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Vertical FDI versus Outsourcing: The Role of Host Country Human Capital

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Abstract:

The existing literature on offshoring neglects the importance of host country conditions in affecting the boundaries of a firm. In this paper, we focus on the role of the host country's human capital in affecting the organization of offshore production. Acknowledging that an input is produced offshore only after training the host labor, we propose that this training cost depends on the human capital gap between the home and the host country. Our model finds that a sourcing firm prefers to offshore production internationally only if the human capital gap between the home and the host country is below a threshold. Secondly, as the human capital gap increases, the probability for international outsourcing vis-à-vis intra-firm trade increases. Finally, as opposed to conventional wisdom, our model shows the possibility of outsourcing inputs of a high-tech good when the human capital gap between the home and the host is high.

Keywords: Outsourcing, Foreign Direct Investment, Training Cost, Human Capital Gap

JEL Classification: D23, F12, F23, L22

Section 1: Introduction

In the early stage of international production fragmentation, every firm faces the "make or buy" choice, that is, it has to choose between offshoring the input production through a subsidiary vis-à-vis an arm's length agent. The importance of this decision is reflected in the recent proliferation of internalization literature on offshoring. Current research reveals that the organizational form of global production sharing is influenced by the degree of standardization of the good, factor intensity of the good, intensity of offshored input in the final good, productivity of sourcing firms, legal framework and market thickness in the host country. None of these factors, however, characterizes the quality of labor in the host country that actually produces the input. In this paper we modify the Antràs (2005) model to analyze the effect of a host country's labor quality on the organization of fragmented production.

From a home country's perspective, offshored inputs usually embody a relatively simple technology. However, a developing host country may not be familiar with the technology and culture of an international firm. Therefore, the workers and managers of a host country must be trained in order to produce the offshored input. For instance, a survey of Indian business process outsourcing (BPO) vendors (The Hindu Business Line, 2005) reveals that 25.2% of total wage cost is spent on training employees to meet quality standards in offshored input production. Similarly, in their extensive fieldwork on Indian software and BPO industry, Arora et al (2000) found that all employees undergo a significant amount of specialized training for an average of 2-3 months before hitting the shop floor.

In the Antràs (2005) model, a final good is produced using two inputs – the high tech input and the low tech input. The model only allows for offshoring the low-tech input such that the supplier makes relationship specific investment (RSI) in this input while the sourcing firm makes RSI in the high-tech input. Each agent produces its respective input, which is then combined to produce the final good. The fact that the RSI in inputs is sunk before its value is realized discourages agents to make optimal RSI because these inputs have no value outside the relationship. The goal of the model is to find an optimal organizational form that minimizes distortions arising from suboptimal RSI in inputs.

Following Hart and Moore (1990), the model differentiates between vertical foreign direct investment (VFDI) and outsourcing in terms of a sourcing firm's share in total revenue. If a sourcing firm integrates, it can fire the supplier if they fail to agree in bargaining and yet appropriate a fraction of the input produced by the subsidiary. Per contra, if an unaffiliated supplier is fired, all input is lost. Thus, integration gives the sourcing firm a greater share in total surplus vis-à-vis outsourcing. The model finds that if the final good is high tech, then the sourcing firm integrates with the supplier and outsources if the final good is low-tech. The rationale for this result lies in the Grossman-Hart-Moore property rights theory, which suggests that in order to minimize distortions in RSI, higher share should be given to the agent who contributes more to total surplus. Since the sourcing firm contributes relatively more when the final good is high-tech, therefore, it makes sense to integrate with the supplier.

Using the framework for organizational choice developed in Antràs (2005), we propose that for the home and the host to be equally productive in producing the offshored input, the host country labor must be trained. Training cost is assumed to be increasing and convex in the human capital gap between the home and the host country. Further, the burden of training cost that falls on the sourcing firm also depends on the mode of organizing offshoring. Using evidence from existing studies in horizontal FDI and licensing as well as offshoring surveys, we argue that in an intra-firm production transfer, the sourcing firm has to bear the cost of training the host country labor while the subsidiary manager has little incentive to make RSI in training the host labor. Per contra, if offshore production is contracted to an unaffiliated supplier, then the supplier incurs a significant proportion of the training costs. By choosing outsourcing over integration, a sourcing firm minimizes the burden of training cost but appropriates a lower share in surplus. Further, since the training cost is borne by the supplier, it also faces a depressed RSI in the low-tech input, which is in addition to that caused by incomplete contracts. Thus, the choice between integration and outsourcing depends on the burden of training cost borne by the sourcing firm along with the distortions in input production caused by training cost and incomplete contracts.

There are four key results of our model. One, a sourcing firm prefers to offshore production internationally only if the human capital gap between the home and the host country is below a threshold. A

high human capital gap implies greater training costs, which depresses a sourcing firm's profit in the international outsourcing mode by discouraging RSI of the supplier while in the VFDI mode it directly increases a sourcing firm's cost burden. Therefore at high human capital gap, offshoring in either form is dominated by domestic production. In fact, the existence of large differences in labor quality between developed countries and several low wage countries explains the geographical confinement of offshoring to a few destinations only.

Two, as the intensity of offshored input increases, the multinational firm's tolerance for low human capital in the host country decreases. A rise in offshored input intensity implies larger offshored input requirement and hence larger training costs. Therefore, to break even in the VFDI mode, the threshold human capital gap must fall.

Three, at high human capital gap, the probability of international outsourcing increases as the human capital gap further increases. On the other hand, at low human capital gap, the probability for VFDI increases as the human capital gap increases. At low human capital gap, an increase in this gap marginally increases the training cost such that a sourcing firm may prefer VFDI. However, if the human capital gap is large, a marginal increase in this gap dramatically increases the training cost such that outsourcing is preferred.

Four, unlike Antràs, it is possible to observe international outsourcing even in a high-tech good if the human capital gap between the home and the host is high. Since training costs are increasing and convex in human capital gap, at high human capital gap, the cost of training the host labor is huge, which makes VFDI a less profitable proposition vis-à-vis outsourcing.

The paper beyond this point is organized as follows. Section 2 briefly discusses the related literature. In section 3 we develop the model and discuss the results while section 4 makes a conclusion.

Section 2: Related Literature

Starting with Grossman and Hart (1986), many authors have underlined the importance of incomplete contracts in influencing a firm's choice between integrating and outsourcing. Recently, the problems of contractual incompleteness have been magnified in an international context in trade models by

Antràs and Helpman (2004) and Antràs (2003, 2005). These models argue that the bargaining power of the sourcing firm is higher in an integrated relationship vis-à-vis outsourcing. Besides this difference between VFDI and outsourcing, Antràs and Helpman (2004) also emphasize that the organizational fixed costs is higher for VFDI relative to international outsourcing. In such an economy, more productive firms venture into VFDI because large fixed costs of integrating can be justified only for highly productive firms.

In the Antràs (2003) model a final good is produced using capital and labor where only the labor input can be offshored. The model finds that VFDI is chosen for a capital-intensive good while a labor intensive good is outsourced to an unaffiliated supplier. The rationale for this result is embedded in the Grossman-Hart-Moore property rights theory, where an agent contributing more to total surplus is given a larger share in surplus to motivate a higher RSI in her input.

Antràs (2005) also introduces time element in his model, as in the Vernon (1966) product cycle model, by assuming that the intensity of high-tech input falls with time. This, when combined with the main result from the Antràs (2005) model that a sourcing firm prefers outsourcing (vis-à-vis VFDI) for a low-tech good implies that products can be outsourced at a later stage in the product cycle. Thus, the degree of standardization for goods whose inputs are outsourced is higher vis-à-vis those that are integrated.

Given the Hart and Moore (1990) hypothesis, that a sourcing firm has a larger share in total surplus in an intra-firm vis-à-vis arm's length production transfer, we expect that the sourcing firm has an incentive to train the host country labor in the VFDI mode. At the same time, a low share in total surplus accruing to the affiliated supplier reduces her incentive to invest in training the host labor. The Ramachandran (1993) model suggests that a licensor's investment in transferring technology to the licensee is a function of its ownership share. His model finds that the investment in technology transfer for fully owned subsidiaries is higher than that for other firms. Similarly, assuming that a licensee's investment is a function of her profit, the model finds that a licensee's investment in technology is higher when it is an independent firm vis-à-vis integrated. The model's predictions are empirically tested for technology transfer agreements signed by Indian firms with firms in the U.S., U.K. and Western Europe in 14 industries. The amount of resources expended in technology transfer was found to vary across ownership structure. For instance, the number of foreigners

sent to India for training (at licensor's cost) is significantly higher for subsidiaries (2.46) vis-à-vis firms in which a licensee had partial equity (0.65) or an independent firm (0.16).

In an international outsourcing relationship, a sourcing firm would be hesitant to train the host country labor because a vendor usually offers services to more than one client. If a sourcing firm trains the host country labor for an unaffiliated supplier, it runs a risk that its trained labor maybe used by the supplier to serve other competitor clients as well. This explains why third party BPO firms in India, like VisualSoft Technologies Ltd, Zensar Technologies, iGate Global Solutions etc. have to spend a considerable proportion of their revenues on training, technology acquisition and absorption.

Chudnovsky (1991) report on north-south technology transfer finds that final good producers do not provide much technical assistance to local suppliers. Egan and Mody (1992) find that in a shoe manufacturing subcontracting relationship the buyer is willing to transmit only the minimum information required to get the product out of the production cycle. If the product must adhere to stringent quality specifications before being accepted, then it is entirely left to the supplier's discretion to take up the contract, get involved in the manufacturing process and produce the good of requisite quality at lowest possible cost, implying that the supplier has to incur a large part of the technology transfer or adaptation cost. Based on the available literature, we make the following assumption:

Assumption 1: *The parent firm incurs a significant share of training costs in the VFDI mode, while it is the unaffiliated input supplier who bears a large proportion of this cost in case of international outsourcing.*

Our assumption is implicit in models like Bartel et al (2005). An increase in the rate of technological change, in their model, increases outsourcing because it allows a sourcing firm to use the services of the supplier based on leading edge technologies without incurring the sunk costs of adopting these new technologies. The assumption implicit in their analysis is that it is always the supplier of the input who bears the cost of training or technology adoption in an outsourcing relationship.

Section 3: The Model:

Consider a world with two countries – the developed north and the low wage south and a good *y* produced using labor only. A producer of good *y* faces the following isoelastic demand:

$$y = \lambda\, p^{-1/1-\alpha} \tag{1}$$

Where *p* is the price of good *y*, α represents the inverse of the elasticity if demand and λ is a given parameter known to the producer.

The final good *y* is produced using two inputs: the high-tech input, x_h, and the low-tech input, x_l, which are combined in intensity (*1-z*) and *z* respectively.

$$y = \left(\frac{x_h}{1-z}\right)^{1-z}\left(\frac{x_l}{z}\right)^{z} \tag{2}$$

We assume that only the low-tech input is offshored because the host country lacks the capability to produce a high-tech input. In the Antràs (2005) model, one unit of a low-tech input is produced using one unit of labor, irrespective of the location of its production.

$$x_l = L^S \tag{3}$$

Where L^S represents the labor of the host country.

Contrary to the Antràs (2005) model, we assume that one unit of the host country labor can produce a unit of the low tech input only if it undergoes training. Without training, there can be no input production[1]. Absorptive capacity of a host country, that is, the ability of its human capital, has been a crucial element of technology transfer costs in Baranson (1970), Mattoo et al (2005), Teece (1977), Pack and Saggi (1997) and Eicher and Kalaitzidakis (1997). In our model, the per unit training cost in the host country is given by:

$$C = C(\xi)$$

Where ξ is the human capital gap between the home and the host country that represents the differences between the home and the host country's labor quality in terms of their competency, knowledge and skill to work efficiently. This gap measures the differences in the absorptive capacity of the home and the host

[1] Our training cost is similar in formulation to Long (2005), except that we make it a function of an exogenously given human capital gap. The purpose of their model is to explain incomplete offshoring rather than determine its organizational form.

country. Since no training is required for a home country's worker, the training cost for a host country depends only on the difference between the knowledge and skills of the workers in the two countries.

We assume that the training cost increases at an increasing rate in the human capital gap between the home and the host, that is:

$$\frac{\partial C}{\partial \xi} > 0, \quad \frac{\partial^2 C}{\partial \xi^2} > 0$$

Assumption 1 suggests that training cost is endogenous with the mode of organizing offshore production. The sourcing firm (supplier) understands that there is little incentive for the supplier (sourcing firm) to train the host labor in an intra-firm (arm's length) production transfer and hence she decides to take a small fixed payment, TT_f^S $\left(TT_o^N\right)$ from the supplier (sourcing firm) in lieu of its insignificant investment in training of host labor. To simplify algebra, and without loss of generality, we assume that these fixed payments are close to 0, implying that all training cost is incurred by a sourcing firm (supplier) in the VFDI (international outsourcing) mode.

Assumption 2: $TT_o^N \approx 0, \quad TT_f^S \approx 0$.

We now consider how the human capital gap influences a firm's choice in the following three organizational forms: (1) Vertical integration in the North or Domestic outsourcing (DO) (2) Unaffiliated Supplier in the South: International Outsourcing (IO) (3) Affiliated Supplier in the South: VFDI.

<u>Vertical Integration in the North or Domestic outsourcing</u>

Assuming complete contract enforcement in the north, vertical integration and DO are equivalent. Given the demand and production functions in (1) and (2) respectively and assuming that one unit of labor produces one unit of each input, the profit of a firm producing in the north is given by:

$$\Pi^N = \lambda^{1-\alpha} \zeta_z^{\alpha} x_h^{(1-z)\alpha} x_l^{z\alpha} - w^N x_h - w^N x_l$$

Where $\zeta_z^{\alpha} = (1-z)^{-(1-z)} (z)^{-z}$ and total revenue is represented by, $R = p\ y = \left(\lambda^{1-\alpha} \zeta_z^{\alpha} x_h^{(1-z)\alpha} x_l^{z\alpha}\right)$

Equilibrium profit and profit maximizing price are respectively given by:

$$\Pi^N = \lambda(1-\alpha)\left(\frac{w^N}{\alpha}\right)^{-\frac{\alpha}{1-\alpha}} \quad \text{and} \quad p^N(z) = \frac{w^N}{\alpha} \tag{4}$$

International Outsourcing- Unaffiliated supplier in south

In the IO mode, the RSI for a sourcing firm comprises of its commitment to producing the high tech input only.

Assumption 3: *Competition among suppliers of low-tech input drives down their profit to zero.*

The profit function for a sourcing firm in the IO mode is given by:

$$\Pi_o^N = \phi R - w^N x_h + T = \phi\left(\lambda^{1-\alpha}\, \zeta_z^{\alpha}\, x_h^{(1-z)\alpha}\, x_l^{z\alpha}\right) - w^N x_h + T$$

Where ϕ is the share of the sourcing firm in total revenue and T is a transfer payment from the supplier to the sourcing firm such that the supplier breaks even.

The RSI of a supplier in the IO mode comprises of its commitment to producing the low-tech input as well as train the host labor. The supplier's profit function is given by:

$$\Pi_o^S = (1-\phi)R - w^S x_l - C(\xi)\, L^S - T = (1-\phi)\left(\lambda^{1-\alpha}\, \zeta_z^{\alpha}\, x_h^{(1-z)\alpha}\, x_l^{z\alpha}\right) - \left(w^S + C(\xi)\right)\, x_l - T \qquad \text{(Using 3)}$$

Profit maximization by the two agents and setting T such that the supplier breaks even leads to the following expression for the sourcing firm's ex-ante profits and price respectively in IO equilibrium:

$$\Pi_o^N = \lambda\ \left[(1-z\alpha) + \phi\alpha(2z-1)\right]\left[\frac{\left(w^N\right)^{1-z}\left(w^S + C(\xi)\right)^z}{\phi^{1-z}\,(1-\phi)^z\,\alpha}\right]^{-\frac{\alpha}{1-\alpha}} \qquad \text{(5a)}$$

$$P_o = \left[\frac{\left(w^N\right)^{1-z}\left(w^S + C(\xi)\right)^z}{\phi^{1-z}\,(1-\phi)^z\,\alpha}\right] \qquad \text{(5b)}$$

To determine the human capital gap for which a sourcing firm prefers IO vis-à-vis DO, we define: $\Theta_1 = \frac{\Pi^N}{\Pi_O^N}$ the relative profit of the sourcing firm in DO vis-à-vis IO. A sourcing firm is indifferent between IO and DO if $\Theta_1 = 1$,that is:

$$\frac{w^N}{w^S} = L_1(\xi, \phi, z, \alpha) \qquad \text{(6)}$$

while it prefers IO over and DO if $\Theta_1 < 1$,that is, $\frac{w^N}{w^S} > L_1(\xi, \phi, z, \alpha)$.

Where $L_1(\xi, \phi, z, \alpha) = \left(1 + \frac{C(\xi)}{w^S}\right)\left(\frac{\phi}{1-\phi}\right)\left[\frac{1-\alpha}{(1-z\alpha)+\phi\alpha(2z-1)}\right]^{\frac{1-\alpha}{z\alpha}} \frac{1}{\phi^{1/z}}$ (Using 4 and 5a)

Determination of the Threshold Human Capital Gap

We now graphically determine the critical human capital gap, $\bar{\xi}_o$, such that the sourcing firm is indifferent between IO and DO, that is, $\Theta_1 = 1$. In figure 1a, we plot the LHS and RHS of equation (6) with respect to ξ. Now, $\frac{\partial L_1(\xi,\phi,z,\alpha)}{\partial \xi} > 0$ and $\frac{\partial^2 L_1(\xi,\phi,z,\alpha)}{\partial \xi^2} > 0$ implying that $L_1(\xi,\phi,z,\alpha)$ is convex in human capital gap[2] while, the RHS of (6), $\frac{w^N}{w^S} = \omega$ is exogenous in our model[3] and therefore can be represented by a horizontal line. The intersection of the LHS and RHS plots in figure (1a) determines $\bar{\xi}_o$. For $\xi > \bar{\xi}_o$, $\frac{w^N}{w^S} < L_1(\xi,\phi,z,\alpha)$, implying that DO is preferred relative to IO while for reverse is true for $\xi < \bar{\xi}_o$

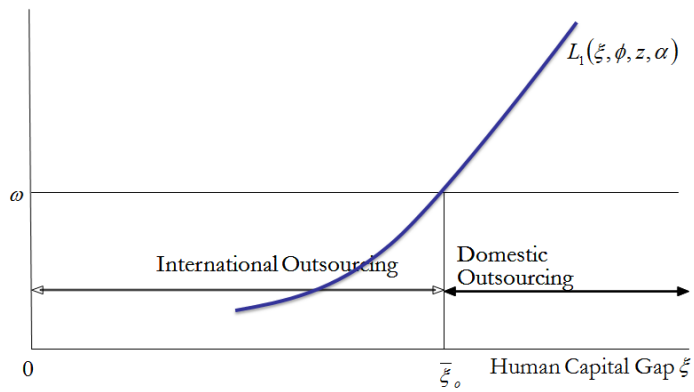

Figure 1a: Tradeoff between northern production and international outsourcing

A sourcing firm stands to gain from IO vis-à-vis DO due to lower host country wages while it loses due to contractual incompleteness (which leads to sub-optimal RSI). The presence of training cost raises the effective wage in the south and therefore further distorts the RSI in low-tech input. For human capital gap above $\bar{\xi}_o$, there are greater distortions in RSI relative to savings from cheap host country labor. Thus, a sourcing firm prefers DO at a high human capital gap.

Proposition 1: *A sourcing firm prefers to outsource production internationally vis-à-vis domestic production only if the human capital gap between the home and the host country is below a critical threshold.*

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[2] The curvature and slope of the curve depends on parameters like z, α and ϕ

[3] Since this is a partial equilibrium model, the wages are determined exogenously.

Choice between IO and DO with respect to other variables

A sourcing firm's choice between IO and DO depends not only on the relative wages but also on the absolute level of host wages[4]. Therefore, it is important to consider how this choice varies with respect to changes in the other variables:

(i) Home and Host Wages (keeping ξ constant)

Partial differentiation of (6) yields: $\frac{\partial w^N}{\partial w^S} = \left(\frac{\phi}{1-\phi}\right)\left[\frac{1-\alpha}{(1-z\alpha)+\phi\alpha(2z-1)}\right]^{\frac{1-\alpha}{z\alpha}} \frac{1}{\phi^{1/z}}$, which is a constant positive slope.

In left panel of figure 1b, we plot this relationship. To the right of $\Theta_1 = 1$ line, host wages are increasing, making DO a more profitable proposition while the reverse is true to the left of this line.

(ii) Home wages and Human Capital gap (keeping w^S constant)

Partial differentiation of (6) yields: $\frac{\partial w^N}{\partial \xi} = \frac{\partial C(\xi)}{\partial \xi}\left(\frac{\phi}{1-\phi}\right)\left[\frac{1-\alpha}{(1-z\alpha)+\phi\alpha(2z-1)}\right]^{\frac{1-\alpha}{z\alpha}} \frac{1}{\phi^{1/z}} > 0$, and $\frac{\partial^2 w^N}{\partial \xi^2} > 0$

In right panel of figure 1b, we plot this relationship. To the right of $\Theta_1 = 1$ curve, ξ is increasing, making DO a more profitable proposition while the reverse is true to the left of this curve.

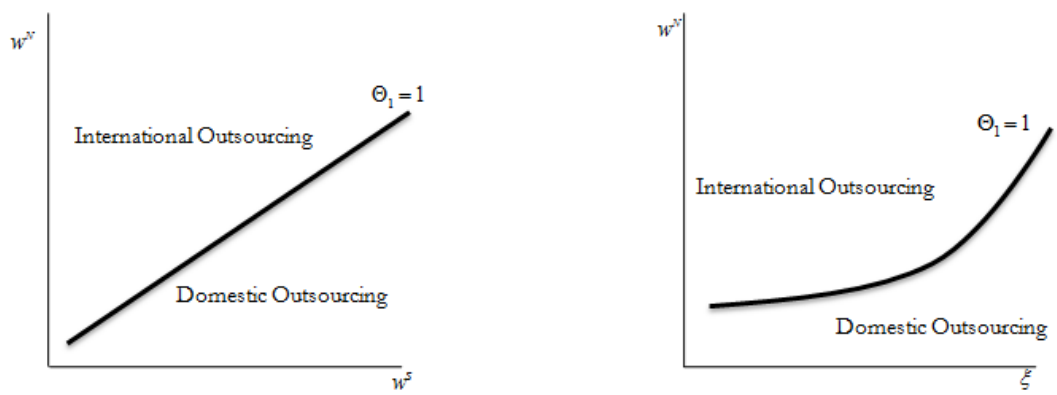

Figure 1b: The choice between IO and DO with respect to other variables

Vertically Integrated supplier in the South or VFDI

We retain the Hart and Moore (1990) premise that the sourcing firm has a higher share in surplus in an intra-firm production transfer vis-à-vis a market transaction. If the two agents fail to agree in bargaining,

[4] I am grateful to an anonymous referee for suggesting this interpretation of equation (6).

then the sourcing firm has the residual rights over a fraction δ of the final good[5]. This translates into $(\delta^{\alpha} R)$ of revenue that a sourcing firm can obtain by selling the final good. The quasi rent from an integrated relationship is thus given by: $(1-\delta^{\alpha})R$. Generalized Nash bargaining gives the sourcing firm its default option plus a fraction ϕ of quasi rent. A sourcing firm's share in surplus in the VFDI mode is thus given by:

$$\bar{\phi} = \delta^{\alpha} + \phi(1-\delta^{\alpha}) > \phi \tag{7}$$

In addition to this standard distinction, we assume that a sourcing firm bears the full cost of training the host country's labor in the VFDI mode. The profit function of a sourcing firm is given by:

$$\Pi_f^N = \bar{\phi} R - w^N x_h - C(\xi) L^S + T' = \bar{\phi}\left(\lambda^{1-\alpha} \zeta_z^{\alpha} x_h^{(1-z)\alpha} x_l^{z\alpha}\right) - w^N x_h - C(\xi) x_l + T'$$

Where we set T' such that competition amongst suppliers drives their profit down to zero.

The profit of the subsidiary manager, (the affiliated supplier) is given by:

$$\Pi_f^S = (1-\bar{\phi})R - w^S x_l - T' = (1-\bar{\phi})\left(\lambda^{1-\alpha} \zeta_z^{\alpha} x_h^{(1-z)\alpha} x_l^{z\alpha}\right) - w^S x_l - T'$$

Profit maximization by the two agents yields the following equilibrium profit and price in the VFDI mode:

$$\Pi_f^N = \lambda \left[(1-z\alpha) + \bar{\phi}\alpha(2z-1) - (1-\bar{\phi})z\alpha \frac{C(\xi)}{w^S}\right] \left[\frac{(w^N)^{1-z}(w^S)^{z}}{\bar{\phi}^{1-z}(1-\bar{\phi})^{z}\alpha}\right]^{-\frac{\alpha}{1-\alpha}} \tag{8}$$

$$P_f = \left[\frac{(w^N)^{1-z}(w^S)^{z}}{\bar{\phi}^{1-z}(1-\bar{\phi})^{z}\alpha}\right] \tag{9}$$

Training cost in the VFDI mode is akin to a fixed cost for the sourcing firm and does not distort prices.

Assumption 4*: Let ϕ = ½, as in Antràs (2005)*

Using assumption 4, we get that for VFDI to yield a positive profit it must be the case that: $\xi < \underline{\xi}$

Where $\underline{\xi} = C^{-1}\left[\frac{(1-z\alpha)+\bar{\phi}\alpha(2z-1)}{(1-\bar{\phi})z\alpha} w^S\right]$ (10)

This is in contrast to the IO mode where the sourcing firm earns positive profit for all range of human capital gap. This is because in the case of IO, the unaffiliated supplier makes RSI in training, while the resulting gain

[5]Failure in bargaining leads to a negative productivity shock such that the overall output is lost by a fraction $(1-\delta)$ rather than only the low-tech input.

in output is also enjoyed by the sourcing firm. In the case of VFDI, the Multinational Company (MNC)[6] makes RSI in training, while both agents enjoy the incremental surplus.

Proposition 2*: The sourcing firm stands to lose from VFDI (even in absolute terms) if the human capital gap between the home and the host is higher than a critical level,* $\underline{\xi}$ *defined in (10).*

Notice that in (10)[7]: $\frac{\partial \underline{\xi}}{\partial z} < 0$, which implies that:

Proposition 3: *As the intensity of offshored input in the final good increases, a multinational firm's tolerance for low absorptive capacity in the host country decreases.*

The threshold level of human capital gap $\underline{\xi}$ represents the zero profit condition for the MNC. Suppose a host country is at this threshold level of human capital gap and the intensity of the offshored input increases, (say, due to the dynamic process of standardization highlighted in Antràs, 2005). The RSI in the low-tech input in the VFDI mode given by (we will derive this later in the paper):

$x_l^f = \lambda\, \bar{\phi}^{\frac{\alpha(1-z)}{1-\alpha}} \left(1-\bar{\phi}\right)^{1+\frac{\alpha z}{1-\alpha}} z\, \alpha^{\frac{1}{1-\alpha}} \left(w^N\right)^{\frac{\alpha(1-z)}{1-\alpha}} \left(w^S\right)^{-\left(1+\frac{\alpha z}{1-\alpha}\right)}$, increases with z.

As z increases, the profit maximizing RSI in the offshored input increases and so does the training cost. In order to maintain the same level of profits, an increase in z must be accompanied by a decline in the human capital gap. Thus, the threshold $\underline{\xi}$ is lower for a low-tech good.

To evaluate the relative prevalence of VFDI vis-à-vis DO we define: $\Theta_2 = \frac{\Pi^N}{\Pi_f^N}$

A sourcing firm is indifferent between VFDI and DO if $\Theta_2 = 1$:

$$\Rightarrow \omega = L_2\left(\xi, \bar{\phi}, z, \alpha\right). \tag{11}$$

While it prefers VFDI relative to DO if $\Theta_2 < 1$, that is $\omega > L_2\left(\xi, \bar{\phi}, z, \alpha\right)$.

[6] A sourcing firm in the VFDI mode is generally referred to as a MNC.

[7] Where we derive this from $\frac{\partial C(\underline{\xi})}{\partial z} = C(\underline{\xi})\left(-\frac{1+\alpha\bar{\phi}}{\left(1-\bar{\phi}\right)\alpha z^2}\right) < 0$

Where $L_2(\xi,\bar{\phi},z,\alpha)=\left(\frac{\bar{\phi}}{1-\bar{\phi}}\right)\left[\frac{1-\alpha}{\left[(1-z\alpha)+\bar{\phi}\alpha(2z-1)-(1-\bar{\phi})z\alpha\frac{C(\xi)}{w^S}\right]}\right]^{\frac{1-\alpha}{z\alpha}}\frac{1}{\bar{\phi}^{\frac{1}{z}}}$

Notice that, $\frac{\partial L_2(\xi,\bar{\phi},z,\alpha)}{\partial\xi}=\frac{L_2(\xi,\bar{\phi},z,\alpha)}{\left[(1-z\alpha)+\bar{\phi}\alpha(2z-1)-(1-\bar{\phi})z\alpha\frac{C(\xi)}{w^S}\right]}\left[\frac{(1-\bar{\phi})}{w^S}\right]z\quad(1-\alpha)\frac{\partial C(\xi)}{\partial\xi}>0$

Determination of Threshold Human Capital Gap

We now graphically determine the critical human capital gap, $\bar{\xi}_f$, such that the sourcing firm is indifferent between VFDI and DO, that is, $\Theta_2=1$. We plot the LHS and RHS of equation (11) in figure 2a and their intersection determines $\bar{\xi}_f$. Note that $\bar{\xi}_f<\underline{\xi}$ because $\Pi_f^N=0$ at $\xi=\underline{\xi}$, such that before hitting zero profits, the sourcing firm must switch to DO.

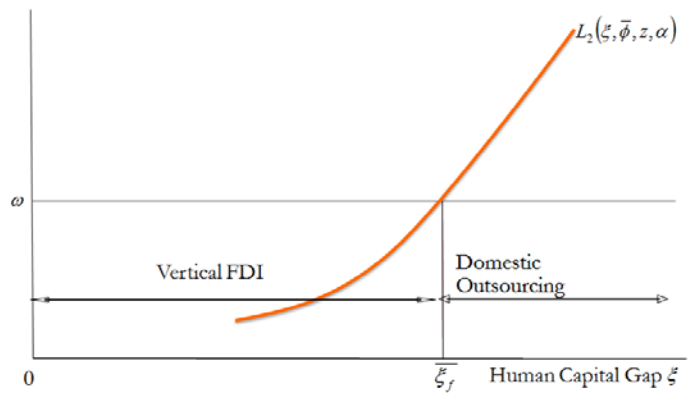

Figure 2a: Tradeoff between northern production and Vertical FDI

A sourcing firm gains from VFDI vis-à-vis DO due to lower host country wages while it loses due to the burden of training costs and sub-optimal RSI in inputs resulting from incomplete contracts. Thus, for $\xi<\bar{\xi}_f$, a multinational prefers VFDI while it prefers DO otherwise.

Proposition 4: *A multinational firm prefers to offshore production to an affiliated supplier vis-à-vis domestic production only if the human capital gap between the home and the host country is below a threshold.*

Choice between VFDI and DO with respect to other variables

We now map the choice between VFDI and DO across other variables using equation (11)

(i) Home and Host Wages (keeping ξ constant)

Partial differentiation of (11) yields: $\frac{\partial w^N}{\partial w^S} < 0$ if $w^S < \left[\frac{(1-\bar{\phi})(1+z\alpha)}{(1-z\alpha)+\bar{\phi}\alpha(2z-1)}\right] C(\xi)$, while $\frac{\partial w^N}{\partial w^S} > 0$ otherwise.

In the left panel of figure 2b, we plot this U-shaped relationship. A sourcing firm prefers VFDI above this indifference curve while it prefers DO below it.

The rationale for this preference and a U shape relationship is as follows: Start with a point on the downward sloping part of the curve such that the sourcing firm is indifferent between VFDI and DO. Now, as w^S increases, ceteris paribus, x_l^f decreases (x_l^f is decreasing and convex in w^S), which decreases the revenue as well as the training cost for the sourcing firm. The former decreases π_f^N while the latter increases it. At lower levels of w^S, the latter effect dominates such that π_f^N increases, which makes VFDI preferable over DO[8]. To maintain indifference between the two modes, w^N must fall, which increases π^N (relatively more than π_f^N). This explains the downward slope of the indifference curve at low levels of w^S. Conversely, starting at a point on the upward sloping part of the indifference curve $\Theta_2 = 1$, such that w^S is high, an increase in w^S, ceteris paribus, reduces π_f^N, thereby making DO preferred over VFDI. To get back to $\Theta_2 = 1$, w^N must rise, which reduces π^N more than it shrinks π_f^N.

(ii) Home wages and Human Capital gap (keeping w^S constant)

Partial differentiation of (11) yields: $\frac{\partial w^N}{\partial \xi} > 0$, and $\frac{\partial^2 w^N}{\partial \xi^2} > 0$

In the right panel of figure 2b, we plot this relationship. To the right of $\Theta_2 = 1$ curve, ξ is increasing, making DO a more profitable proposition while the reverse is true to the left of this curve.

[8] In equilibrium, $\frac{\partial R}{\partial C(\xi)} = \frac{w^S}{1-\bar{\phi}}$ while $\frac{\partial[C(\xi)x_l^f]}{\partial x_l^f} = C(\xi)$

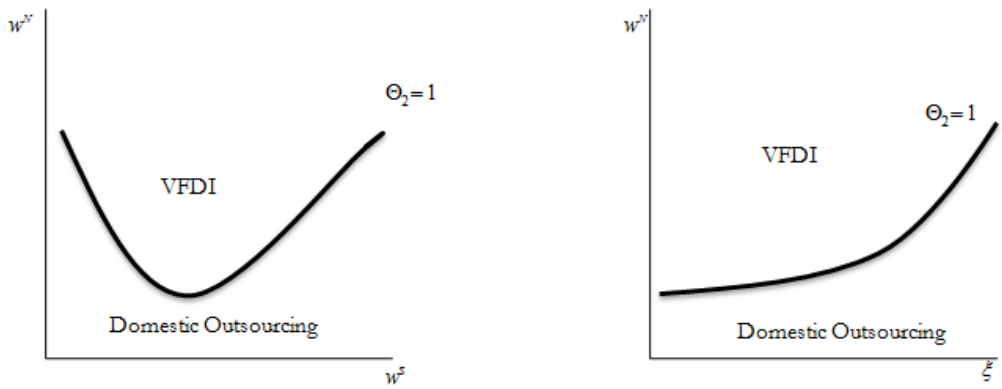

Figure 2b: The choice between VFDI and DO with respect to other variables

<u>Comparing International VFDI with International Outsourcing</u>

To compare the relative preference of VFDI over IO, we define $\Theta = \frac{\Pi_o^N}{\Pi_f^N}$. Using equations (5a), (8) and (7) and ϕ = ½, we get:

$$\Theta = \left[\frac{\left(1-\frac{1}{2}\alpha\right)}{\left[\left(1-\frac{1}{2}\alpha\left(1+\delta^{\alpha}(1-2z)\right)\right)-\frac{1}{2}\alpha\, z\left(1-\delta^{\alpha}\right)\frac{C(\xi)}{w^S}\right]}\right]\left[\frac{1}{\left(1+\delta^{\alpha}\right)^{\frac{1-z}{z}}\left(1-\delta^{\alpha}\right)}\right]^{\frac{\alpha}{1-\alpha}}\left[\left(\frac{w^S+C(\xi)}{w^S}\right)^{z}\right]^{-\frac{\alpha}{1-\alpha}}$$

To have a meaningful comparison between VFDI and IO, we need to hold $\xi < \underline{\xi}$, because for $\xi \geq \underline{\xi}$ VFDI yields zero or negative profits and hence would never be chosen by a sourcing firm.

Partial differentiating Θ with respect to ξ we get:

$$\frac{\partial\Theta}{\partial\xi} = \Theta\, z\, \alpha\, \frac{\partial C(\xi)}{\partial\xi}\frac{\left(w^S\left(\alpha(1-z)\delta^{\alpha}-\frac{1}{2}\left(1+\delta^{\alpha}\right)\right)+C(\xi)\left(1-\delta^{\alpha}\right)\left(1-\alpha(1-z)\right)\right)}{\left[\left(1-\frac{1}{2}\alpha\left(1+\delta^{\alpha}(1-2z)\right)\right)-\frac{1}{2}\alpha\, z\left(1-\delta^{\alpha}\right)\frac{C(\xi)}{w^S}\right]\left(w^S+C(\xi)\right)}$$

Now, $\alpha(1-z)\delta^{\alpha} < \frac{1}{2}\left(1+\delta^{\alpha}\right)$, such that $\frac{\partial\Theta}{\partial\xi} > 0$ if $\xi > \xi^*$ Otherwise $\frac{\partial\Theta}{\partial\xi} < 0$.

Where $\xi^* = C^{-1}\left[\frac{w^S\left(\frac{1}{2}\left(1+\delta^{\alpha}\right)-\alpha(1-z)\delta^{\alpha}\right)}{\left(1-\delta^{\alpha}\right)\left(1-\alpha+z\alpha\right)}\right]$

The above inequality implies that if VFDI occurs at $\xi > \xi^*$, then, a further increase in ξ increases the relative profitability from IO and hence the probability that IO would be chosen over VFDI.

Thus, we make the following two propositions:

Proposition 5a: *At high human capital gap, the profitability of international outsourcing increases if the human capital gap increases.*

Proposition 5b: *At low human capital gap, the profitability of VFDI increases if the human capital gap increases*

Determination of the Threshold Human Capital Gap

We now determine the critical human capital gap, $\bar{\xi}_{f,o}$, such that the sourcing firm is indifferent between VFDI and IO, that is, $\Theta = 1$. Once we have this cutoff, we then determine the range of human capital gap such that one mode is preferred over the other. Finally, we compare our model's results with the Antràs (2005) model by relating the organizational choice pattern with the characteristic of the final good.

Consider the case where $\frac{\partial \Theta}{\partial \xi} > 0$, implying that the slope of $L_2(\xi, \bar{\phi}, z, \alpha)$ is higher than the slope of $L_1(\xi, \phi, z, \alpha)$. In such a situation, we have two cases:

Case a: $L_2(\xi, \bar{\phi}, z, \alpha)$ curve cuts the $L_1(\xi, \phi, z, \alpha)$ curve from below, as depicted in figure 3a.

Case b: $L_2(\xi, \bar{\phi}, z, \alpha)$ curve lies above the $L_1(\xi, \phi, z, \alpha)$ and the two curves do not intersect at all. This case is depicted in figure 3b.

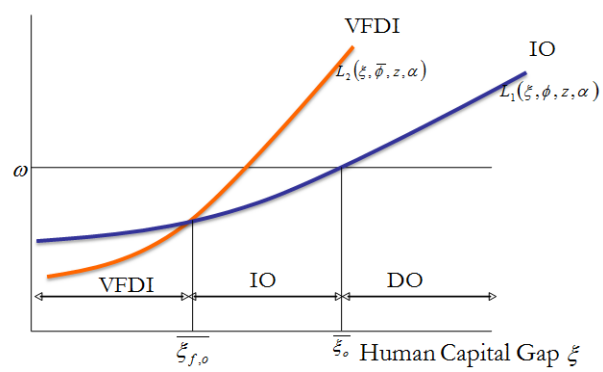

Figure 3a: Tradeoff between IO and VFDI

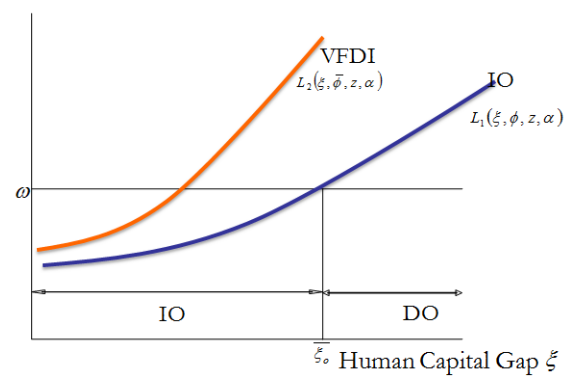

Figure 3b: Tradeoff between IO and VFDI

In a diametrically opposite situation where $\frac{\partial \Theta}{\partial \xi} < 0$, implying that the slope of $L_1(\xi, \phi, z, \alpha)$ is higher than the slope of $L_2(\xi, \bar{\phi}, z, \alpha)$, there are two possible cases:

Case a: $L_1(\xi,\phi,z,\alpha)$ curve cuts the $L_2(\xi,\bar{\phi},z,\alpha)$ curve from below, as depicted in figure 4a.

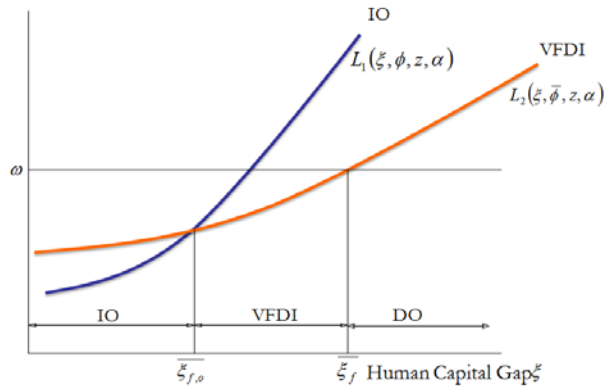

Figure 4a: Tradeoff between IO and VFDI

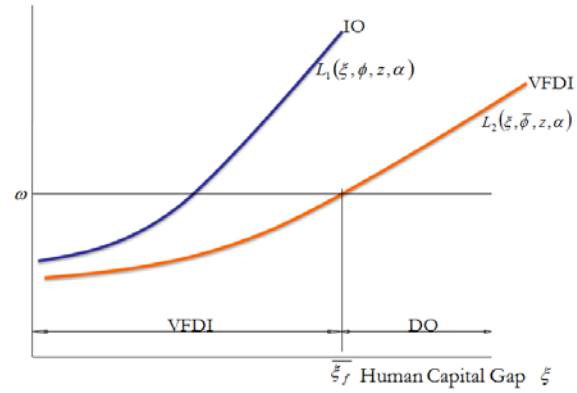

Figure 4b: Tradeoff between IO and VFDI

At high human capital gap, the profitability from IO is higher (proposition 5a and 5b), such that the configuration in figure 4a, where VFDI follows IO at high ξ, would be impossible .

Case b: $L_1(\xi,\phi,z,\alpha)$ curve lies above the $L_2(\xi,\bar{\phi},z,\alpha)$ and the two curves do not intersect at all. This case is depicted in figure 4b.

Our task now is to typify the characteristics of the good (in terms of z) that displays organizational forms depicted in figures 3a, 3b and 4b. To develop an intuition for the organizational regimes across varying levels of human capital gap for a low-tech (high-tech), we consider the RSI in the low-tech (high-tech) inputs in the VFDI mode vis-à-vis the IO mode. The first order conditions for maximizing the sourcing firm's and the supplier's profit gives the following relationship between x_h and x_l in the IO mode:

$$x_h^o = \left(\frac{\phi}{1-\phi}\right)\left(\frac{1-z}{z}\right)\left(\frac{w^s + C(\xi)}{w^N}\right) x_l^o \tag{12a}$$

Where x_l^o and x_h^o represent the RSI in the low-tech and high-tech inputs respectively in the IO mode.

Solving the model using equations (1), (2) and (12a) yields the following expression for x_l^o:

$$x_l^o = \lambda\, \phi^{\frac{\alpha(1-z)}{1-\alpha}} (1-\phi)^{1+\frac{\alpha z}{1-\alpha}}\, z\, \alpha^{\frac{1}{1-\alpha}} \left(w^N\right)^{-\frac{\alpha(1-z)}{1-\alpha}} \left(w^s + C(\xi)\right)^{-\left(1+\frac{\alpha z}{1-\alpha}\right)} \tag{13a}$$

Since $C(\xi)$ is increasing and convex in ξ, (13a) implies that x_l^o is decreasing and concave in ξ.

Similarly, profit maximization by the two agents in the VFDI mode gives the following relationship between x_h and x_l:

$$x_h^f = \left(\frac{\bar{\phi}}{1-\bar{\phi}}\right)\left(\frac{1-z}{z}\right)\left(\frac{w^S}{w^N}\right) x_l^f \tag{12b}$$

Where x_l^f and x_h^f is the RSI in the low-tech and high-tech inputs respectively in an intra-firm relationship.

Solving the model using equations (1), (2) and (12b) yields the following expression for x_l^f:

$$x_l^f = \lambda\, \bar{\phi}^{-\frac{\alpha(1-z)}{1-\alpha}} \left(1-\bar{\phi}\right)^{1+\frac{\alpha z}{1-\alpha}} z\, \alpha^{\frac{1}{1-\alpha}} \left(w^N\right)^{-\frac{\alpha(1-z)}{1-\alpha}} \left(w^S\right)^{-\left(1+\frac{\alpha z}{1-\alpha}\right)} \tag{13b}$$

Notice that the RSI in the low-tech input in the VFDI mode is independent of ξ.

From (13a), (13b) and using $\phi = ½$, we have, in equilibrium:

$$\frac{x_l^f}{x_l^o} = \left(1+\delta^\alpha\right)^{\frac{\alpha(1-z)}{1-\alpha}} \left(1-\delta^\alpha\right)^{1+\frac{\alpha z}{1-\alpha}} \left(\frac{w^S}{w^S + C(\xi)}\right)^{-\left(1+\frac{\alpha z}{1-\alpha}\right)}$$

Partially differentiating the above expression with respect to ξ we get: $\dfrac{\partial\left(x_l^f / x_l^o\right)}{\partial \xi} > 0$

Since RSI in the low-tech input in the IO mode falls with a rise in ξ, while it does not change in the VFDI mode, the relative RSI in the low-tech input must fall in the IO mode as human capital gap increases.

Is it possible for $x_l^o > x_l^f$? Yes, if (necessary but not sufficient condition):

$$\left(1+\delta^\alpha\right)^{\frac{\alpha(1-z)}{1-\alpha}} \left(1-\delta^\alpha\right)^{1+\frac{\alpha z}{1-\alpha}} < 1 \tag{14a}$$

Condition (14a) is more likely satisfied for higher values of z, that is, a low tech good. Thus, for a low-tech good, a sourcing firm is likely to prefer contracting to an unaffiliated supplier vis-à-vis an affiliated one.

To check the likelihood of condition (14a) being met, we plot the function $\left(1+\delta^\alpha\right)^{\frac{\alpha(1-z)}{1-\alpha}} \left(1-\delta^\alpha\right)^{1+\frac{\alpha z}{1-\alpha}}$ in MATLAB for $\delta = 0.4$ and $\delta = 0.8$ and $\alpha = 0.67$ against z (figure 5), and find a monotonically negative relationship. Moreover, the relative RSI in the VFDI mode is depressed as δ rises because a high δ decreases a supplier's bargaining. We see that even for a modest $\delta = 0.4$, $\left(1+\delta^\alpha\right)^{\frac{\alpha(1-z)}{1-\alpha}} \left(1-\delta^\alpha\right)^{1+\frac{\alpha z}{1-\alpha}} < 1$ for all z.

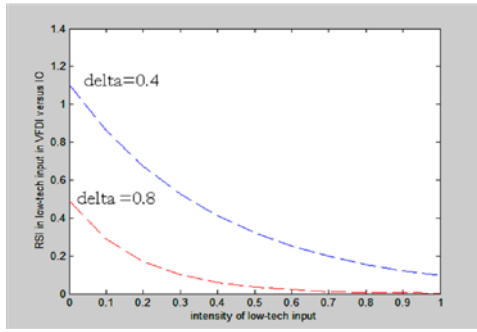

Figure 5: The behavior of RSI in the low-tech input and intensity of low-tech input

In figure 6, we graph the RSI in the low tech input in the two modes, in cases where δ and z are both high such that such that IO is preferred. Thus, the configuration in figure 3b is representative of a low-tech good. This result is essentially the same as in the Antràs (2005) model.

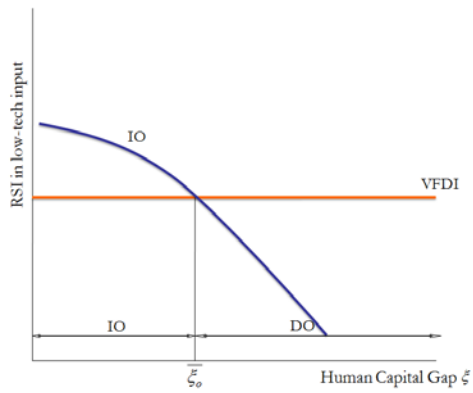

Figure 6: Optimal Organizational form when δ and z are high

Proposition 6: *For a low-tech good, a sourcing firm is more likely to choose an unaffiliated supplier for offshore production. At higher levels of human capital gap between the home and the host country, it prefers Domestic Outsourcing.*

To derive the optimal organizational form for a high tech good, we consider the relative RSI in the high-tech inputs in the two modes. Using equations (12a), (12b), (13a) and (13b) we get:

$$\frac{x_h^f}{x_h^o} = \left(1+\delta^\alpha\right)^{\frac{\alpha(1-z)}{1-\alpha}+1}\left(1-\delta^\alpha\right)^{\frac{\alpha z}{1-\alpha}}\left(\frac{w^S}{w^S+C(\xi)}\right)^{-\left(1+\frac{\alpha z}{1-\alpha}\right)}$$

Partially differentiating the above expression with respect to ξ we get: $\frac{\partial\left(x_h^f / x_h^o\right)}{\partial\xi} > 0$

For $x_h^o > x_h^f$, we need that (necessary but not sufficient condition):

$$\left(1+\delta^{\alpha}\right)^{\frac{\alpha(1-z)}{1-\alpha}+1}\left(1-\delta^{\alpha}\right)^{\frac{\alpha z}{1-\alpha}} < 1 \tag{14b}$$

This is a much stronger condition vis-à-vis condition (14a). This condition is also more likely satisfied for a high z, that is, for a low-tech good. For a high tech good, condition (14b) is not likely satisfied such that $x_h^o < x_h^f$ is always true for a high-tech good. We plot this function, using MATLAB, in figure 7. Notice that in figure 7, condition (14b) is satisfied for $\delta = 0.4$ only for $z > 0.6$, that is, for a low-tech good. Thus, for a high-tech good, a sourcing firm prefers VFDI for low human capital gap while it prefers IO or DO otherwise (the latter choice depends on the extent of this gap and wages in the two countries).

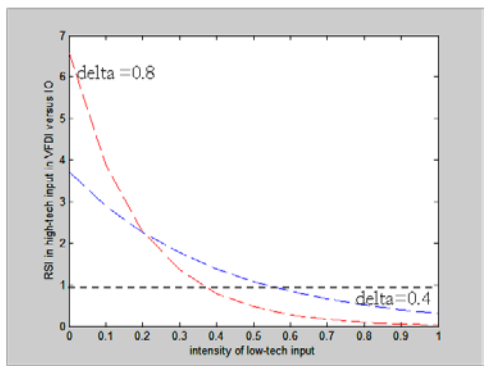

Figure 7: The behavior of RSI in the high-tech input and intensity of low-tech input

In figure 8a we graph the RSI in the high-tech input in the two modes, such that $\left(1+\delta^{\alpha}\right)^{\frac{\alpha(1-z)}{1-\alpha}+1}\left(1-\delta^{\alpha}\right)^{\frac{\alpha z}{1-\alpha}} > 1$.

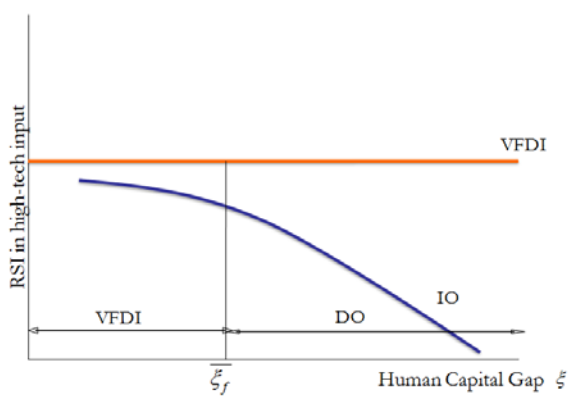

Figure 8a: Relative RSI in the low-tech input when z is low

Thus the configuration in figure 4b is more likely observed for a high-tech good. We now augment our discussion by introducing the effect of the burden of training cost on the internalization decision of a sourcing firm. At high human capital gap, the burden of training cost on the sourcing firm may overwhelm the gain due to higher RSI in high-tech input. Therefore, at a high level of ξ, a sourcing firm may prefer IO (proposition 5a). We depict this case in figure 8b. Thus, a high-tech good is may also display organizational form depicted in figure 3a.

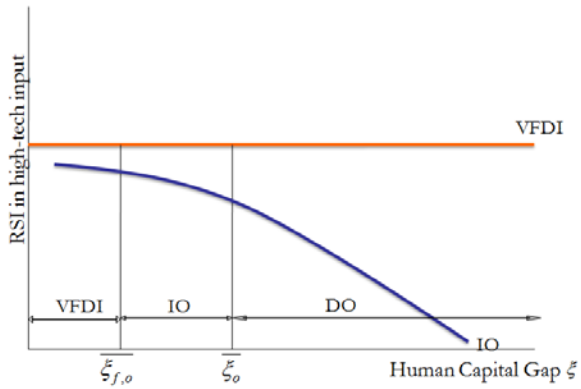

Figure 8b: Relative RSI in the low-tech input when z is low but training cost dominates

Proposition 7: *For a high-tech good, a sourcing firm prefers to offshore production to an affiliated supplier, however, it may outsource internationally at high human capital gap.*

The result indicates a clear space for policy on reducing the human capital gap between the home and the host. The large human capital gap between the home and the host particularly explains the absence of international outsourcing to many low-wage countries. Both the host country and the sourcing firms stand to lose with no offshoring vis-à-vis offshoring. Therefore, it makes sense for the host country government as well as the sourcing firm to invest in host country human capital development that reduces this gap and encourages more offshoring.

Section 5: Conclusion

This paper builds on the framework provided by Antràs (2005) to determine the organizational mode for offshoring in the presence of human capital gap between the home and the host country. Acknowledging the importance of contractual differences between VFDI and outsourcing, we additionally propose that in case of VFDI, a significant proportion of the training cost is borne by the sourcing firm. Per contra, in an international outsourcing relationship, the cost of training the host country worker is undertaken by the supplier. We find that a sourcing firm prefers to offshore production internationally only if the human capital gap between the home and the host country is below a certain threshold. At low levels of absorptive capacity of the host country, there would be no offshoring. As this human capital gap increases, international outsourcing is preferred at higher levels of human capital gap. Finally, our model refines the results of the Antràs (2005) model and shows the possibility of internationally outsourcing the input of a high-tech good when the human capital gap is high. Our model also explains the reason we do not observe offshoring to many developing countries despite their low wages. A high human capital gap between the home and the host immensely increases the training cost because learning ability is contingent on this gap. In such cases, firms prefer to produce domestically, or seek alternative host locations with lower human capital gap.

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