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**INTERNATIONAL OUTSOURCING,  
ENVIRONMENTAL COSTS,  
AND WELFARE**

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**Abstract**

This paper explores the welfare consequences of international outsourcing in the presence of resulting environmental damage in a three-stage model of North–South trade. In stage 1, outsourcing firms in the North (e.g., United States [US] and Europe) cause environmental damage to the vendor country in the South, as exemplified by the People’s Republic of China (PRC). But, as its primary goal, the South pursuing economic development is willing to bear the costs of environmental degradation. Moving into Stage II, the environmental deterioration becomes so severe in the South that the vendor country begins to tackle the environmental problem by enacting government regulations. As a result, the costs and, hence, the prices of outsourced goods and services tend to increase for the firms in the North. However, the environmental protection measures undertaken generally fall short of the levels needed to restore the environmental quality acceptable by WHO standards. We present a framework for analyzing the effects of international outsourcing on environment and, ultimately, social welfare in terms of gains and losses under three alternative scenarios regarding no, partial or full accountability for outsourcing induced environmental damages. The policy implication is clear: to fully resolve the environmental problem in Stage III, the implementation of strong regulations or the fostering international cooperation is desirable; that is, until the environmental costs of outsourcing are fully accounted for by the outsourcing firms in the North. Such firms, however, may react by resorting to insourcing, diversified outsourcing and other strategies.

**Keywords:** outsourcing, labor-augmenting effect, environmental costs, internalization, vendor countries

**JEL Classification:** F11, F13, F22

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## 1. INTRODUCTION

In recent decades, amid the increasing trend of globalization resulting from the rapid advancement in communication and transportation technology, the outsourcing of intermediate and/or finished goods or services to firms in foreign countries for the purposes of lowering production costs and increasing production efficiency has become prevalent in world trade. For example, client firms in developed countries in the North (i.e., the US and EU), while maintaining management bases and conducting research and development (R&D) at home, shift their manufacturing activities to developing countries in the South where labor costs are lower (e.g., the PRC, India, Malaysia, Philippines, Thailand, and Viet Nam) and/or buy a substantial amount of parts or services from local Southern firms.

It is noteworthy that, while the focus on international outsourcing (also known as “offshoring or fragmentation”) has been mainly placed on North-South outsourcing, a firm’s decision to outsource can actually be driven by a variety of factors, including (but not limited to) the lowering of labor costs. Such factors can be related to capital, technology and organizational competency. The paramount aim is to enhance the operational capability and profitability of the firm’s production. To illustrate, both the US and EU countries outsource products from each other. The PRC outsources a variety of intermediate goods (such as crude petroleum, integrated circuit and iron ore) from Australia; Germany; Hong Kong, China; Japan; and the Republic of Korea among others, while itself shifting the outsourcing of goods (of garments, apparels, toys, foot wares, and tools) to other developing countries in Asia, Latin America, and Africa. The evolution of these outsourcing patterns over recent years reveals two important facts: (a) outsourcing can occur universally among countries; whereby, it can be of any direction (i.e., from North to South, from North to North, from South to North, and from South to South); (b) each time goods and services are imported, the importing country has possibly outsourced a portion of economic activity from abroad – that is, all international trade is likely to involve some outsourcing of intermediate inputs.

Consequently, international outsourcing has become a major topic for the study of international trade and stimulated a spate of intellectual contributions to the literature from economists in the field. (e.g., Chao and Yu 1993; Bhagwati, Panagariya, and Srinivasan 2004; Kohler 2004; Long 2005; Görg and Hanley 2005; Jones 2005).<sup>1</sup> Among the rich and still growing body of literature studying various aspects of international outsourcing are the two notable works, both of which use the Neoclassical Heckscher-Ohlin (HO henceforth) general equilibrium framework: one by Bhagwati, Panagariya, and Srinivasan (2004, BPS henceforth) and the other by Batra and Beladi (2010, BB henceforth). In the former, BPS (2004) argue that trade opportunity increases as a result of advances in information technology, which converts the traditional non-tradable service into a so-called Mode 1 service. Analytically this is equivalent to a growth agent. Further, BPS (2004), without formally integrating outsourcing into the Neoclassical growth model, examined the terms of trade and the welfare effects of outsourcing.

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<sup>1</sup> Other recent studies on the subject of outsourcing include Feenstra (1998), Deardorff (2001), Egger and Egger (2003), Grossman and Rossi-Hansberg (2006), Helpman, Melitz and Yeaple (2004), Jones, Kierzkowski and Lurong (2005), among others.

Later, BB (2010), inspired by Mankiw's argument for offshoring, explored several major properties of outsourcing, particularly the welfare effect of international trade, by incorporating a labor-augmenting feature of outsourcing into the HO model of general equilibrium.<sup>2</sup> Here, it is worthwhile to note that: (a) BPS' (2004) argument for the growth effect of outsourcing is confined to the case of a Mode 1 service type of outsourcing, which anticipates BB's (2010) study of the labor-augmenting effect of outsourcing; (b) both BPS (2004) and BB (2010) do not expound the equivalency of the effects of various types of outsourcing on economic growth. More recently, Choi and Beladi (2012) extended BB's work (2010) by exploring the internal and external gains for a small outsourcing country in the presence of variable returns to scale (VRS).<sup>3</sup>

Over recent decades, the dramatic expansion of outsourcing by Northern firms to the South has inflicted massive damage upon the once fertile air and soil of the South. A marked example is the case of the PRC, the so called "World Factory," where the production of myriad of outsourced goods and services (i.e., garments, apparels, toys, foot wares, tools, light machineries, electronics, and information-technology products) has contaminated the air, water, and soil, depleted labor and material pools, triggered deforestation/desertification and global warming, and (more seriously) endangered public health. However, the vendor countries in the South are mostly developing countries whose primary goal is economic development. Hence, despite the environmental damage, they opt (in their early period of international offshoring) to provide a hospitable business environment to Northern outsourcing firms.

But, as outsourcing activities expanded, the environmental costs resulting thereof became too heavy for the vendor countries to bear. Therefore, as beginning about a decade and half ago, major vendor countries (notably the PRC) have begun to account for or internalize the environmental costs of outsourcing by enacting environmental regulations and taxes. This policy shift increases the prices of their outsourced goods and services to firms in the North. However, the extent of such a move is still considerably below the level necessary to bring the South back to an acceptable environmental quality, as specified by the WHO standard. This argument is supported by numerous observations on the presently stagnating or regionally deteriorating environmental quality of the PRC and its neighboring countries, including the Republic of Korea, Cambodia, India, Lao People's Democratic Republic, Malaysia, and the Philippines. To quote from a few recent reports by mass media:<sup>4</sup>

"The cost of environmental degradation in [the People's Republic of] China was about \$230 billion in 2010, or 3.5% of the nation's gross domestic product—three times that in 2004, in local currency terms."

"The acidic deposition damages buildings, degrades the environment and reduces crop yields. In India, wheat growing near a power plant suffered a 49% reduction in yield compared with that grown 22 kilometers away."

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<sup>2</sup> See Mankiw, Romer and Weil (2004) and Mankiw and Swagel (2006) for their extensive account of the debate around Mankiw's 2004 statement about welfare gains from outsourcing.

<sup>3</sup> BB (2010) and Choi and Beladi (2012) deal with the factor-augmenting effects of outsourcing without environmental consideration.

<sup>4</sup> See internet articles (i) and (v) in the Reference section for these reports. Other reports on outsourcing and environmental degradation in the South include (vii), (ix), (x), and (xi), as listed in the same Reference section.

Another development in international outsourcing is that many Northern firms have adopted new strategies to counter the rising costs of outsourcing, as instigated by Southern regulations. Firms have resorted to vendor-country diversification, partial outsourcing, insourcing, or resourcing. Since the mid-1990s, there have been numerous reports about the changing patterns of outsourcing by Northern firms.<sup>5</sup>

The purpose of this paper is to investigate the welfare consequences via the environmental impact of international outsourcing in a three-stage model of North-South trade. In stage I, the outsourcing firms of the North inflict environmental damage upon the vendor country in the South, but the South (pursuing economic development as its primary objective) is willing to bear the burden of environmental spillovers. In stage II, when the environmental damages become substantial, the vendor country begins to internalize the environmental costs by enacting regulations. However, the regulations in Stage II and the resulting increase in the price (level) of outsourced goods and services are far below the level that can bring the Southern environment back to the internationally acceptable level. This paper assesses the gains and losses of the South as caused by outsourcing from the North, explicitly expounding upon the environmental costs to the South. The policy implication of our finding is clear: Further environmental regulations by the South and/or international collaboration are required to fully account for the environmental costs to the South, as in stage III.

## 2. ASSUMPTIONS AND THE MODEL

We deploy a three-stage 2x2 model to depict an outsourcing country in the North, which has two sectors under perfect competition: sector 1 producing good 1 in the amount of  $X_1$ , and sector 2 producing good 2 in the amount  $X_2$ . Each sector utilizes two factors, labor ( $L$ ) and capital ( $K$ ) that are fixed in supply and perfectly mobile between the two sectors. Flexible wage and rental ensure the full-employment of labor ( $L$ ) and capital ( $K$ ). Since non-constant returns to scale can obscure the cost effect of outsourcing, the present analysis is confined to a constant returns to scale (CRS) case. Further, it is assumed that, for mutual benefits, the outsourcing firms and the foreign vendor firms share technologies in producing the outsourced goods and services. The factor augmenting effects of outsourcing differ depending on the direction and type of the outsourcing. However, this paper will focus on the labor-augmenting case because (a) it is the major reason behind the North-South trade causing the environmental problems in the South, and (b) once its effects are identified, the effects of other types of factor-augmenting outsourcing can be similarly deduced. In the presence of the labor-augmenting effect of outsourcing, the production functions of the two sectors can be written as

$$X_i = F_i(A_i L_i, K_i) \quad i = 1, 2 \quad (1)$$

where  $L_i$  and  $K_i$  are the labor and capital employed by sector  $i$ ,  $F_i$  is linearly homogeneous in its inputs and subject to the law of diminishing returns,  $A_i$  is a labor-augmenting factor derived from the outsourced goods and services in sector  $i$ , and  $(A_i - 1)L_i$  is the effective quantity of labor services supplied by the outsourcing activity. Equation (1) shows that, in sector  $i$ ,  $A_i$  is initially equal to unity in the absence of outsourcing. As the firms in the sector engage in outsourcing,  $A_i$  rises above its

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<sup>5</sup> For media reports on the recently changing patterns of outsourcing, see internet articles (ii), (iii), (iv), (vi), (viii) and (xii) in the References section.

value of unity and renders an automatic reduction in the use of domestic labor via a labor-augmenting effect upon the sector's productivity. That is,  $A_i$  is a choice variable to the  $X_i$  producers that increases with the volume of outsourcing; further, it cannot be less than unity because that would mean that outsourcing raises firms' unit costs. Further,  $dA_i = 0$  in the absence of outsourcing, and  $dA_i = d(A_i - 1) > 0$  in the presence of an additional outsourcing in sector  $i$ .

Let  $p_i$  denote the price of good  $i$  ( $i=1, 2$ ), and  $p = p_1 / p_2 = p_1$  the relative price of good 1 in terms of good 2 setting  $p_2 = 1$  initially. Then, the marginal revenue product (or the value of the marginal product) of the labor-augmenting factor  $A_1$  ( $A_2$ ) can, respectively, be written as  $a_1 = p_1(\partial F_1 / \partial A_1) = p(\partial F_1 / \partial A_1 L_1)(\partial A_1 L_1 / \partial A_1) = pF_{A_1 L_1} L_1 > 0$  and  $a_2 = (\partial F_2 / \partial A_2) = (\partial F_2 / \partial A_2 L_2)(\partial A_2 L_2 / \partial A_2) = F_{A_2 L_2} L_2 > 0$  where  $\partial F_i / \partial A_i L_i = F_{A_i L_i}$ , and  $\partial^2 F_i / \partial (A_i L_i)^2 < 0$  due to diminishing returns ( $i=1, 2$ ).

Assuming that presence of many outsourcing firms and vendor firms renders the international outsourcing market as competitive as all other input markets, outsourcing firms are thus the price takers of the labor-augmenting factor ( $A_i$ ) in each stage of outsourcing.<sup>6</sup> In stage I, the outsourcing by the Northern firms inflicts environmental damages to the South, but the vendor country (with its primary objective being economic growth) is willing to bear the environmental costs of outsourcing. Therefore, the actual price of the labor-augmenting factor ( $A_i$ ) in this stage does not include the environmental cost. However, moving into stage II, when the environmental damage become significant, the vendor country begins to internalize the environmental costs by enacting regulations. Consequentially, vendor firms begin to raise the prices of outsourced goods and services due to higher costs. Let  $b_i$  and  $b_i^*$  respectively denote the actual price (reflecting the marginal cost) level of the outsourced goods and services ( $A_i$ ) in terms of good 2 in stage I and stage II. Assuming a competitive international outsourcing market in each stage,  $b_i$  ( $b_i^*$ ) is perceived as a given parameter by both the outsourcers and the vendors. Then  $b_i^* - b_i > 0$  can be shown graphically as the upward shift in the perfectly elastic supply curve of  $A_i$  to the outsourcing firms resulting from the regulatory measures of the environmental costs in stage II. Since the firms engage in outsourcing mainly to lower their costs of production, we postulate,

$$A_i = 1, \text{ if } a_i \leq b_i \text{ in stage I (or if } a_i \leq b_i^* \text{ in stage II) for all levels of } A_i$$

$$\text{and } A_i > 1 \text{ if } a_i > b_i \text{ in stage I (or if } a_i > b_i^* \text{ in stage II) for some levels of } A_i. \quad (2)$$

In another words, if  $a_i \leq b_i$  in stage I (or if  $a_i \leq b_i^*$  in stage II) for all levels of  $A_i$ , there is no outsourcing in that stage and hence  $A_i = 1$ ; but if  $a_i > b_i$  in stage I (or if  $a_i > b_i^*$  in stage II) for some levels of  $A_i$ , the outsourcing firms in sector  $i$  engage in outsourcing and  $A_i$  rises above its initial value of unity. Further, an increase in the volume of outsourcing by the outsourcing firms elevates their production efficiency and raises the value of the labor-augmenting factor ( $A_i$ ) – thus, the value of  $A_i$  implicitly measures the volume of outsourcing.

<sup>6</sup> The assumption of competitive international outsourcing markets eliminates some trivial outcomes in our comparative static analyses and allows us to focus on the environmental costs of outsourcing.



Since outsourcing firms make profit-maximizing decision based on the marginal revenue product ( $a_i = pF_{A_i L_i} L_i$ ) and the costs of the outsourced goods and services ( $b_i$ ), we postulate  $A_i = A_{ia} + A_i(a_i, b_i)$  where  $A_{ia}$  is an exogenous (or autonomous) component of outsourcing and  $A_i(a_i, b_i)$  is an endogenous component responding to  $a_1$  and  $b_1$ . This is similar to the well-known macroeconomic procedure used to obtain consumption or import multipliers. Note that additional outsourcing lowers the firm's unit cost only when  $a_i > b_i$  and hence  $A_i > 1$ . For all values of  $A_i$  for which  $a_i \leq b_i$ , the firms would not undertake an additional outsourcing ( $A_i = 1$ ).

In factor markets, perfect factor mobility ensures identical factor prices equal to the value of the marginal product of each factor,

$$\begin{aligned} w &= pF_{A_1 L_1} A_1 = F_{A_2 L_2} A_2 \\ r &= pF_{K_1} = F_{K_2} \end{aligned} \quad (3)$$

where  $w$  and  $r$  respectively denote the wage and rental rate in terms of the second good, and  $F_{L_i}$   $F_{K_i}$  respectively stand for the partial derivatives of  $F_i$  with respect to labor and capital ( $i = 1, 2$ ).

The full employment condition in the factor markets implies

$$\begin{aligned} L_1 + L_2 &= L, \\ K_1 + K_2 &= K. \end{aligned} \quad (4)$$

The system of equations consisting of (1)–(4) represents the production side of the general equilibrium model of outsourcing. To facilitate the ensuing analysis, it is imperative to conduct a comparative static analysis to identify two basic properties of the present model, namely, sectoral output response to outsourcing and sectoral output response to price change.

Since the derivation of these effects is quite lengthy, we relegate it to the Appendix and state only the summary results in the following proposition:<sup>7</sup>

*Proposition 1:* (i) For a given commodity's prices and the environmental cost of outsourcing, outsourcing gives rise to an ultra-biased effect on sectoral outputs (i.e., it increases the output of the outsourcing sector at the expense of that of the other); (ii) For a given level of outsourcing and the environmental cost of outsourcing, sectoral output responds positively to its relative price.

To be specific, the ultra-biased effects on sectoral outputs implies  $dX_i / dA_i > 0$  and  $dX_j / dA_i > 0$  ( $i, j = 1, 2; i \neq j$ ), and the positive price-output response in each sector means  $dX_1 / dp > 0$  and  $dX_2 / dp > 0$ .

Meanwhile, the demand side of the outsourcing country is represented by the expenditures function

$$E(p, U) = \min (pD_1 + D_2),$$

<sup>7</sup> Choi and Beladi (2012) conducted a similar comparative static analysis under variable returns to scale (VRS). To focus on the environmental costs of outsourcing, our analysis is confined to CRS case.

where  $D_i$  ( $i = 1, 2$ ) is the consumption of the two goods, and  $U$  is a strictly quasi-concave utility function,  $U(D_1, D_2) \geq U$ . Note that the expenditure function is derived by minimizing the expenditure subject to a utility constraint.

### 3. OUTSOURCING, ENVIRONMENTAL COSTS, INTERNALIZATION, AND WELFARE

The economy's budget constraint stipulates that the total value of expenditure is determined by the value of national income:

$$E(p, U) = I, \quad (5)$$

where  $I [= pX_1 + X_2 - b_1(A_1 - 1) - b_2(A_2 - 1)]$  denotes the national income expressed in terms of good 2. free trade is assumed so that the domestic prices and the international prices of the traded goods are synchronized at the ratio of  $p$ . Totally differentiating (5), we obtain the expression for the welfare effect of outsourcing occurring in the two sectors ( $dW$ ).

$$dW = E_U dU = p dX_1 + dX_2 - E_1 dp - b_1 dA_1 - b_2 dA_2 - (A_1 - 1) db_1 - (A_2 - 1) db_2 \quad (6)$$

where  $E_p = \partial E / \partial p = D_1$ , and  $E_1 = D_1 - X_1$  denotes the excess demand in sector 1.

Now suppose that an autonomous outsourcing takes place via the firms in sector 1, i.e.,  $A_1 > 1$ ,  $dA_1 > 0$ ,  $A_2 = 1$ , and  $dA = 0$ .<sup>8</sup> Note that the outputs of the two industries are directly affected by the outsourcing and indirectly affected by the adjustment in the terms of trade, as consequent to the outsourcing. We may postulate that

$$X_i = X_i(A_1, p)$$

so that

$$\frac{dX_i}{dA_1} = \frac{\partial X_i}{\partial A_1} + \frac{\partial X_i}{\partial p} \frac{dp}{dA_1}, \quad i = 1, 2. \quad (7)$$

The first term (on the right-hand side) captures the direct output effect of outsourcing, and the second term indicates the indirect output effect caused by a change in the terms of trade.

Now, we are ready to analyze the welfare effect of outsourcing in sector 1. Differentiating (6) with respect to  $A_1$  and using (7), we obtain the expression for the welfare effect of the outsourcing occurring in sector 1:

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<sup>8</sup> This assumption is made solely for simplicity's sake. The analysis of outsourcing in sector 2 simply involves the same procedure (as that in the present case of outsourcing in sector 1). When outsourcing occurs in both sector 1 and 2, the total effect of outsourcing is the summation of the relevant effects of the two sectors.

$$\begin{aligned} \frac{dW}{dA_1} &= \frac{pdX_1}{dA_1} + \frac{dX_2}{dA_1} - E_1 \frac{dp}{dA_1} - b_1 - (A_1 - 1) \frac{db_1}{dA_1} \\ &= \left[ \frac{p\partial X_1}{\partial A_1} + \frac{\partial X_2}{\partial A_1} - b_1 - (A_1 - 1) \frac{db_1}{dA_1} \right] + \left( \frac{p\partial X_1}{\partial p} + \frac{\partial X_2}{\partial p} - E_1 \right) \frac{dp}{dA_1}. \end{aligned} \quad (8)$$

Since the terms of the trade effect could distract the present analysis from focusing on the environmental effects of outsourcing, we assume that the international commodity markets are competitive, and hence the outsourcing country (North) is a price taker of the two final goods, i.e.,  $dp/dA_1 = 0$ .<sup>9</sup> Then, (8) reduces to

$$\frac{dW}{dA_1} = \frac{pdX_1}{dA_1} + \frac{dX_2}{dA_1} - b_1 - (A_1 - 1) \frac{db_1}{dA_1}$$

which can be rewritten as

$$\begin{aligned} \frac{dW}{dA_1} &= \frac{p[(F_{ALL1}A_1dL_1 + F_{ALL1}L_1dA_1 + F_{K1}dK_1)]}{dA_1} + \frac{[(F_{L2}dL_2 + F_{K2}dK_2)]}{dA_1} - b_1 - (A_1 - 1) \frac{db_1}{dA_1} \\ &= \frac{(wdL_1 + a_1dA_1 + rdK_1) - (wdL_1 + rdK_1)}{dA_1} - b_1 - (A_1 - 1) \frac{db_1}{dA_1} \\ &= a_1 - b_1 - (A_1 - 1) \frac{db_1}{dA_1} = a_1 - b_1^*. \end{aligned} \quad (9)$$

Equation (9) shows the various effects of outsourcing upon the welfare of the country: the marginal revenue product of the outsourced goods and services ( $a_1$ ) minus the price of the outsourced goods and services ( $b_1$ ), as coupled with the change in the price of the outsourced goods and services ( $(A_1 - 1)(db_1/dA_1)$ ). Without fully internalizing environmental costs, outsourcing depletes environment quality during stage I; but in stage II, the South enacts environmental regulations to account for the environmental costs, thereby increasing the price of outsourced goods and service ( $(A_1 - 1)(db_1/dA_1) > 0$ ). Hence, in stage II,  $b_1^* = b_1 + (A_1 - 1)(db_1/dA_1)$  is regarded as the new exogenously given parameter by the Northern outsourcing firms.

Equation (9) shows that, in the absence of environmental costs, ( $(A_1 - 1)(db_1/dA_1) = 0$ ),  $b_1 = b_1^*$ . Therefore, outsourcing should occur until  $a_1 = b_1$  (or  $a_1 = b_1^*$ ), where  $dW/dA_1 = 0$ . This implies that outsourcing necessarily enhances the welfare of the outsourcing country and attains the optimum resource allocation for the world as well. Hence, the following proposition:

*Proposition 2. In the absence of induced environmental cost, outsourcing enhances the welfare up to the optimal level of both the country and the world.*

<sup>9</sup> This model can be extended to a large country case where the terms of trade are variable. See for example, Choi and Yu (1985).

However, when environmental costs exist,  $((A_1-1)(db_1/dA_1) > 0)$ , the actual cost of outsourcing paid by the Northern firms in Stage II ( $b_1^*$ ) depends on the degree of internalization of the environmental costs, as subject to the regulations of the South. Specifically, based on the extent of internalization, the marginal cost of outsourcing to the outsourcing country ( $b_1^*$ ) in Stage II can be positioned somewhere between the two extreme values, namely,  $b_1$  under no internalization and  $b_1^{*f}$  under full-internalization, i.e.,  $b_1 \leq b_1^* \leq b_1^{*f}$ .

Considering Stage III; there will be a full-internalization of the environmental costs,  $b_1^* = b_1 + (A_1-1)(db_1/dA_1) = b_1^{*f}$ . Outsourcing occurs up to the extent where  $a_1 = b_1^{*f}$  and  $dW/dA_1 = 0$  in equation (9). In this case, the volume of outsourcing obviously shrinks compared with the case of Stage I (where, due to no internalization of the environmental costs, outsourcing occurs up to where  $a_1 = b_1$ ). However, outsourcing under the full-internalization in Stage III determines the optimal level of outsourcing for the world, ensuring efficient world-wide resource allocation (including attaining quality environment). In contrast, when the environmental costs are not accounted for (as in stage I),  $b_1^* = b_1$ , and hence outsourcing occurs up to the level of  $a_1 = b_1$ , implying over-outsourcing (vis-à-vis the optimum level of outsourcing that occurs at  $a_1 = b_1^{*f}$ ). Here, it is our view that the over-outsourcing (under no internalization) in stage I is a major cause of massive environmental damage to the South (e.g., the PRC). Then, what is the current state of internalization in the North-South outsourcing? The answer can be inferred from the presently stagnating or even regionally deteriorating environmental quality in the South, as frequently reported by the mass media (see Note 4). That is, North-South outsourcing is presently in a state of the partial internalization of its environmental costs. Under such a partial internalization (in Stage II), the actual price of the outsourced goods and services ( $b_1^{*c}$ ) is higher (lower) than those under no internalization (full-internalization), i.e.,  $b_1 < b_1^{*c} = b_1^{*f}$ .

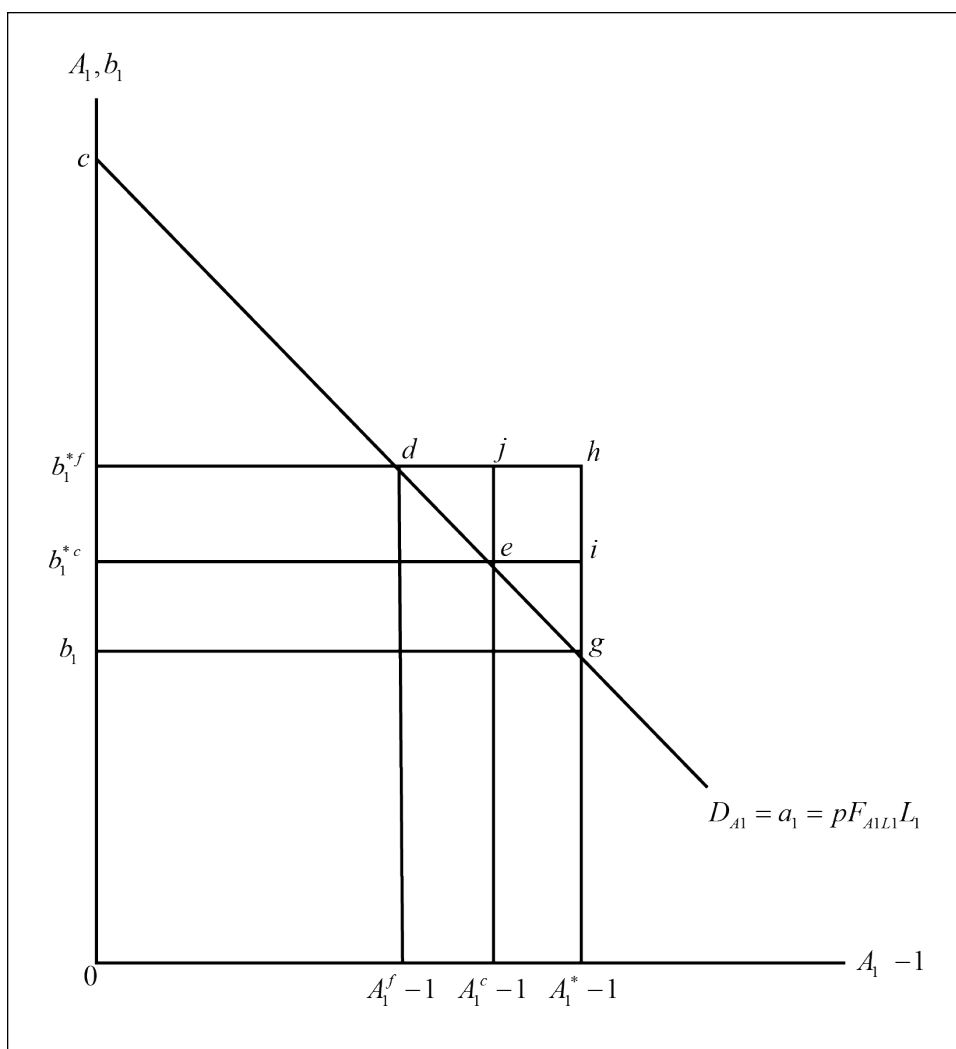
In the present case, over-outsourcing still occurs and creates an environmental burden for the South, although the degree of over-outsourcing is less than that under no-internalization. Then, another question may arise; why does North-South outsourcing remain at a level of partial-, rather full-internalization (under which the environmental problem would be resolved)? There are several possible explanations: Firstly, the economies of the vendor countries in the South are still in the infant stages of development, and hence, are in need of international liquidities and Northern technologies to pursue their primary goals of economic development. Therefore, they are reluctant to employ a potent policy that could totally discourage outsourcing by the North; Secondly, as the prices of outsourced goods and services go up due to the environmental regulations implemented by the South in stage II, the Northern firms resort to counter-measures to lower the costs of outsourcing, such as vendor-country diversification, partial outsourcing, insourcing, or resourcing.<sup>10</sup> Thirdly, in stage II, the

<sup>10</sup> When facing rising outsourcing costs due to the internalization of environmental costs, as in stage II, the outsourcing firms of the North opt to search for a new optimal strategy to lower outsourcing costs. Among a few alternative strategies are: (a) shifting their outsourcing post(s) to other vendor countries in the South where the costs of outsourcing are lower than the current vendor countries. This strategy, leading to vendor country diversification, as well as slowing the rate at which the price of outsourced goods and services is rising, can be observed in the migration of US and EU firms from the PRC to other vendor countries in the South (where the environmental problems are less severe and the costs of outsourcing are lower than in the PRC; i.e., Cambodia, Dominican Republic, Ghana, India, Indonesia, Malaysia, the Philippines, Rwanda, and Viet Nam); (b) bringing their outsourcing post(s) back to the home country in the North through insourcing or resourcing; (c) adopting a partial outsourcing strategy by mixing outsourcing and insourcing strategies.

increasing price of outsourced goods and services induces the entry of new vendor firms into the outsourced industry; thus, the increased competition among vendors hinders prices from rising in the outsourcing market. Hence, we can state the following proposition:

*Proposition 3. In the presence of the environmental costs of outsourcing, the optimal outsourcing, as ensuring an environment acceptable to the world community, can be obtained under the full-internalization of the environmental costs. However, if the environmental costs are not fully internalized, over-outsourcing and environmental deterioration occurs in the vendor country. In this case, the level of over-outsourcing and the degree of environmental deterioration vary inversely with the degree of the internalization, as bounded by no versus full-internalization.*

**Figure 1: Gains and Losses from Internalization of Environmental Costs of Outsourcing**



It is obvious that the choice of strategies should determine the future pattern and geography of global outsourcing. For terminology related to “insourcing,” (i.e., “reshoring,” backshoring,” and “inshoring”), see “Insourcing” and “offshoring” in Wikipedia (internet article (xii) in the References section).

Figure 1 shows the gains and losses from outsourcing for the North and the South in the presence of environmental costs. In the graph,  $A_1-1$  (or  $A_1$ ) denotes the level of outsourcing, and  $a_1 = pFA_1L_1L_1$  indicates the demand for (or the marginal revenue product of)  $A_1$ . Since the outsourcing firms are the price takers of  $A_1$ , they face a perfectly elastic supply curve of  $A_1$  at  $b_1$  ( $b_1^*$ ) when the environmental costs are not (are) internalized by the South in stage 1 (stage II). In stage I, when outsourcing between the South and the North takes place at the price of  $b_1$ , equilibrium outsourcing occurs at  $g$  and the level of outsourcing is  $A_1^n - 1$ . It is clear that the North gains by the area of  $b_1 b_1^{*f} dg$  because it pays no environmental cost, and the South loses by the area of  $b_1 b_1^{*f} hg$  because it bears the whole burden of the environmental costs. Therefore, the welfare loss occurs to the world by the area of  $dhg$ , which represents the deadweight loss caused by the misallocation of resources due to over-outsourcing. That is, in stage I, the South subsidizes the North in terms of enduring the environmental costs of outsourcing.

In stage II, the actual price of the outsourced goods and services ( $b_1^*$ ) depends on the degree of the internalization of the environmental costs. Under the full-internalization scheme in Stage III, the price is  $b_1^{*f}$ . Thus, the transition from Stage I through Stage II to Stage III entails movement of the equilibrium point from  $g$  to  $d$ , and hence decreases the level of outsourcing from  $A_1^n - 1$  to  $A_1^f - 1$ . As a result, the North loses by  $b_1 b_1^{*f} dg$ , the South gains  $b_1 b_1^{*f} hg$ , and the world gains by  $dhg$  owing to the recovery of the deadweight loss of stage I. This confirms that the optimum level of outsourcing to the world community occurs when the environmental costs of outsourcing are fully internalized.

Suppose, as of now, the North-South outsourcing industry is in a state of partial internalization (as in stage II), such that, in Figure 1, the price of the outsourced goods and services ( $b_1^{*c}$ ) is situated between  $b_1$  and  $b_1^{*f}$  (i.e.,  $b_1 < b_1^{*c} < b_1^{*f}$ ), and the equilibrium outsourcing point is  $e$ . Then, it is clear that, at the outsourcing level  $A_1^c - 1$  (as compared with the no-internalization case in Stage I), the South (North) gains (losses) by the area  $b_1 b_1^{*c} ig$  ( $b_1 b_1^{*c} eg$ ), and the world gains  $eig$ ; whereas, compared with the case of full-internalization, the South (North) loses (gains) by the area  $b_1^{*c} b_1^{*f} je$  ( $b_1^{*c} b_1^{*f} de$ ). Here, our finding is that, as the level of internalization increases from Stage I toward the full-internalization of stage III, the level of outsourcing decreases. The South (North) gains (losses) more, and the welfare gain for the world increases. Therefore, to resolve the environmental problem, strong Southern environmental regulations and/or international collaboration are highly desirable. The summary results are presented in Table 1 and Table 2 below.

**Table 1:**

Policy	Equilibrium	Gains (+) and Losses (-) from No or Full Internalization of Environmental Costs		
		South	North	World
(a) Outsourcing Costs with Full Environmental Costs →No Internalization (Stage I)	$d \rightarrow g$	$-b_1 b_1^{*f} hg$	$+b_1 b_1^{*f} dg$	$-dhg$
(b) No Internalization →Full Internalization (Stage II)	$g \rightarrow d$	$+b_1 b_1^{*f} hg$	$-b_1 b_1^{*f} dg$	$+dhg$
(a)+(b) Net welfare change				

Table 2:

Policy	Equilibrium	Gains (+) and Losses (-) from Partial Internalization of Environmental Costs		
		South	North	World
(c) No Internalization →Partial Internalization at the current price of $b_1^{*c}$	$g \rightarrow e$	$+b_1 b_1^{*c} ig$	$-b_1 b_1^{*c} eg$	$+eig$
(d) Partial Internalization at the current price of $b_1^{*c}$ →Full Internalization	$e \rightarrow d$	$+b_1^{*c} b_1^{*f} je$	$-b_1^{*c} b_1^{*f} de$	$+dje$
(c)+(d) Total welfare change	$g \rightarrow e \rightarrow d$	$+b_1 b_1^{*f} jeig$	$-b_1 b_1^{*f} dg$	$eig + dje$

## 4. CONCLUSIONS

In recent decades, it has become prevalent in world trade that firms in one country outsource intermediate and/or finished goods or services from vendor firms in other countries for the purpose of increasing production efficiency and lowering production costs. It is of note that, while public focus on international outsourcing is mainly directed upon North-South outsourcing, a firm's decision to undertake outsourcing can be driven by a host of factors (besides reducing labor costs). The ultimate aim thereof is to enhance the profitability and capability of the firm's operation. To illustrate, both the US and EU countries have outsourced materials and goods from each other. The PRC outsources a variety of intermediate goods (such as crude petroleum, integrated circuit, iron ore, gold, and cars) from Australia; Germany; Hong Kong, China; Japan; the Republic of Korea, among others, while shifting its outsourcing of garments, apparels, toys, foot wares, and tools to other developing countries in Asia, Latin America, and Africa.

The evolution of these outsourcing patterns reveals that (a) outsourcing can occur universally among trading countries, whereby its direction can be of any type (North to South, North to North, South to North, and South to South). (b) A generalized theory of international outsourcing covering all possible patterns will be the topic of future research.

This paper has investigated the environmental effects of international outsourcing for both the North and the South using a three-stage general equilibrium model of international trade. We argue that the degree of internalization remains substantially below the level that can bring the South back to an internationally acceptable level of environmental quality. Thus, the tightening of environmental regulations and the fostering of international cooperation are warranted in order to promote better welfare for all.

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## APPENDIX

This Appendix derives the effects of labor-augmenting outsourcing on sectoral outputs and the price-output response, which are essential to the analyses in the text. Suppose that autonomous outsourcing takes place by the firms in sector 1 only, i.e.,  $A_1 > 1$ ,  $dA_1 > 0$ ,  $A_2 = 1$ , and  $dA_2 = 0$ . Differentiating Equations (1) yields

$$\begin{aligned} dX_1 &= F_{A_1 L_1} A_1 dL_1 + F_{A_1 L_1} L_1 dA_1 + F_{K_1} dK_1 \\ dX_2 &= F_{L_2} dL_2 + F_{K_2} dK_2 \end{aligned} \tag{A-1}$$

Using (A-1), (2) and (3), we obtain

$$\begin{aligned} \hat{X}_1 &= \theta_{L_1} \hat{L}_1 + \theta_{K_1} \hat{K}_1 + \theta_{A_1} \hat{A}_1, \\ \text{and } \hat{X}_2 &= \theta_{L_2} \hat{L}_2 + \theta_{K_2} \hat{K}_2, \end{aligned} \tag{A-2}$$

where the circumflex, “ $\wedge$ ”, indicates the relative change of the variable (e.g.,  $\hat{X}_1 = dX_1 / X_1$ ) except  $\hat{A}_1 = dA_1 / (A_1 - 1)$ , and  $\theta_{ji}$  ( $j = L, K; i = 1, 2$ ) represents the share of the  $j$ th factor in the total value of  $i$ th good, and  $0 \leq \theta_{A_1} = a_1(A_1 - 1) / p_1 X_1 < 1$  denotes the share of the effective labor-augmenting factor ( $A_1 - 1$ ) in the total value of good 1. The determinant of  $\theta_{ji}$  matrix, is positive (negative) according to whether good 1 is labor-intensive (capital-intensive) relative to good 2 [i.e.,  $k_1 < (>) k_2$ ], where  $k_i = K_i / L_i$  ( $j = L, K; i = 1, 2$ ). Perfect competition in the two traded goods markets ensures average-cost-pricing in each of the final goods industries, i.e.,  $wL_1 + rK_1 + b_1(A_1 - 1) = pX_1$  and  $wL_2 + rK_2 = X_2$ .<sup>11</sup>

Defining the elasticity of factor substitution of the  $j$ th sector as

$$\sigma_i = \frac{\hat{K}_i - \hat{L}_i}{\hat{w} - \hat{r} > 0_i} \quad i = 1, 2 \tag{A-3}$$

where each  $\sigma_i$  is positive. Substituting (A-3) in (A-2) and using the average-cost-pricing condition, we obtain

$$\begin{aligned} \hat{L}_1 &= [\hat{X}_1 - \theta_{K_1} \sigma_1 (\hat{w} - \hat{r}) - \theta_{A_1} \hat{A}_1] / (1 - \theta_{b_1}), \quad \hat{L}_2 = \hat{X}_2 - \theta_{K_2} \sigma_2 (\hat{w} - \hat{r}), \\ \hat{K}_1 &= [\hat{X}_1 - \theta_{L_1} \sigma_1 (\hat{w} - \hat{r}) - \theta_{A_1} \hat{A}_1] / (1 - \theta_{b_1}), \quad \hat{K}_2 = \hat{X}_2 + \theta_{L_2} \sigma_2 (\hat{w} - \hat{r}). \end{aligned} \tag{A-4}$$

where  $0 \leq \theta_{b_1} = b_1(A_1 - 1) / pX_1 < 1$  is the share of the actual payment for the effective labor-augmenting factor ( $A_1 - 1$ ) in the total value of good 1.

Since  $p_2$  is set to unity initially, using (A-3), (A-4) and the average-cost-pricing condition, we obtain

<sup>11</sup> Since the outsourcing firms in sector 1 pay  $b_1$  for the price of the labor-augmenting factor in stage 1, average-cost-pricing implies  $wL_1 + rK_1 + b_1(A_1 - 1) = p_1 X_1$  and  $\theta_{L_1} + \theta_{K_1} + \theta_{b_1} = 1$  where  $\theta_{b_1} = b_1(A_1 - 1) / pX_1$ . Then,  $|\theta| = \theta_{L_1} - \theta_{L_2}(1 - \theta_{b_1}) = \theta_{K_2}(1 - \theta_{b_1}) - \theta_{K_1}$ .

$$\theta_{L1}\hat{w} + \theta_{K1}\hat{r} = (\theta_{A1} - \theta_{b1})\hat{A}_1 - \theta_{b1}\hat{b}_1 + \hat{p}$$

and  $\theta_{L2}\hat{w} + \theta_{K2}\hat{r} = 0.$  (A-5)

Note that  $\theta_{A1} > \theta_{b1}$  in the presence of outsourcing because outsourcing occurs only if  $a_1 > b_1$ .

Since the international outsourcing market is competitive, the outsourcing firms are price takers of the outsourced goods and services, i.e.,  $b_1 = 0(b_1^*)$  in stage I (stage II).

Solving (A-5) for  $\hat{w}$  and  $\hat{r}$ , we derive

$$\begin{aligned}\hat{w} &= (1/|\theta|)[\theta_{K2}(\theta_{A1} - \theta_{b1})\hat{A}_1 + \theta_{K2}\hat{p}] \\ \hat{r} &= (1/|\theta|)[\theta_{L2}(\theta_{A1} - \theta_{b1})\hat{A}_1 - \theta_{L2}\hat{p}] \\ \hat{w} - \hat{r} &= (1/|\theta|)[(\theta_{A1} - \theta_{b1})\hat{A}_1 + \hat{p}].\end{aligned}$$
 (A-6)

Differentiation of the full-employment conditions (4) yields

$$\begin{aligned}\lambda_{L1}\hat{L}_1 + \lambda_{L2}\hat{L}_2 &= \hat{L}, \\ \lambda_{K1}\hat{K}_1 + \lambda_{K2}\hat{K}_2 &= \hat{K}\end{aligned}$$
 (A-7)

where  $\lambda_{ji}$  ( $j = L, K; i = 1, 2$ ) is the proportion of the  $j$ th factor in the  $i$ th industry.

Setting  $\hat{L} = \hat{K} = 0$ , and substituting (A-3), (A-4) and (A-5) into (A-7), we get a system of equations in matrix form,

$$\begin{bmatrix} \lambda_{L1} & \lambda_{L2} \\ \lambda_{K1} & \lambda_{K2} \end{bmatrix} \begin{bmatrix} \hat{X}_1 \\ \hat{X}_2 \end{bmatrix} = \begin{bmatrix} \delta_L(\theta_{A1} - \theta_{b1})\hat{A}_1/|\theta| + [\lambda_{L1}\theta_{A1}/(1 - \theta_{b1})\hat{A}_1 + (\delta_L\hat{p}/|\theta|) \\ -\delta_K(\theta_{A1} - \theta_{b1})\hat{A}_1/|\theta| + [\lambda_{K1}\theta_{A1}/(1 - \theta_{b1})\hat{A}_1 - (\delta_K\hat{p}/|\theta|)] \end{bmatrix}$$
 (A-8)

where,

$$\begin{aligned}\delta_L &= \lambda_{L1}\theta_{K1}\sigma_1(1 - \theta_{b1}) + \lambda_{L2}\theta_{K2}\sigma_2, \\ \delta_K &= \lambda_{K1}\theta_{L1}\sigma_1(1 - \theta_{b1}) + \lambda_{K2}\theta_{L2}\sigma_2.\end{aligned}$$

Here,  $\delta_j > 0$  ( $j = L, K$ ) denotes the change in the use of the  $j$ th factor per unit of output that occurs in both industries due to the change in wage-rental ratio.

## A.1 Outsourcing and Sectoral Outputs

### Effect of Outsourcing on Sectoral Outputs

To identify the effects of outsourcing on sectoral outputs at constant commodity prices (i. e.,  $\hat{p} = 0$ ), we solve the system of equations in (A-8) using the Cramer rule; thus, we obtain

$$\begin{aligned}
\frac{\hat{X}_1}{\hat{A}_1} &= \frac{1}{|\lambda|} \left\{ \lambda_{K2} \left[ \frac{\delta_L(\theta_{A1} - \theta_{b1})}{|\theta|} + \frac{\lambda_{L1}\theta_{A1}}{(1-\theta_{b1})} \right] - \lambda_{L2} \left[ \frac{-\delta_K(\theta_{A1} - \theta_{b1})}{|\theta|} + \frac{\lambda_{K1}\theta_{A1}}{(1-\theta_{b1})} \right] \right\} \\
&= \left\{ \theta_{A1} + \frac{(\lambda_{K2}\delta_L + \lambda_{L2}\delta_K)(\theta_{A1} - \theta_{b1})}{|\lambda||\theta|} \right\}, \\
\frac{\hat{X}_2}{\hat{A}_1} &= \frac{1}{|\lambda|} \left\{ \lambda_{L1} \left[ -\frac{\delta_K(\theta_{A1} - \theta_{b1})}{|\theta|} + \frac{\lambda_{K1}\theta_{A1}}{(1-\theta_{b1})} \right] \hat{A}_1 - \lambda_{K1} \left[ \frac{\delta_L(\theta_{A1} - \theta_{b1})}{|\theta|} + \frac{\lambda_{L1}\theta_{A1}}{(1-\theta_{b1})} \right] \hat{A}_1 \right\} \\
&= \frac{-1}{|\lambda||\theta|} (\lambda_{L1}\delta_L + \lambda_{K1}\delta_K)(\theta_{A1} - \theta_{b1}) \tag{A-9}
\end{aligned}$$

where  $|\lambda| = \lambda_{L1}\lambda_{K2} - \lambda_{K1}\lambda_{L2}$  is the determinant of the  $\lambda_{ji}$  matrix. Note that  $|\lambda| = \lambda_{L1}\lambda_{K2} - \lambda_{K1}\lambda_{L2} = (L_1L_2 / LK)(k_2 - k_1)$ , which is positive (negative) according to whether good 1 is labor-intensive (capital-intensive) relative to good 2 (i.e.,  $k_1 < (>)k_2$ ). Therefore,  $|\lambda|$  has the same sign as  $|\theta|$ . Furthermore,  $\theta_{A1} - \theta_{b1} > 0$  for outsourcing to occur. Therefore,  $\hat{X}_1 / \hat{A}_1 > 0$  and  $\hat{X}_2 / \hat{A}_1 > 0$ . That is, outsourcing creates “ultra-biased” effects on sectoral outputs, i.e., the output of the outsourcing sector increases at the expense of the other sector.

### A.2 Price-Sectoral Outputs Response

We obtain the expression for commodity price–output response at a given level of outsourced goods and services ( $\hat{A}_1 = 0$ ) by solving the system of equations in (A-8) using the Cramer rule:

$$\begin{aligned}
\frac{\hat{X}_1}{\hat{p}} &= \frac{1}{|\lambda|} \left[ \frac{\lambda_{K2}\delta_L + \lambda_{L2}\delta_K}{|\theta|} \right] > 0 \\
\frac{\hat{X}_2}{\hat{p}} &= -\frac{1}{|\lambda|} \left[ \frac{\lambda_{L1}\delta_K + \lambda_{K1}\delta_L}{|\theta|} \right] > 0.
\end{aligned}$$

That is, in the stable system, a rise in the relative price of a good always increases the output of the good and decreases that of the other good. Note that this result is consistent with Neary’s (1978) proposition that the price-output response is always normal (i.e., positive) under a stable system. Therefore, Proposition 1 in the text follows from the results in A.1 and A.2.