including "wages and hours". Such policies, within our theoretical framework, are likely to ensure a positive impact of offshoring on the developing world.

The next section discusses some related literature. Section 3 presents the free trade

[6] It is relevant here that Harrison and Scorse (2008) find evidence from Indonesia that there is stricter compliance of minimum wage and other labor standards by foreign firms relative to domestic firms as the former are more focused targets of activism by labor advocacy groups and anti-sweatshop campaigns. Thus, at least effectively, there exists a sector-specific minimum wage. For the analogous case of the implementation of environmental regulations, see Krautheim and Verdier (2015) who look at the endogenous emergence of NGO activism in the presence of offshoring that makes it costly for multinational firms to implement dirty technology that hurts consumers at home.

model, Section 4 presents some simulations to highlight the conditions when wages rise or fall or respond non-monotonically to technology improvements, Section 5 discusses the impact of offshoring cost reductions on global welfare, Section 6 is on labor market policies, and Section 7 presents the "large" country case where output prices are endogenous. Section 8 concludes.

2 Related Literature

The new literature on offshoring pioneered by GRH has focused policy attention on the effects of offshoring on labor-market effects in developed nations. The literature has established that, contrary to popular belief, laborers in developed nations can benefit from offshoring. The empirical literature has established that offshoring and developed nations' employment can be complements rather than substitutes. For example, Desai et al. (2005) show a strong positive correlation between foreign activities and domestic activities of US multinational firms. Mankiw and Swagel (2006) conclude that increased employment in the overseas affiliates of U.S. multinationals is associated with more employment in the U.S. parent. Harrison and McMillan (2011) find that foreign employment and domestic employment are substitutes for firms undertaking horizontal foreign direct investment and they are complements for firms undertaking vertical foreign direct investment. Most of the remaining recent related theoretical literature also focuses on the impact on the developed world.[7]

There are some other extensions and modifications of the GRH framework available in the literature. For example, Ottaviano, Peri and Wright (2013), for their empirical work on offshoring and immigration in the US context, begin by providing a theory that uses the GRH approach to modeling not only offshoring but also immigration at the same time. There has also been some important work on two-way offshoring between similar

[7]For example, in line with the theoretical results in GRH discussed above, Mitra and Ranjan (2010) show that offshoring from a developed to a developing country may reduce the developed country's equilibrium search unemployment. See also Ranjan (2013) for how the impact of offshoring on unemployment depends on the nature of labor market institutions (collective bargaining versus individual bargaining) but again has a developed country focus (for example, US versus Euope). For an in-depth survey of the literature on offshoring and labor markets, see Hummels, Munch and Xiang (2016).

countries.[8]

On the impact of offshoring on developing countries, there is recent work by Bergin, Feenstra and Hanson (2011). This paper is related to ours in that it also shows a channel through which offshoring from a developed to a developing country can have an adverse effect on the latter but, differently from ours, this effect works through the export of volality from the former to latter.[9] There is also the earlier influential work by Feenstra and Hanson (1996, 1997) which looks at the impact of offshoring of tasks (or inputs) that vary by skill intensity from a developed to a developing country. While they look at the impact on both the developed as well as the developing country their main variable of interest is wage inequality (the ratio of the skilled to unskilled wage). Specifically, they show that offshoring can shift the least skill-intensive tasks from a developed country to a developing country and yet these tasks could end up being among the most skill-intensive of all tasks in the latter. Thus, the relative demand for skilled labor goes up in both developed and developing countries, resulting in a rise in wage inequality. Another important and insightful paper on the foreign and domestic labor-market consequences of offshoring is Davidson, Matusz and Shevchenko (2008), who present a model with search frictions in the labor markets of both a Northern and a Southern country. Thus their labor-market setting is quite different from ours. Wages in their model are negotiated via generalized Nash bargaining. The paper shows that outsourcing high skilled work by firms in the Northern country to the South raises Southern high skilled wages. The increase in outsourcing of high-skilled work abroad is made possible by a reduction in the cost of vacancy posting in the South.

There is an older literature that looks at the impact of offshoring in the form of vertical foreign direct investment (FDI) on developing country labor markets. One example of such a paper on vertical FDI is Helpman (1984), in which unskilled wage can go up in developing countries as a result of such FDI. While many empirical and earlier

[8]For example, Grossman and Rossi-Hansberg (2012) focus on "trade in tasks" between two similar countries, with an economies-of-scale element embedded in the model.

[9]Wage increases in the developed country during upswings of the business cycle will result in increases in offshoring to the developing country, while during downswings offshoring will go down. Thus offshoring stabilizes the wage in the developed country but increases its volatility in the developing country.

theoretical papers on vertical FDI arrive at the conclusion that vertical FDI has positive effects on developing country labor markets (McMillan, 2009), unlike our paper they do not look at the impact of small and gradual reductions in offshoring costs (fall in trade costs, easier overseas supervision and monitoring and greater automation) that bring in more and more complex tasks into the fold of offshoring. We view the earlier theoretical literature, that does not have a task-trade view of offshoring but focuses on vertical FDI, and our work as complementary in the understanding of the impact of offshoring on developing country labor markets.

Thus the focus of the recent literature on offshoring modeled as trade in tasks is predominantly on the developed nations' labor markets. The developing nations' markets are typically black-boxed by assuming that they supply labor at constant terms-of-trade. It is, however, important to explore how such offshoring may impact developing nations. While this focus is important by itself, it also informs us about the feedback effects on developed nations.

3 A Parsimonious Two-Country Model of Offshoring

Consider a world where there is a developed nation and a developing nation. The developed nation allocates her workers between two sectors, x^* and y^*. Both the developed and developing nations are small open economies who take prices p_x, p_y as given. Henceforth, we take y as the numeraire and set $p_y = 1$. The production technology in y^* uses labor only, $F_y^*(L_y^*)$, and exhibits strictly diminishing marginal returns.[10] Let the derived labor demand in y^* given w^* be $L_y^*(w^*) = \{L_y^* | \partial F_y^*(L_y^*)/\partial L_y^* = w^*\}$. In x^*, tasks can be performed domestically, in the developing country, or both. Along the lines of GRH, a unit of x^* requires a continuum of labor tasks $i \in [0, 1]$ to be performed. Total labor supply of the developed nation is inelastically given at $\bar{L}^*$. The economy-wide wage rate

[10]One can view our production functions for sectors y and y^* as standard constant-returns-to-scale technology in labor and a sector-specific factor (say land). Diminishing returns to labor is a consequence of that fixed/specific factor in the background. The other sector (offshoring sector) also has constant-returns-to-scale but no specific factor for tractability and clarity. Our model falls in the broad class of specific-factors trade models.

in the developed nation is fully flexible and competitively determined, w^*.

The developing nation H likewise allocates workers between two sectors y and x. Production technology in y, $F_y(L_y)$, exhibits strictly diminishing marginal returns. As in the developed nation, let derived labor demand in y given w be $L_y(w) = \{L_y | \partial F_y(L_y)/\partial L_y = w\}$. Workers in the x sector perform tasks offshored from the developed nation. There are $\bar{L}$ total number of workers here, and wages in the two sectors are flexibly and competitively determined, w.

In the standard labor market representation, we denote i as the complexity of a task. Offshoring a task i from the developed to the developing nation requires a cost of $\beta t(i)$ of the developing nation's labor [where $\beta > 0$ and $\beta t(i) > 1$ for all i].[11] Assume henceforth that $t(i)$ is monotonically increasing in i so that the offshoring cost is increasing in the complexity of the task. Furthermore, let any task i require a^* units of labor to complete in the developed nation and a units of labor to complete in H. For simplicity let $a^* = a = 1$. Therefore, a task i is offshored to H if and only if:

$$w^* \geq w\beta t(i)$$

Or,

$$t(i) \leq \frac{w^*}{w\beta}. \tag{1}$$

Define $I = \{i | t(i) = w^*/(w\beta)\}$. By monotonicity of $t(i)$, it is clear that tasks $i \in (I, 1]$ cost more to be done in the developing nation, and hence are conducted in the developed nation. The remaining tasks $i \in [0, I]$ are offshored to the developing nation. Thus, total employment in x^* is simply $L_x^* = x^*(1 - I)$, while total employment in x is given by $L_x = x^* \beta \int_0^I t(i) di$. The employment ratio of tasks conducted in the developing country relative to tasks conducted in the developed country is:

$$\lambda = \frac{L_x}{L_x^*} = \frac{\beta \int_0^I t(i) di}{1 - I}. \tag{2}$$

[11] In the rest of the paper we refer to a reduction of β as an improvement in offshoring technology, or as a parametric reduction in offshoring cost. It is important to note that offshoring cost also involves endogenous elements like the range of tasks offshored and the wage rates at which such tasks are performed. Hence, when we write "parametric reduction in offshoring cost", we are referring solely to the exogenous element of the cost, captured by β.

Henceforth we shall refer to λ the offshored employment intensity of sector x. As shown, this intensity depends only on the marginal task offshored I, or equivalently, the relative wage cost, $w^*/(w\beta)$, for $I = \{i | t(i) = w^*/(w\beta)\}$. Denote the relative wage cost

$$\frac{w^*}{w\beta} \equiv \rho$$

Since λ is increasing in the complexity of the marginal task I, the offshored employment intensity λ is thus strictly increasing in the relative wage cost ρ. Henceforth, let ϵ denote the elasticity of the efficiency adjusted offshored employment intensity with respect to ρ: $\epsilon = d\log(\lambda/\beta)/d\log(\rho)$.

Full employment in the developed and developing nations requires that:

$$\begin{aligned} \bar{L}^* &= L_y^*(w^*) + L_x^* = L_y^*(w^*) + x^*(1 - I), \\ \bar{L} &= L_y(w) + L_x = L_y(w) + x^*\beta \int_0^I t(i)di. \end{aligned}$$

Using (2), the full employment conditions in the two countries can be succinctly summarized as follows:

$$\lambda L^*(w^*) = L(w) \tag{3}$$

where $L^*(w^*) \equiv \bar{L}^* - L_y^*(w^*)$ denotes the effective labor supply to x^* in the developed nation and $L(w) \equiv \bar{L} - L_y(w)$ denotes the effective labor supply to x in the developing nation. Henceforth, let η^* and η, both positive, respectively denote the elasticity of $L^*(w^*)$ and $L(w)$.

Henceforth, denote a $\hat{}$ as proportionate change ($\hat{x} = dx/x$). Equation (3) gives

$$(\eta^* + \epsilon)\hat{w^*} - (\eta + \epsilon)\hat{w} = (\epsilon - 1)\hat{\beta}. \tag{4}$$

(4) defines a global labor market equilibrium. In Figure 1, this is denoted as schedule L. From (4), we note that factors that tighten the developed country labor market by raising w^* will spill over and raise w as well. The strength of this link, or effectively the slope of L, will depend on the relative labor supply elasticities, η^* and η adjusted with ϵ to reflect the tie between the two countries via the offshoring relationship.

Interestingly, a reduction in the offshoring cost has two effects on schedule L. First it has a negative labor demand impact on the intensive margin as each unit of a task offshored can be performed by fewer workers. Second there is a positive impact on the extensive margin of offshoring in that the measure or proportion of tasks offshored goes up, i.e., I goes up, which means that the marginal task performed has a higher degree of complexity. As can be seen from equation (4), the former effect dominates when $1-\epsilon > 0$, which leads to a reduction in the offshoring cost to shift the L schedule up, in which case the value of w compatible with a given w^* will now be lower (Figure 1). Obviously the shift will be in the reverse direction when $1 - \epsilon < 0$.

To close the model, we note that the price (p_x) equal unit cost relation in the production of x^* is given by:

$$w^*(1 - I) + w\beta \int_0^I t(i)di = p_x. \tag{5}$$

Denote

$$\theta^* = \frac{w^*(1 - I)}{p_x}$$

as the developed country share of the total labor cost in the production of x^*, we have, upon totally differentiating (5),

$$\theta^* \hat{w^*} + (1 - \theta^*)\hat{w} = -(1 - \theta^*)\hat{\beta}. \tag{6}$$

This zero profit condition is depicted graphically as schedule π in Figure 1. From (6), any increases in w^* must lead to a reduction in w, all else equal. The strength of this link is determined by the wage cost share θ^*. Furthermore, the productivity impact of a reduction in offshoring cost applies unambiguously here as a reduction in β shifts the π schedule upwards (Figure 1).

The equilibrium impact of a reduction in offshoring cost on w^* and w thus depend on the relative strength of the three aforementioned effects: (i) the intensive margin labor demand impact, (ii) the marginal task complexity or extensive margin impact, and (iii) the productivity impact. Making use of (4) and (6), the balance of these three effects are summarized here:

$$\frac{\hat{w^*}}{\hat{\beta}} = -\frac{(1-\theta^*)(1+\eta)}{\theta^*(\eta+\epsilon)+(1-\theta^*)(\eta^*+\epsilon)} < 0, \quad \frac{\hat{w}}{\hat{\beta}} = -\frac{\epsilon+\eta^*-\theta^*(1+\eta^*)}{\theta^*(\eta+\epsilon)+(1-\theta^*)(\eta^*+\epsilon)}. \tag{7}$$

Furthermore, since

$$\frac{\hat{\rho}}{\hat{\beta}} = \frac{\hat{w^*}}{\hat{\beta}} - \frac{\hat{w}}{\hat{\beta}} - 1, \tag{8}$$

substituting the solutions we have obtained for $\hat{w^*}/\hat{\beta}$ and $\hat{w}/\hat{\beta}$, we have

$$\frac{\hat{\rho}}{\hat{\beta}} = \frac{-(1+\eta)}{(\eta+\epsilon)\,\theta^* + (\eta^*+\epsilon)\,(1-\theta^*)} < 0. \tag{9}$$

Since $t(I) = \rho$, we have $dI/d\beta = (1/t'(I))\,(d\rho/d\beta) < 0$. Thus the range or proportion of tasks offshored and the complexity of the marginal task offshored increases with a reduction in β.

Defining the demand for labor from the offshoring sector faced by the developing country as $L_x^d = \lambda L^*(w^*)$ and further denoting the total elasticity of L_x^d with respect to w, factoring in its impact on w^*, as ξ^d, we show in the appendix that $\xi^d = (\epsilon+\eta^*(1-\theta^*))/\theta^*$. Thus we have the following proposition.

Proposition 1 *A parametric reduction in the cost of offshoring*

- *always increases the range of tasks offshored, I,*
- *always increases the developed country wage, w^*.*
- *decreases (increases) the developing country wage w if and only if $(\epsilon+\eta^*)/(1+\eta^*) < (>)\theta^*$, or alternatively, if and only if $\xi^d < (>)1$.*

These fundamentally *unequal* wage responses to the same cost saving technological improvement are only possible when the intensive margin labor demand impact exceeds the task complexity impact: $1 > \epsilon$. If this is indeed the case, then an asymmetric wage response to a reduction in β is all the more likely when the developed country labor supply $L^*(w^*)$ is sufficiently inelastic (η^* is small). This is shown in Figure 1, where the upward shift of the L schedule more than completely erases any potential developing country wage gains through the shift in π. At the limit, where the developed country labor market is fully inelastic ($\eta^* = 0$), a reduction in the cost of offshoring raises w^* but decreases w if and only if the task complexity impact ϵ is less than the developed country wage share θ^*.

In our analysis, the labor costs of offshoring are incurred in the developing country and, as a result, offshoring cost reductions reduce effective labor requirements per unit task performed there. As explained earlier, this could be a result of automation taking place in countries, such as China. It could also be a result of reduction in regulatory burdens taking place in the developing world brought about by economic policy reforms, thereby saving on resource costs to follow or get around regulations. Thirdly, this could be a reduction in transport costs, modeled in iceberg form, so that less of each type of intermediate input needs to be transported to the developed country for a unit to reach there. An alternative to all of the above could be a form of offshoring cost that is incurred in the developed country. For example, better coordination and communication technology, while increasing labor productivity in the South, could also reduce communication costs incurred in the developed world. If our focus had been on the latter, it is highly likely that the developing country would unambiguously benefit from such an offshoring cost reduction. However, the types of offshoring cost reductions we focus on, namely those leading to a decline in unit labor requirements in the South, are important enough for us to restrict our attention to them in this paper.

If we define developed and developing country welfare (M^* and M) simply as the total value added or income generated in the two sectors:

$$M^* = F^*(L_y^*) + w^* x^*(1 - I), \quad M = F(L_y) + w x^* \beta \int_0^I t(i) di \tag{10}$$

then an immediate corollary of proposition 1, replacing wage with welfare, applies immediately under the exact same set of conditions.[12]

As indicated above, while $1 - \epsilon > 0$ or $\epsilon < 1$ ensures an upward shift in the L

[12] In the presence of identical and homothetic preferences and constant final goods prices, aggregate welfare is maximized when aggregate income is maximized (aggregate welfare is increasing in aggregate income).

schedule, for this upward shift to be greater than the upward shift in the π curve we need the more stringent condition $(\epsilon+\eta^*)/(1+\eta^*) < \theta^*$, or equivalently $\epsilon < \theta^* - (1-\theta^*)\eta^* < 1$. This is more likely to happen when the developed country's share in the cost is high and/or the labor supply to the x^* sector is highly elastic. In what follows, we will demonstrate in a series of numerical simulations that these intuitions are indeed borne out.

4 Simulations

In this section, we introduce specific functional forms in order to demonstrate the diverse ways in which the cost of offshoring can impact wages in developing countries as summarized in Proposition 1. Specifically, let

$$t(i) = \begin{cases} \frac{1}{1-\sigma i} & \text{for } i \in [0, \frac{1}{\sigma}), \sigma > 0 \\ \infty & \text{for } i \in [\frac{1}{\sigma}, 1], \sigma > 0 \end{cases} \tag{11}$$

and furthermore, let

$$L^*(w^*) = \ell^*(w^*)^\phi, \quad L(w) = \ell w^\phi, \quad \ell^*, \ell > 0, \quad \phi > 0. \tag{12}$$

The cost of offshoring $t(i)$ is strictly increasing and convex in the complexity of the task. At given task complexity i, a sector with a high parameter σ faces a higher increase in offshoring cost as task complexity increases. To focus on the role of the cost of offshoring, we make simple assumptions on the labor supply to the x sector in the two countries, at constant elasticity $\phi > 0$.

Using (8), the elasticity ϵ and the wage share θ^* can be expressed succinctly as:

$$\epsilon = \frac{1}{\log(\rho)} + \frac{1}{\rho(\sigma-1)+1}, \quad \theta^* = \frac{\rho(\sigma-1)+1}{\rho(\sigma-1)+1+\log(\rho)}. \tag{13}$$

As shown, ϵ and θ^* are completely determined by the parameter σ, and the variable ρ. All else equal, a higher σ translates to (i) a reduction in the elasticity of offshored employment intensity with respect to the relative wage cost, ϵ, and (ii) an increase in the developed country wage cost share θ^* as offshoring higher complexity task to the developing country is costly at high σ. Thus, while a priori the inequality displayed in

Proposition 1 may or may not be satisfied, it is conceivable that the developing country wage will be adversely affected by a parametric reduction in offshoring cost β in industries where σ is sufficiently high.

With the addition of (12), the two equations (3) and (5) can be solved numerically.[13] Figure 2 plots the equilibrium developing country wage as a function of the cost of offshoring β for successively increasing values of σ's.[14] As shown, starting from σ sufficiently small (at $\sigma = 5$ where ϵ is relatively high, all else equal), the developing country wage response to a reduction in β is monotonically positive. As σ rises (at $\sigma = 10, 15$), the developing country wage response exhibits an inverted U-shape.These results are consistent with the findings reported in Proposition 1.

The basic messages are two-fold. First, the developing country wage impact of a parametric reduction in the cost of offshoring depends on how steeply the task-specific offshoring cost is rising in task complexity, where the steepness of this relationship and the responsiveness of the proportion of tasks offshored to a change in the effective relative wage, $\frac{w^*}{w\beta}$ are inversely related. Furthermore, the developing country wage impact of a reduction in the cost of offshoring can change as increasingly complex tasks are offshored. Indeed, as shown in Figure 2, for example, the developing country wage exhibits an inverted U-shaped relationship with β (for σ= 10; 15), indicating that the developing country wage first rises, and then eventually falls with successive parametric reductions in the cost of offshoring.

As a reality check of the equilibrium values of wages in the two countries, Table 1 displays the simulated equilibrium relative wage cost ρ and the equilibrium index of the marginal offshored task, I, for given cost of offshoring β. Of the three values of σ shown in Figure 1, we consider the intermediate case of $\sigma = 10$. Blinder (2009) reports a wide range of offshorable task estimates ranging from 11% to 38% for the United States. Since not all offshorable tasks are offshored in equilibrium, these values represent the upper

[13]Specifically, (3) and (12) jointly imply $\lambda^{-1/\phi} = \rho\beta$. The implicit solution of this equilibrium relationship, using (2), gives the equilibrium relative wage cost ρ. Substituting ρ into (5) gives $w = p_x\sigma/(\beta(\rho(\sigma - 1) + 1) + \log(\rho))$.

[14]In addition to the values of σ indicated, we furthermore make the following assumptions: $\phi = 2$, $p_x = 1$.

bound on the offshoring phenomenon. Based on the simulated values of I^* shown in Table 1, the simulated share of offshored tasks range from 5.4 to 8%, and thus uniformly lower than the 11 - 38% range. In terms of relative wage costs, McKinsey Global Institute (2003) reports that the cost savings for every dollar spent by offshoring firms abroad is \$0.58. This translates to a home to developing country cost ratio at $1/0.42 = 2.38$. In Table 1, the simulated wage cost ratios ($\rho = w^*/(w\beta)$) are similar in order magnitude, ranging from 2.185 to 5.053.

Given these parameter values, consider a parametric reduction in the cost of offshoring starting from $\beta = 1.2$. We chose this value of β for the developing country wage attains a maximum value around here as shown in Figure 2. Note that the developing country wage decreases by 0.15% to 2.33% as β decreases from 1.2 to 0.8. Meanwhile, the developed country wage increases by 0.31% to 1.38%. By contrast, raising the cost of offshoring starting from $\beta = 1.2$ decreases both the developing and the developed country wages w and w^*. In the next section, we relate these changes in the developing country wage to the national welfare of the developed and the developing country.

Table 1: Simulation Results

			% change from when β =1.2	
β	ρ	I	in w	in $w*$
0.8	5.053	0.080	-2.33%	1.38%
0.9	4.426	0.077	-1.25%	1.00%
1	3.941	0.075	-0.54%	0.65%
1.1	3.557	0.072	-0.15%	0.31%
1.2	3.246	0.069	0.00%	0.00%
1.3	2.989	0.067	-0.06%	-0.30%
1.4	2.774	0.064	-0.30%	-0.57%
1.5	2.593	0.061	-0.68%	-0.83%
1.6	2.437	0.059	-1.19%	-1.08%
1.8	2.185	0.054	-2.51%	-1.53%

5 The Impact of Parametric Offshoring Cost Reduction on Global Welfare

As mentioned earlier, national welfare rises (falls) with a reduction in β as wage rises (falls). When both w and w^* rise with a reduction in β it is quite clear that the joint welfare of the developed country and the developing country, which we will call global welfare from now on, will rise. However, there is also the case where w falls and w^* rises with a fall in β. In that case what happens to global welfare? This question is important since it answers the question whether offshoring would still benefit the developed country even if it had to compensate the developing country for the loss in its welfare.

We can write global welfare as the sum of the developed and developing country welfares as follows.

$$M^G = F_y^*(L_y^*) + w^*(\bar{L}^* - L_y^*) + F_y(L_y) + w(\bar{L} - L_y). \tag{14}$$

Totally differentiating with respect to β and noting that $F_y^{*\prime}(L_y^*) = w^*$ and $F_y'(L_y) = w$ we have

$$\frac{dM^G}{d\beta} = (\bar{L}^* - L_y^*)\frac{dw^*}{d\beta} + (\bar{L} - L_y)\frac{dw}{d\beta}$$

This, in turn, can be written as

$$\begin{aligned} \frac{dM^G}{d\beta} &= (\bar{L}^* - L_y^*)\left[1 + \left(\frac{1-\theta^*}{\theta^*}\right)\left(\frac{\hat{w}/\hat{\beta}}{\hat{w}^*/\hat{\beta}}\right)\right]\frac{dw^*}{d\beta} \\ &= L_x^*\left[\frac{\eta\theta^* + \epsilon + \eta^*(1-\theta^*)}{(1+\eta)\theta^*}\right]\frac{dw^*}{d\beta} < 0 \end{aligned}$$

Therefore, we get the following proposition.

Proposition 2 *Global welfare always increases with a parametric reduction in offshoring costs (a reduction in β).*

6 Policy Implications and Optimal Policy

As the offshoring decisions in the developed country directly affect labor demand in the developing country's offshoring sector, the policies we look at directly target workers in that sector. In particular, we analyze the effects of a sector-specific wage tax and minimum wage policy in the developing nation. We also derive optimal levels of these policies in our setting. Here it would be in order to make a clarification. As discussed earlier, offshoring is a form of trade. In trying to fix a directly trade related distortion, the first-best line of attack is trade policy. However, noting that these services (performing of offshored tasks) are exclusively produced for export and viewing workers in the developing country's offshoring sector as exporters of these services, it is easily seen that there is no difference effectively between an export tax and a wage tax. However, to trading partners using trade policy disguised in the form of a wage tax or a minimum wage might be less objectionable than the direct use of trade policy to shift real income.

6.1 Wage Tax

We first consider here an exogenous tax, τ on the wage in the offshoring sector in the developing country. In equilibrium, under perfect intersectoral labor mobility the wage paid by the employers in sector y would be $w(1-\tau)$. Therefore, in the presence of this wage tax we modify the derivation of schedule L slightly. We replace $L(w) = \bar{L} - L_y(w)$ with $L(w(1-\tau)) = \bar{L} - L_y(w(1-\tau))$. Nowhere else in the equation for schedule L or even schedule π does τ enter. It is easy to see that this means that in Figure 1, the schedule L with a positive τ will lie to the right of the schedule L with $\tau = 0$. Any further increase in τ will shift schedule L further to the right. Schedule π remains unchanged. This means that equilibrium w increases with τ.

We are going to assume that the tax revenue collected in the developing country will be distributed lump sum equally within the population. As a result, aggregate welfare in the developing country is given by

$$M = F_y(\bar{L} - L_x) + wL_x. \tag{15}$$

Note that the post-tax wage bill received by workers in the offshoring sector in the developing country is $w(1-\tau)L_x$ and the tax revenue collected $w\tau L_x$ is distributed by the government equally to the population. Thus wL_x is the after-tax wage bill received by workers in the offshoring sector plus the government's tax revenue. As mentioned above, in equilibrium, workers should be indifferent between working in sector y and sector x, which means employers in the y sector will be paying wage $w(1-\tau)$. Using $dL_x^d(w, w^*, \beta)/dw = \partial L_x^d/\partial w + \left(\partial L_x^d/\partial w^*\right)(dw^*/dw)$, where dw^*/dw is a movement along the existing schedule π, we have

$$\frac{dM}{d\tau} = -F_y' \frac{dL_x^d}{dw} . \frac{dw}{d\tau} + L_x \frac{dw}{d\tau} + w \frac{dL_x^d}{dw} . \frac{dw}{d\tau}$$

Substituting $F_y' = w(1-\tau)$, we have

$$\frac{dM}{d\tau} = \left[1 - \tau \xi^d\right] L_x \frac{dw}{d\tau}. \tag{16}$$

At $\tau = 0$, clearly $dM/d\tau = L_x(dw/d\tau) > 0$. Thus starting from a zero wage tax, a small increase in wage tax increases welfare, indicating that the the optimal wage tax is positive. Since $0 \leq \tau < 1$, when $\xi^d < 1$ we have $\left[1 - \tau \xi^d\right] L_x (dw/d\tau) > 0$. In other words, when $\xi^d < 1$, i.e., $(\epsilon + \eta^*)/(1 + \eta^*) < \theta^*$, $dM/d\tau > 0$. In fact, $dM/d\tau > 0$ when $\xi^d < 1/\tau$. This means that for a small enough ξ^d and/or τ there will be an increase in welfare from raising τ.

The first order condition to obtain the optimal wage tax in (16) is $dM/d\tau = \left[1 - \tau \xi^d\right] L_x(dw/d\tau) = 0$, which gives us the following optimal wage tax:

$$\tau^o = \frac{1}{\xi^d}. \tag{17}$$

Note that this solution will obtain as long as there is an interior solution to maximizing welfare with respect the wage tax rate. Since $0 \leq \tau^o < 1$, the existence of an interior solution to this optimal tax problem means that at that tax $\xi^d > 1$, i.e., $(\epsilon+\eta^*)(1+\eta^*) > \theta^*$. Note that these elasticities are endogenous variables in our model and, except under rare cases, are not exogenous parameters. This means, for instance, it is possible that $\xi^d < 1$ at $\tau = 0$ but rises with w (which rises with τ) so that at τ^o we have $\xi^d > 1$.

We need to understand here the intuition behind a positive optimal wage tax. As a seller of services or tasks, the developing country in our model has monopoly power in the world market. Just as a monopoly firm in the market sets a markup over its cost in inverse relation to its elasticity of demand, the government of this country also levies a tax on wages received in this sector, which is inversely related to the labor demand elasticity. The reason in both cases is to use market power to restrict output to get a better price for what the country or the firm is selling. A higher elasticity would mean that a wage tax would lead to a larger distortion in the domestic labor market, while it would bring about a terms of trade benefit. As a result when this elasticity is low the wage tax rate is high.

Since we have shown earlier that $\xi^d = (\epsilon + \eta^*(1-\theta^*))/\theta^*$, we can equivalently write the optimal wage tax formula as

$$\tau^o = \frac{\theta^*}{\epsilon + \eta^*(1-\theta^*)}$$

Intuitively, the higher is the developed country's wage share the greater is the scope for shifting real income away from the developed to the developing country. However, if the proportion of tasks offshored is highly responsive to the relative wage, a high wage tax in the developing country will greatly reduce the number of tasks offshored and also, therefore, will lead to a reduction in developing country employment in the offshoring sector. And finally, if the domestic labor supply faced by the offshoring sector in the developed country is very elastic, then an increase in the wage tax in the developing country will severely reduce the quantity of domestic labor supplied to the developed country's offshoring sector (from the rest of the economy) and in turn, by complementarity, reduce the demand for labor in the developing country's offshoring sector. The reason is that the induced increase in the developing country's gross-of-tax wage will reduce developed country wage by the zero profit condition.

We next look at how welfare changes with a change in β, first in the presence of an exogenous wage tax and then in the presence of an optimal wage tax. In the presence of an exogenous wage tax we have

$$\frac{dM}{d\beta} = \left[1 - \tau\xi^d\right] L_x \frac{dw}{d\beta} + \tau w \left[\frac{dL_x^d}{d\beta}\right]_{dw=0}. \tag{18}$$

When $\xi^d < 1$,we have $\left[1 - \tau\xi^d\right] L_x(dw/d\beta) > 0$. We also show in the appendix that when

$\xi^d < 1$, we have $\left[dL_x^d/d\beta\right]_{dw=0} > 0$. Thus, welfare falls with a parametric reduction in offshoring costs in the presence of an exogenous wage tax as long as $\xi^d < 1$.

In the presence of an optimal wage tax, which adjusts optimally to any changes in β, we have

$$\frac{dM}{d\beta} = \tau w \left[\frac{dL_x^d}{d\beta}\right]_{dw=0}. \tag{19}$$

In the appendix we show that $\left[dL_x^d/d\beta\right]_{dw=0} < 0$ when $\xi^d > 1$ (always true at an interior optimal tax rate). Thus, if a wage tax can be optimally set, then $dM/d\beta < 0$. The reason is that the terms of trade loss or the wage rate decline as a result of a parametric reduction in the offshoring costs is neutralized by an offsetting change in the optimal wage tax rate. Thus we have the following proposition.

Proposition 3 *(A) Starting from a zero wage tax, a small increase in this tax increases welfare.*
(B) The optimal wage tax is given by $\tau^o = 1/\xi^d$, i.e., the optimal wage tax rate equals the inverse of the total labor demand elasticity in the offshoring sector of the developing country.
(C) While at an exogenously given wage tax a parametric reduction in the offshoring cost may increase or decrease developing country welfare, when the wage tax is always optimally set this offshoring cost reduction will unambiguously increase welfare.

6.2 Offshoring Cost Reduction: Effects on Optimal Tax, Wages and Foreign Welfare

Although the presence of an optimal tax rules out welfare reduction for the developing nation, we have to delve deeper to see how wages in the two nations are affected due to an offshoring cost reduction. This is because the optimal tax itself changes in response to a fall in β, thereby affecting wages in both nations. Proposition 4 presents results pertaining to changes in the optimal tax, wages, and welfare. The proof of these results are relegated to the appendix.

Proposition 4 *For linear or concave labor demand function in the developing nation's* *offshoring sector, the optimal wage tax must rise with an offshoring cost reduction. Wages and welfare in both nations must rise.*

The effect of β on the elasticity of labor demand in the developing nation's offshoring sector is best understood by focusing on the two following effects. First, given β, the effect of a change in w for the offshoring firm's wage cost is scaled by β [i.e., $d(w\beta) = \beta dw$]. Consequently, at a lower β, a given change in w has a lower effect on this wage cost, thus eliciting a smaller employment response from the firm. Second, for any wage w, a lower β implies a lower effective wage cost $w\beta$, which means the level of employment is higher. The higher level of employment (second effect) compounded with a lower reaction to change in wage (first effect) means a smaller percentage change in labor demand in response to a one percent change in w. In other words, demand is less elastic at a lower β. At a lower elasticity, the tradeoff for the developing government between wage hike and the resulting employment loss becomes more favorable. This prompts the developing nations government to raise its optimal wage tax. Developing nation wage rises because of two effects. First, at the optimal tax equilibrium, demand is elastic, and a fall in β leads to a sufficiently large increase in labor demand which offsets the labor saving effect of the technological change. This tends to increase w. Second, as the optimal tax rises, labor supply to the offshoring sector is reduced, and this leads to a further rise in w.

The offshoring firm's zero profit condition implies a negative relationship between the effective wage cost of offshored work (i.e., $w\beta$) on the one hand, and the developed nation wage w^*, on the other (see Eqs. 5 and 6). As β falls, w rises, but not enough to raise $w\beta$. Therefore, w^* must rise. Now, recall that y^* is constant returns to scale in labor L_y^* and the specific factor. As far as sector y^* is concerned, the rise in w^* simply transfers income from the specific factor to labor employed in that sector. On the other hand, the rise in w^* raises the income in sector x^* to the tune of $L_x^* dw^*$, and this is the net welfare gain for the developed nation.

Using the notations developed in Section 4, the size of the optimal tax, and the associated wage in the offshoring sector of the developed and the developing country can be simulated.[15] In Figures 3a and 3b, we display the relationships between the w and β, and w^* and β, respectively, under the optimal wage tax, where labor demand linearity ($\phi = \phi^* = 1$) is assumed. As shown, once an optimal wage tax is in place, any adverse impact that a reduction in offshoring cost can have on the developing country wage no longer applies. Indeed, the wage in the offshoring sector in both countries are monotonically increasing with respect to successive parametric reductions in the offshoring cost. Furthermore, the potential asymmetric welfare consequences of a reduction in β likewise no longer applies. Indeed, from Proposition 4, both developing and developed country welfare rise with reductions in β in the presence of the optimal wage tax as shown in Figures 3a and 3b.

6.3 Minimum Wage

In place of the wage tax, let us now consider an exogenous binding minimum wage, $\bar{w}$ in the offshoring sector of the developing country. Whoever cannot be employed in this sector at this minimum wage finds employment in the other sector at a lower wage. Thus, wages differ between the sectors (and there are no tax revenues). Hence, a higher minimum wage results in a higher inequality between workers in the two sectors. However, with the wage tax we saw that the net-of-tax wage was equal between the sectors and there was no such inequality generated. Despite the inequality arising out of the sector-specific minimum wage, it might be worth considering it for good reasons. For example, a discriminatory tax on workers in a particular sector could be unpopular, but a wage floor on workers working for foreign employers or outsourcers might not be since it would be viewed as something that narrows the gap with the employees of these firms in the developed country. As argued in the introduction, this might also be faciliated by the activism of labor advocacy groups and antisweat shop campaigns. Aggregate welfare in

[15]Specifically, using (12) upon replacing w with $w(1-\tau)$ in the presence of a wage tax, the relationship between ρ and the wage tax is given implicitly by $\tau = \rho\beta\lambda^{-\phi}$, where λ itself is a function of ρ. In addition, by the optimal wage tax formula in (17), $\tau = \theta^*/(\epsilon + \eta(1-\theta^*))$ where the right hand side is once again a function of ρ. The optimal tax simultaneously solves these two equations in two unknowns τ and ρ.

the developing country in the presence of this minimum wage is then given by

$$M = F_y(\bar{L} - L_x) + \bar{w}L_x. \tag{20}$$

We then have

$$\frac{dM}{d\beta} = \left(\bar{w} - F_y'\right)\left[\frac{dL_x^d}{d\beta}\right]_{dw=0} \lesseqgtr 0 \text{ as } \xi^d \gtreqless 1$$

since F_y' is the wage in sector y in this country and is below the binding minimum wage, $\bar{w}$ in the sector x. Thus when the demand for labor in the offshoring sector is elastic, a parametric fall in the offshoring cost leads to an increase in the developing country's aggregate welfare but in the presence of an inelastic demand this parametric offshoring cost reduction leads to a decline in a aggregate welfare in the developing country. We have shown in the appendix that $\left[dL_x^d/d\beta\right]_{dw=0} \lesseqgtr 0$ as $\xi^d \gtreqless 1$.

The formula for the optimal minimum wage in the offshoring sector follows the formula for the optimal tax as follows.

$$\frac{\bar{w}^o - F_y'}{\bar{w}^o} = \frac{1}{\xi^d}. \tag{21}$$

Thus the wedge between the wages in the two sectors is the same under both the optimal wage tax and the optimal minimum wage in the offshoring sector. Effectively, the optimal minimum wage will equal the equilibrium developing country wage corresponding to the optimal wage tax. As illustrated by the simulations in Figure 3a, the optimal minimum wage will rise with a reduction in β.

What happens when the minimum wage is economywide? Then there is unemployment and in the presence of an exogenous given minimum wage, $\bar{w}$ we have

$$\frac{dM}{d\beta} = \bar{w}\left[\frac{dL_x^d}{d\beta}\right]_{dw=0} \lesseqgtr 0 \; as \; \xi^d \gtreqless 1. \tag{22}$$

The welfare effect of an offshoring cost reduction does not change qualitatively.

Now what is the optimal economywide minimum wage? Denoting the economy's total employment by N, we now have

$$\frac{dM}{d\bar{w}} = \left[s_x - s_x\xi^d - (1 - s_x)\xi_y^d\right] N \tag{23}$$

where ξ_y^d is the elasticity of labor demand in the sector y and $s_x = L_x/N$. Thus if the employment weighted average labor demand elasticity in the economy is less than s_x, i.e., if labor demand on average is quite inelastic at the equilibrium with no government intervention then there will be a welfare gain from setting a minimum wage at least slightly above that equilibrium wage. However, if the share of employment in the offshoring sector is low and labor demand is fairly elastic on average, the optimal policy of the government will be to not set an economywide minimum wage. In the first case (highly inelastic labor demand and/or high employment share of the x sector), if an interior optimum economywide binding minimum wage exists it will the one where the following condition holds

$$s_x = s_x \xi^d + (1 - s_x)\xi_y^d. \tag{24}$$

It is important to see that with a binding general minimum wage there will be some unemployment. Also, it is easy to see that this minimum wage will be inferior to the sector-specific minimum wage analyzed earlier.[16]

7 Extension: Output Market Terms of Trade Effects and a Large Country Analysis

Changes in offshoring technology or in the wage tax, in addition to affecting factor markets, affects supply/demand in the output market. If the source and host nations of offshoring are large in the output market, this alters the goods market terms-of-trade. This section extends our previous analysis to consider such output market terms-of-trade effects within a two-country framework.

Allowing for the price of good x to change, and also considering the possibility of the wage tax τ being in place, Eqs. (4) and (6) can be written as, respectively,

$$(\eta^* + \epsilon)\hat{w}^* - (\eta + \epsilon)\hat{w} = \eta\hat{T} + (\epsilon - 1)\hat{\beta}, \text{ where, } T = 1 - \tau > 0, \text{ and} \tag{25}$$

[16] Any sector-specific minimum wage of the same level as the optimal general minimum wage will result in a higher developing country welfare (as output in sector x will not change but the output in sector y will be higher). In turn, the optimal sector-specific minimum wage wil result in at least as much, if not even higher, welfare.

$$\theta^*\hat{w}^* + (1-\theta^*)\hat{w} = \hat{p}_x - (1-\theta^*)\hat{\beta}. \tag{26}$$

Defining $D = (\eta^* + \epsilon)(1-\theta^*) + (\eta + \epsilon)\theta^* > 0$, Eqs. (25) and (26) yield:

$$D\hat{w}^* = (\eta + \epsilon)\hat{p}_x + \eta(1-\theta^*)\hat{T} - (1-\theta^*)(1+\eta)\hat{\beta}, \text{ and} \tag{27}$$

$$D\hat{w} = (\eta^* + \epsilon)\hat{p}_x - \eta\theta^*\hat{T} - [\epsilon + \eta^* - \theta^*(1+\eta^*)]\,\hat{\beta}. \tag{28}$$

Eqs. (27) and (28) imply that a higher price of good x must raise wages in both nations. In addition, $\hat{w}/\hat{p}_x > \hat{w}^*/\hat{p}_x$, if and only if $\eta^* > \eta$. Using this in Eq. (26) we have that $|\hat{w}| > |\hat{p}_x| > |\hat{w}^*|$, if and only if $\eta^* > \eta$. In other words, a rise in the price of good x must raise (reduce) the real wage in terms of good x in the developing (developed) nation, when labor supply to sector x is more elastic in the developed nation. This, however, does not directly translate to welfare gains or losses, because as w rises, the income of the specific factor in the developing nation (in sector y) falls. We explore welfare gains later in this section.

Eqs. (27) and (28) also imply that a rise in the wage tax in the developing nation raises the developing nation wage in sector x, while reducing the developed nation wage, for given output price and wage tax. The effects of changes in β are qualitatively similar to our previous analysis.

In order to account for the welfare implications of terms of trade effects, let M and M^* denote, as before, the income levels of the developing and the developed nations respectively. Representative consumers in the two nations have indirect utility functions $v(p_x, p_y = 1, M)$ and $v^*(p_x, p_y = 1, M^*)$, respectively. Denoting the expenditure functions in the two nations as $e(p_x, p_y = 1, v)$ and $e^*(p_x, p_y = 1, v^*)$, the international market clearing equation for good x is:[17]

$$e_{p_x}[p_x, 1, v(p_x, 1, M(p_x, \tau, \beta))] + e^*_{p_x}[p_x, 1, v^*(p_x, 1, M^*(p_x, \tau, \beta))] = x^*(p_x, \tau, \beta). \tag{29}$$

Eq. (29) yields the market clearing price as:

$$p_x = p_x(\tau, \beta) \tag{30}$$

[17] The revenue from any taxes is assumed to be redistributed lump sum.

Let the elasticity of price of good x with respect to $\tau > 0$ and β accounting for general equilibrium effects be $E^{\tau} > 0$ and $E^{\beta} > 0$, respectively.[18] Then, using Eqs. (28) and (30) we get,

$$D\hat{w} = \left[(\eta^* + \epsilon)E^{\tau} + \frac{\tau\eta\theta^*}{1-\tau}\right]\hat{\tau} - [(\epsilon + \eta^*)(1 - E^{\beta}) - \theta^*(1 + \eta^*)]\hat{\beta}. \tag{31}$$

An increase in the wage tax must raise the developing nation wage, while a fall in β will be more likely to reduce the developing nation's wage compared to the small-country analysis. This latter part is best understood for the case where $\epsilon + \eta^* = \theta^*(1 + \eta^*)$, such that $D\hat{w}/\hat{\beta} = E^{\beta} > 0$. Under this condition, the small-country analysis suggested that w is invariant with respect to β. In the large-country case, however, as global excess supply reduces p_x, it tends to drag down factor reward w with it, making a developing country wage reduction more likely. This, however, does not mean that the developing country is necessarily worse off, because a reduction in the price of good x could potentially confer offsetting consumption gains. We turn next to a welfare analysis that considers both the price and income effects of changes in τ and β.

Let us consider the case of homothetic preferences. Because preferences are preserved through monotonic transformations, we can assume without loss of generality that the utility function of the developing nation is homogeneous of degree one, such that $e(p_x, 1, u) \equiv e(p_x, 1, 1)u$. Using expenditure income identity, we have:

$$e(p_x, 1, 1)u = M \implies u = M(p_x(\tau, \beta), \tau, \beta)/e(p_x(\tau, \beta), 1, 1). \tag{32}$$

Eq. (32) yields,

$$(\hat{u}/\hat{\beta})_{|\tau=0} = \alpha^P \hat{w}/\hat{\beta} - \alpha^C E^{\beta}, \tag{33}$$

where $\alpha^P(= wL_x/M)$ and $\alpha^C(= p_x e_{p_x}/M)$ are the shares of income from sector x and share of consumption of good in the developing nation respectively. Also, $\hat{w}/\hat{\beta}$ is as

[18] Consider identical and homothetic preferences between the two nations. A rise in τ must raise p_x by reducing relative supply of good x, while not directly affecting its relative demand. The effect of a fall in β is a bit more complicated, because the technology improvement allows for greater resources to be available for production of both goods in the developing nation. However, w^* must rise (at a given p_x), therefore sector y^* must shrink. In addition, if w rises or remains constant, then y falls or remains constant, respectively. In this case, relative supply of good x must rise, and the market clears at a lower p_x. Note that this will also remain true unless w falls very steeply (the fall in w relative to the fall in β is very steep).

defined in Eq. (31) above, which endogenizes the effect of β on p_x. Consumption gains due to a fall in p_x are captured by the last term of Eq. (33), and they make a welfare reduction less likely. On the other hand, because wage reductions are accentuated by the fall in p_x, the wage income losses captured by the first term on the right-hand-side of Eq. (33) tend to pull welfare down. Accordingly, if preferences in the developing nation are such that consumption is skewed toward good y, then welfare decline in the developing nation becomes more likely in this large-country case.

In the special case of $\alpha^P = \alpha^C = \alpha$, Eq. (33) reduces to:

$$(\hat{u}/\hat{\beta})_{|\tau=0} = \alpha[(\hat{w}/\hat{\beta})_{|\tau=0,dp_x=0} + \theta^*(\eta^* - \eta)E^\beta/D]. \tag{34}$$

When $\eta^* > \eta$, a fall in the price of good x tends to reduce real wage, and that is sufficient for welfare loss for the developing nation if its wage falls with technology improvement.

The effect of a small wage tax starting from non-intervention is:

$$e(p_x, 1, 1)\left(\frac{\partial u}{\partial \tau}\right)_{|\tau=0} = L_x\left(\frac{\partial w}{\partial \tau}\right)_{|\tau=0,dp_x=0} + \left[L_x\left(\frac{\partial w}{\partial p_x}\right)_{|\tau=0} - c_x\right]\left(\frac{\partial p_x}{\partial \tau}\right)_{|\tau=0}, \tag{35}$$

where c_x is consumption of good x in the developing nation. From Eqs. (27) and (28), we can establish that the first term on the right-hand-side of Eq. (35) is positive. This is the factor market terms of trade effect. The last term can be positive or negative. It is positive if the wage income effect of a change in p_x dominates the consumption loss from a higher price. If consumption is skewed toward good y, a small wage tax will raise developing nation welfare.

Thus, when the two countries are large in the market for final goods, we introduce another channel that works through the final good price. The original channel is the impact of the wage tax on the developing country wage at given final good price. However, the new channel is working through the impact of this wage tax on the world relative price of x, which also increases with the tax. There is a direct consumption cost associated with the higher price but the price increase also increases the developing country wage. Thus, when good x is not an important component of the consumption basket, the net impact of this price increase on welfare is positive, and adds to the original direct positive impact. As a result, we would expect the positive welfare impact of the wage tax to be greater in the large country case, and accordingly the optimal wage tax can in fact be larger in the large country case. Using analogous logic, the large country case will result in a lower optimal wage tax (than the small country case) when good x is a relatively important component of the consumption basket.

8 Discussion and Conclusion

In this paper, we have studied certain channels through which a reduction in the cost of offshoring can affect wages in a developing country. In addition to a positive "productivity effect," these channels include an increase in the demand for developing country labor as a result of an increasing range of tasks offshored but a decline in labor demand due to a lower labor requirement per unit task. Since all the effects through these various channels are not in the same direction, we get a variety of results, depending on parameter values, showing that the impact in the developing country of a reduction in the cost of offshoring need not always be a wage increase. In fact, a wage reducing impact is quite possible. We show the following possibilties in response to parametric reductions in the offshoring cost: (1) wages monotonically improve, (2) wages monotonically decline, and (3) wages exhibit an inverted U.

Our analysis shows that while improvements in offshoring technology must benefit the developed nation and the two nations (developed and developing) taken together, its effect on the developing nation is ambiguous. If the labor saving effect of technological improvement (effectively a terms of trade loss) dominates, the developing nation may suffer a welfare loss. This outcome arises when the labor demand in the offshoring sector is inelastic. We get similar results using an optimal minimum wage.

There are a few possible extensions that come to mind. One possibility is bringing in multiple developing nation's to which firms in the developed country offshore.[19] When setting optimal policies these developing countries will compete with each other. With symmetric developing countries, we expect that due to the competition effect the equi-

[19]An example of a paper on strategic sourcing to multiple countries is Sly and Soderbery (2014).

librium wage tax rate will be lower than what is optimum for these countries together. If these countries are setting their minimum wage then the equilibrium might be that of no intervention at all as otherwise a country can lower its binding minimum wage below those of other countries to become the recipient of all the offshoring.

9 Appendix

A. To prove: The condition for a parametric reduction in the cost of offshoring to reduce the developing country wage, w can be equivalently written as $\xi^d < 1$ (while the condition for the developing country wage to rise as a result of the offshoring cost reduction is $\xi^d > 1$).

Proof: We can write the demand for labor in the developing country from the offshoring industry as $L_x^d = \beta.(\lambda/\beta).L^*(w^*)$. Assuming no change in β, the total elasticity of L_x^d with respect to w, factoring in its impact on w^*, can be written as $\xi^d = -\frac{d\ln L_x^d}{d\ln w} = -\left(\frac{d\ln(\lambda/\beta)}{d\ln\rho}.\frac{d\ln\rho}{d\ln w} + \frac{d\ln L^*(w^*)}{d\ln w^*}.\frac{d\ln w^*}{d\ln w}\right) = -\epsilon\left(\frac{d\ln w^*}{d\ln w} - 1\right) - \eta^*\frac{d\ln w^*}{d\ln w}$. With $d\ln\beta = 0$, we have, from the zero profit condition, $\theta^* d\ln w^* + (1-\theta^*)d\ln w = 0 \Rightarrow \frac{d\ln w^*}{d\ln w} = -(1-\theta^*)/\theta^*$. Substituting this, we now have $\xi^d = -\epsilon\left[-((1-\theta^*)/\theta^*) - 1\right] + \eta^*(1-\theta^*)/\theta^* = (\epsilon + \eta^*(1-\theta^*))/\theta^*$. Our condition in proposition 1 can be written as $(\epsilon+\eta^*)/(1+\eta^*) \lesseqgtr \theta^* \iff \epsilon + \eta^* \lesseqgtr \theta^*(1+\eta^*) \iff \epsilon + \eta^*(1-\theta^*) \lesseqgtr \theta^* \iff (\epsilon + \eta^*(1-\theta^*))/\theta^* \lesseqgtr 1 \Leftrightarrow \xi^d \lesseqgtr 1$.

B. To prove: (i) $\left[\hat{L_x^d}/\hat{\beta}\right]_{dw=0} \lesseqgtr 0$ as $\xi^d \gtreqless 1$. (ii) $\left[\hat{L_x^d}/\hat{\beta}\right]_{dw=0} < 0$ at $\tau = \tau^0$.

Proof: $L_x^d = \beta.(\lambda/\beta).L^*(w^*)$. At $dw = 0$, we have $\hat{L_x^d} = \hat{\beta} + \epsilon(\hat{w}^* - \hat{\beta}) + \eta^*\hat{w}^*$. From the zero-profit condition equation (which is represented by the schedule π in Figure 1), we have $\hat{w}^* = -(1-\theta^*)\hat{\beta}/\theta^*$, $\hat{w}^* - \hat{\beta} = -\hat{\beta}/\theta^*$ when $dw = 0$. Thus we have $\left[\hat{L_x^d}/\hat{\beta}\right]_{dw=0} = 1 - \frac{\epsilon}{\theta^*} - \eta^*(1-\theta^*)/\theta^* = 1 - \left[(\epsilon + \eta^*(1-\theta^*))/\theta^*\right] = 1 - \xi^d$. Therefore, $\left[\hat{L_x^d}/\hat{\beta}\right]_{dw=0} \lesseqgtr 0$ as $\xi^d \gtreqless 1$. Since $1 - \xi^d < 0$ at $\tau = \tau^0$, we have $\left[\hat{L_x^d}/\hat{\beta}\right]_{dw=0} < 0$ at $\tau = \tau^0$.

C. To prove: *Proposition 4*

Proof: Eq. (16) can be stated as $M_\tau(\tau,\beta)=0$. Using the second order condition of the optimal tax, $M_{\tau\tau}(\tau,\beta)<0$, we have: $\frac{d\tau}{d\beta}<0$ iff $[M_{\tau\beta}]_{\tau=\tau^0}<0$ iff $\left[d\xi^d/d\beta\right]_{\tau=\tau^0}>0$. Using Eqs.(1), (2) and (5), and noting from page 11 that $L_x^d=\lambda L^*(w^*)$, we can express labor demand in the offshoring sector as $L_x^d=\beta f(w\beta)$, where $f'(.)<0$. This yields $\xi^d=-w\beta f'(w\beta)/f(w\beta)\Rightarrow d\xi^d/d(w\beta)=\xi^d\left[(1+\xi^d)/(w\beta)+f''/f'\right]>0$ if $f''\leq 0$. Thus, if labor demand is linear or concave (i.e.,$f''\leq 0$), then $\left[d\xi^d/d\beta\right]_{\tau=\tau^0}=\left[d\xi^d/d(w\beta)\right][d(w\beta)/d\beta]_{\tau=\tau^0}>0$, because from Eq. (7) we know that $-\hat{w}/\hat{\beta}<1\Rightarrow [d(w\beta)/d\beta]_{\tau=\tau^0}>0$. Therefore, if $f''\leq 0$, then $d\tau/d\beta<0$.

Developing nation's wage is given by: $L_x^d=\beta f(w\beta)=\bar{L}-L_y(w(1-\tau))\implies w=w(\beta,\tau)$. We have previously discussed that when the optimal tax is in place, $w_\beta<0$. Also w_τ is always positive, because at a higher tax labor supply to the offshoring sector falls. Hence, $\frac{dw}{d\beta}=w_\beta+w_\tau\frac{d\tau}{d\beta}<0$, because $\frac{d\tau}{d\beta}<0$. From the previous section, we also know that $\frac{dM}{d\beta}<0$. We have shown above that under demand linearity or concavity, ξ^d is positively and monotonically related to $w\beta$. When a fall in β raises the optimal tax, (the inverse of the optimal tax) is lower, which means w is smaller. Now, using Eq. (6) which is not directly affected by $\tau:\ \theta^*\hat{w}^*=-(1-\theta^*)(\hat{w}+\hat{\beta})>0$, if $\hat{w}+\hat{\beta}<0$. Given that a fall in β reduces $w\beta$, we have that $\hat{w}+\hat{\beta}<0$, which implies that $\hat{w}^*>0$. Since the fall in β raises w^*, we have that $\frac{dw^*}{d\beta}<0$. Let developed nation's fixed factor in y^* be $\bar{T}^*$ with factor reward ρ^*, such that its welfare function is: $M^*=w^*\bar{L}^*+\rho^*\bar{T}^*$. Zero profit condition in y^* implies that $\bar{T}^*\frac{d\rho^*}{d\beta}=-L_y^*\frac{dw^*}{d\beta}$. Thus, $\frac{dM^*}{d\beta}=\bar{L}^*\frac{dw^*}{d\beta}+\bar{T}^*\frac{d\rho^*}{d\beta}=(\bar{L}^*-L_y^*)\frac{dw^*}{d\beta}<0$. Thus, a fall in β also raises developed nation's welfare.

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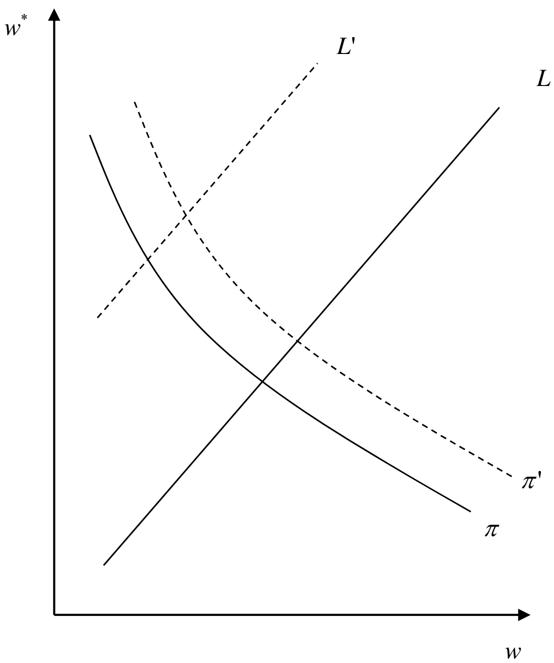

Figure 1. Unequal Gains from a Reduction in Offshoring Cost

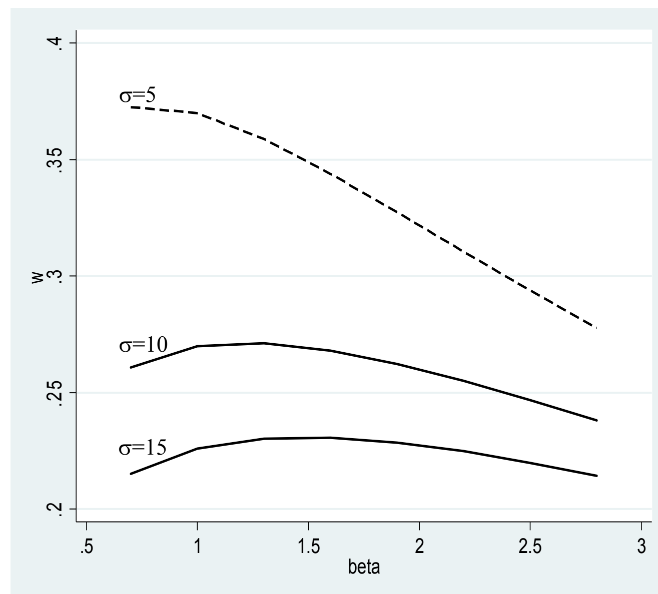

Figure 2. Developing Country Wage (w) Simulation: (Unregulated)

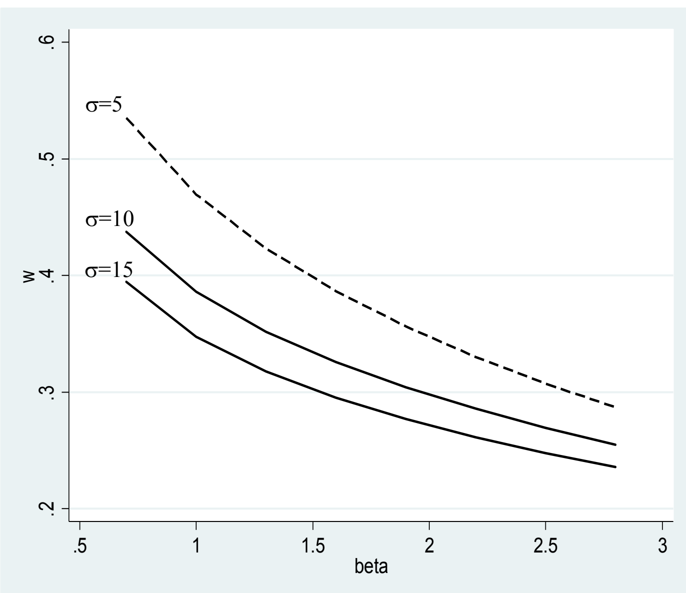

Figure 3a. Developing Country Wage (w) Simulation: (With Optimal Wage Tax)

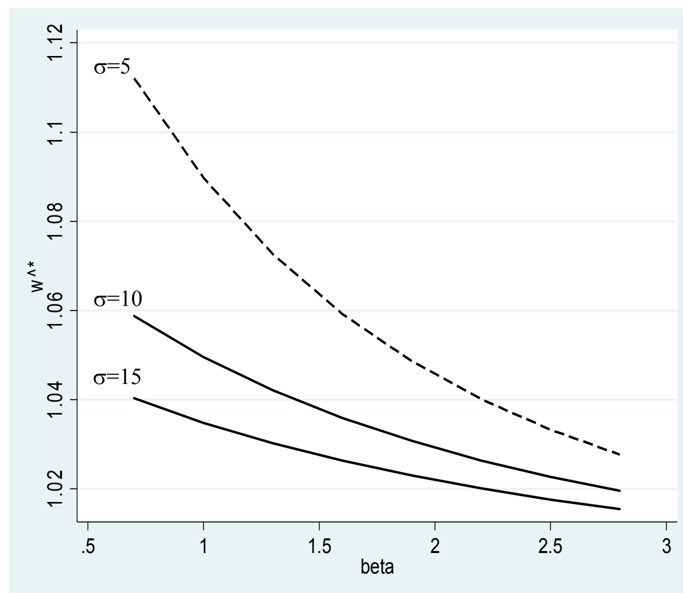

Figure 3b. Developed Country Wage (w) Simulation: (With Optimal Wage Tax)*