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Ownership Structure and Technological Upgrading in International Joint Ventures*

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Abstract

In a model of a joint venture between a local and a foreign firm who provide complementary inputs, this paper derives optimal ownership structures under different sharing rules. The local firm's profits may be maximized by assigning a majority share to the foreign firm. Efficiency (i.e. the minimization of double moral hazard) requires that the firm with the more productive input should get majority ownership. When only the foreign firm can upgrade its input, it should receive a larger share than what it receives in the absence of upgrading. The analysis implies that a blanket policy of prohibiting majority foreign ownership is theoretically unfounded.

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1. Introduction

International joint ventures have always been of concern to policy-makers in developing countries and the degree of foreign ownership of such enterprises has frequently been controversial. A typical policy in many developing countries has been to restrict the degree of foreign ownership of joint ventures. For example, upon its entry to the World Trade Organization (WTO), China recently agreed to raise the limit on foreign ownership of joint ventures in the telecommunications industry to 49%. Similarly, the maximum foreign ownership permitted in the insurance and automobile industries in China is 50%. Such limits on foreign ownership are in place in several other developing and transition economies (particularly in the services sector) even though they contradict the 'no limitations' principle of the WTO which advocates that the market should determine the equity division of joint ventures.[1]

How should ownership be shared between joint venture partners? What is the effect of prohibiting majority foreign ownership of joint ventures on local welfare? How should one design the ownership structure of a joint venture to take into account static *and* dynamic factors? It is these questions our paper attempts to answer. In our model, a local firm and a foreign firm with complementary strengths form a joint venture wherein each provides one of the two inputs necessary for production. While firms bear the full cost of providing their respective inputs, the revenue generated by joint production is shared between them.

The two firms are confronted with a fundamental dilemma regarding revenue sharing. On the one hand, each firm wants to obtain as large a share of total revenue as possible. On the other hand, it has an incentive to give its partner a large share of total revenue in order to induce the partner to internalize more fully the value of its contribution to the joint venture. This point is not lost on joint venture partners in the real world. For example, the Managing Director of

British Oxygen Company (China) once said, in appraisal of the Chinese partners, "...they were really looking for making profit together, not out of each other," (see *China Joint Venturer*, 1995). Of course, a larger share for one partner necessarily implies a smaller share for the other. Thus, a sensible ownership structure must minimize double moral hazard and balance the incentives for input provision of the two firms.

To shed light on some important dynamic aspects of a joint venture, we examine the two-way relationship between ownership structure and technological upgrading within the joint venture. First, we ask how a firm's incentive to upgrade depends upon the ownership structure of the joint venture. Second, we investigate whether the presence of one-sided upgrading (i.e. upgrading by only the foreign firm) requires an alteration of the ownership structure of a joint venture. Our motivation for investigating these questions is simple: the foreign firm may be able to upgrade the technology it initially provides, whereas the local firm may be able to expand its network of connections (*guanxi*) or invest in reducing red-tape and bureaucratic hurdles.

In our basic model, we abstract from technological upgrading and focus on input provision. In order to parameterize the value of each partner's contribution to the joint venture, we use a Cobb-Douglas production function. We examine three different sharing arrangements: the local firm's most preferred sharing rule, the foreign firm's most preferred rule, and the sharing rule that maximizes the joint venture's total profits. It is shown that the optimal ownership structure under all three sharing rules depends solely on the relative importance (or productivity) of the two inputs. In particular, under the sharing arrangement that maximizes the local firm's profit, the local firm's share is negatively related to the productivity of the foreign firm. Furthermore, the foreign firm is given a *majority* share of the joint venture if its input is significantly more valuable than that of the local firm. This result implies that insisting on majority share of the joint venture by the local firm (or government) may sometimes harm the local firm. Of course, exactly the opposite results hold for the share arrangement that maximizes the foreign firm's profits. In particular, it may not be in the interest of the foreign firm to insist on too large a share, particularly if the local partner's contribution is important. It is noteworthy that an IEU-Anderson Consulting study of seventy foreign investment enterprises in China found that the average equity share of foreign firms in profitable joint ventures was a moderate 54% compared to 71% in non-profitable ones. This report comments that "foreign firms sometimes make the mistake of pushing too hard to gain voting and management control. The challenge facing joint ventures is to ensure that ... both partners are contributing resources and expertise," (see Child, 1998).

Our results also show that to maximize total profits of the joint venture, a firm should get a majority share of the joint venture if and only if it is more productive than its partner. Moreover, a firm's optimal share declines continuously with its partner's productivity. This corresponds well to the WTO's "no-limitation principle". As the relative importance of the two inputs is likely to vary from case to case, setting caps on foreign ownership a priori may hamper the foreign partner's incentive for input provision, thereby marring the joint venture's performance.

In the second part of the paper, we extend our basic model by examining scenarios where the foreign firm can upgrade its effective input to the joint venture. In this situation, a change in the foreign firm's share has both a direct effect and an indirect effect on the profit of the local firm. The direct effect is simply that increasing the foreign firm's share reduces the local firm's share of total revenue. The indirect effect arises because an increase in the foreign firm's share strengthens its incentive for upgrading thereby increasing the total revenue of the joint venture.[2] We show that it is in the interest of the local firm to give the foreign firm a larger share than the share the latter gets in the absence of upgrading. Doing so induces the foreign firm to invest more in upgrading, which raises the productivity of the joint venture thereby also benefitting the local firm. An illustration of this result is found in Pepsi's experience in China. In the joint ventures formed between Pepsi and Chinese firms, initially Pepsi's equity share was between 17% to 30%. Later, to encourage Pepsi to inject more capital and to buy new equipment for manufacturing and distribution, the Chinese partners agreed to increase Pepsi's share to 60% (*China Joint Venturer*, October, 1996, p.17). A similar result is also obtained regarding the share arrangement that maximizes total profits of the joint venture.

In the last part of the paper, we examine the case when both firms can upgrade their inputs. In this case, a modified version of our original (static) result resurfaces: to maximize total profits, the firm whose input is more productive should get a share larger than the one it receives when neither firm can upgrade. One implication of this result is that foreign partners should be given greater shares in industries (such as telecommunications) where they are more likely to improve their technologies relative to local firms. Alternatively, if the local firm's contribution is primarily in the form of lowering red-tape and bureaucracy and the local economy undergoes significant economic liberalization, the ownership share of the local firm will need to be lowered in order to account for the reduced importance of its contribution.[3]

The major driving force behind most of our results is the assumption that the two partners provide complementary inputs to the joint venture. This assumption has strong empirical support. For example, in a recent survey of seventy six joint ventures in six developing countries, more than 65% of the foreign respondents rated knowledge of local politics, government regulations, local customs, and local markets as important considerations for seeking local partners (see Miller et. al.

1997). Similarly, more than 70% of the local firms in developing countries sought joint ventures with multinationals because of their superior product and process technologies as well as international reputation. Luo (1997) reports that *guanxi* by Chinese firms were an important factor leading to joint ventures between Chinese firms and foreign firms.[4]

The relationship between ownership structure and performance has received growing attention in the theoretical literature on joint ventures. For example, Lee and Shy (1992) study the effect of limiting the foreign partner's equity share on the quality of the technology contributed to the joint venture.[5] Al-Saadon and Das (1996) also analyze equity division within a joint venture but they focus on host country tax policies and transfer pricing of the foreign partner's input. They show that it may be in the interest of both firms to give the local firm a larger share since it results in a lower tax rate for the enterprise, thereby increasing total profits. Since Al-Saadon and Das (1996) focus mostly on external factors, they assume that the joint venture's total profit does not depend on the structure of its ownership. Our paper complements the work of Al-Saadon and Das (1996) in that we focus on internal factors such as the relative importance of inputs and technological upgrading within the joint venture. A major difference between our paper and existing literature is that we explicitly model the complementarity between inputs and emphasize the incentive problems inherent to the decision making of partners, with respect to both input choice and technological upgrading.[6]

An important factor affecting the ownership structure of a joint venture that we abstract from is the level of profit each firm would earn if they failed to form a joint venture (i.e. each firm's outside option). For example, if the foreign firm's outside option is relatively attractive, then it may refuse to participate in a joint venture unless it is given a share close to its most preferred one. Dinopoulos and Syropoulos (1998) analyze technology licensing as a contest between two technologically asymmetric firms and show that ex post both firms benefit from a technology licensing agreement only if the technological distance between them is sufficiently small.[7] Our focus is different: Rather than analyzing a bargaining process that determines whether firms agree to form a joint venture, we analyze the most preferred sharing arrangements of the two parties assuming that a joint venture has already been formed. Alternatively, in our model, one can interpret the outside option of each firm as being zero: The complementarity of their inputs is so strong that neither firm can produce on its own.

2. Basic model

Consider two firms: firm 1 (local firm) and firm 2 (foreign firm) who form a joint venture to produce good z that requires inputs x_1 and x_2. The local firm is more efficient at supplying input x_1 and the foreign firm at input x_2. Furthermore, assume that these efficiency differences are large enough that it is optimal for each firm to supply only the input in which it has an efficiency advantage. The production function for the joint venture is given by:

$$z(x_1,\, x_2) = Ax_1^{\alpha_1}x_2^{\alpha_2}, \quad A > 0,\ \alpha_1 + \alpha_2 < 1. \tag{1}$$

Parameters α_1 and α_2 in the production function measure the importance of the two inputs, respectively, to the joint venture. Let the cost (disutility) functions of the two inputs x_1 and x_2 be given by $C_1(x_1) = x_1^{k_1}/k_1$ and $C_2(x_2) = x_2^{k_2}/k_2$, $k_i \geq 1$ where $i = 1, 2$. The revenue generated by the joint venture is shared by the firms where s denote the local firm's share.

Firms choose their input efforts non-cooperatively to maximize their individual profits.[8] In particular, the local firm chooses x_1 to maximize

$$\underset{x_1}{Max}\ \ sAx_1^{\alpha_1}x_2^{\alpha_2} - x_1^{k_1}/k_1$$

The first order condition for the above problem is

$$\alpha_1 sAx_1^{\alpha_1}x_2^{\alpha_2} = x_1^{k_1}.$$

Similarly, the foreign firm chooses x_2 to maximize

$$\underset{x_2}{Max}\ (1-s)Ax_1^{\alpha_1}x_2^{\alpha_2} - x_2^{k_2}/k_2$$

The first order condition for the above problem is given by

$$\alpha_2(1-s)Ax_1^{\alpha_1}x_2^{\alpha_2} = x_2^{k_2}.$$

Substituting the above first order conditions back into the production function in equation (1) yields the joint venture's total revenue (price is normalized to one):

$$z^J(s) = A^{\frac{1}{1-\beta_1-\beta_2}} (\alpha_1 s)^{\frac{\beta_1}{1-\beta_1-\beta_2}} (\alpha_2(1-s))^{\frac{\beta_2}{1-\beta_1-\beta_2}}, \text{ where } \beta_i \equiv \frac{\alpha_i}{k_i}. \qquad (2)$$

By definition, parameter β_i is the ratio of the importance of the input supplied by firm i (α_i) to the cost parameter (k_i) of providing that input. Thus, it can be viewed as a measure of firm i's *productivity.*

Using the above first order conditions, we can calculate each firm's profits

$$\pi_1(s) = s(1-\beta_1)z^J(s) \quad \text{and} \quad \pi_2(s) = (1-s)(1-\beta_2)z^J(s), \qquad (3)$$

and the total profits of the joint venture

$$\pi(s) = \pi_1(s) + \pi_2(s) \qquad (4)$$

Double moral hazard in input provision

As is well understood, since firms choose their inputs non-cooperatively, the joint venture suffers from double moral hazard (DMH): for a given sharing arrangement $(s, 1-s)$, each firm ignores the positive impact of its input choice on the other. As a result, the equilibrium level of effort of each firm is below what is jointly optimal. Clearly, the degree of DMH depends on the ownership structure of the joint venture. We next derive three different ownership patterns: the one most preferred by the local firm, the one most preferred by the foreign firm, and the one that minimizes the degree of DMH (i.e. the *efficient* sharing arrangement or ownership structure).

3. Ownership patterns and input provision

The ownership share s that is most preferred by the local firm is the solution to

$$\underset{s}{Max}\ \pi_1(s) \tag{5}$$

Note that the above solution will coincide with the local government's choice if it can dictate the ownership structure of the joint venture and it is concerned only with the profits of the local firm. Alternatively, this solution will prevail if the local firm has all the bargaining power and can determine the ownership structure of the joint venture.

The foreign firm's most preferred ownership structure is obtained by solving the following problem:

$$\underset{s}{Max}\ \pi_2(s) \tag{6}$$

Finally, if firms choose shares to maximize joint profits, then s is the solution to:

$$\underset{s}{Max}\ \pi_1(s) + \pi_2(s) \tag{7}$$

The solution to this joint-profit maximization problem minimizes the degree of DMH and is thus the second-best solution from the viewpoint of economic efficiency.[9]

For convenience, the maximization problems specified in equations (5) through (7) can be subsumed into the following problem:

$$\underset{s}{Max}\ \sigma\pi_1(s) + (1-\sigma)\pi_2(s) \tag{8}$$

where $\sigma \in [0, 1]$ and the above objective function can be thought of as the weighted profits of the joint venture. Let $s^*(\sigma)$ denote the optimal solution to the above problem. The most preferred share structure of the local firm, the foreign firm, and the one that minimizes the degree of double moral hazard are thus $s^*(1)$, $s^*(0)$, and $s^*(1/2)$. We can show the following:

Proposition 1: *Given that the joint venture has the Cobb-Douglas production function given in equation (1), the following hold:*

(i) $s^*(0) = \beta_1$ *and* $s^*(1) = 1 - \beta_2$*; and*

(ii) $s^*(0) < s^*(1/2) < s^*(1)$ *and* $s^*(1/2) = \frac{1}{1+\sqrt{\frac{(1-\beta_1)\beta_2}{(1-\beta_2)\beta_1}}}$ *(so that* $s^* > 50\%$ *if and only if* $\beta_1 > \beta_2$*).*

While the quantitative features of the above proposition clearly depend on the Cobb-Douglas specification of our model, the qualitative aspects of the proposition do reveal some general insights regarding joint venture share determination, particularly from the local firm's perspective. Part (i) of the proposition tells us that the firm that gets to choose the share structure of the joint venture will give its partner a share equal to its productivity parameter (β_j) and keep the rest $(1-\beta_j)$ itself. This result has two immediate implications. First, since $\beta_2+\beta_2 < 1$, the local firm's most preferred share, $s^*(1)$, is greater than what it would receive if the foreign firm gets to choose the share scheme, $s^*(0)$. Although expected, this result highlights the basic conflict of interest between the two partners regarding ownership shares. It also indicates that local government's insistence on a larger share for the local firm, relative to what the foreign firm would concede, has some economic ground and may not be purely motivated by political considerations. Second, and more importantly, even when one party has full bargaining power, there exists a upper limit on its share of the joint venture revenue, and this upper limit is determined by the other party's productivity parameter β_j. This implies that a firm should not insist on getting a *majority* share of the joint venture under all circumstances. For example, since $s^*(1) = 1 - \beta_2$, if the productivity of the foreign firm is significantly larger than that of the local firm, $\beta_2 > 0.5 > \beta_1$, then giving the foreign firm a majority share may be in the best interest of the local firm (of course the foreign firm may prefer something even higher).[10]

The intuition for the above results is simple: An increase in s has two effects on the local firm's profit. The direct effect is that increasing s enables the local firm to receive a larger fraction of the total revenue, whereas the indirect effect is that such a change hampers the foreign firm's incentive for input provision, thereby lowering total revenue. If the foreign firm is more productive than the local firm ($\beta_2 > 0.5$), the indirect effect is so strong that the foreign firm should be granted a majority share in order to maximize *local* welfare. It also follows that in countries where the local firm's expertise, say in working with local customers or/and in dealing with local bureaucrats, is crucial to the operation of the joint venture (β_1 is large), it may be in the interest of the foreign firm to give the local firm a majority share.

Part (*ii*) of proposition 1 concerns the efficient sharing arrangement (i.e. the one that minimizes the degree of DMH). First, the local firm's share under the efficient arrangement is bounded by its share under the two individually preferred arrangements. This result reflects the fact that efficiency is achieved by balancing the input provision incentives of the two firms. Moreover, the efficient arrangement depends on the productivity of both firms, where the local firm's share $s^*(1/2)$ increases with its productivity (β_1) and decreases with that of the foreign firm (β_2). Most importantly, the local firm gets a majority share of the joint venture if and only if it is more productive than the foreign firm. This result shows that if partners seek to achieve an efficient outcome then their productivity should determine the share division between them. Finally, part (*ii*) also corresponds well to the 'no-limitation principle' of the WTO regarding foreign ownership of joint ventures. In particular, the foreign partner's share, $1 - s^*(1/2)$, can take any value between zero (if $\beta_2 = 0$) and 1 (if $\beta_1 = 0$). In other words, there should be *no a priori limitation* on the ownership structure of the joint venture.

We next examine the case where the foreign firm can improve its efficiency of providing input x_2 during the operation of the joint venture. We are interested in studying how the ownership structure under different sharing arrangements needs to be altered to account for the foreign firm's incentive for upgrading, as well as to encourage input provision at the production stage of the joint venture.

4. One-sided upgrading

Suppose that prior to the stage where firms provide their inputs to the joint venture, the foreign firm can upgrade input x_2 through a costly investment. The production function for the joint venture, post upgrading by the foreign firm, is given by

$$z(x_1,\ x_2;\Gamma) = Ax_1^{\alpha_1}\left(\Gamma x_2\right)^{\alpha_2}, \text{ where } \Gamma > 1.$$

In other words, relative to the case where the effectiveness of input x_2 was normalized to 1, upgrading increases its effectiveness to $\Gamma > 1$.[11] Let the cost of upgrading input x_2 to level Γ be given by $F(\Gamma)$, $F' > 0$, $F'' \geq 0$. Clearly, the foreign firm's incentive for upgrading depends on its share of the joint venture, $1 - s$. Next, we derive the equilibrium extent of upgrading by the foreign firm for a given s, and then examine how the local firm's most preferred share and the efficient arrangement change in the presence of upgrading.

Upgrading decision

Since upgrading changes the production function of the joint venture, input choices and firm profits also change. Let $\pi_i(s,\Gamma)$ denote the firm i's (reduced form) profit post upgrading. The expression for $\pi_i(s,\Gamma)$ can be easily recovered from equations (2) and (3). In particular,

$$\pi_1(s,\Gamma) = s(1-\beta_1)z^U(s,\Gamma) \quad \text{and} \quad \pi_2(s,\Gamma) = (1-s)(1-\beta_2)z^U(s,\Gamma)$$

where

$$z^U(s,\Gamma) = A^{\frac{1}{1-\beta_1-\beta_2}}\left(\alpha_1 s\right)^{\frac{\beta_1}{1-\beta_1-\beta_2}}\left[\alpha_2(1-s)\right]^{\frac{\beta_2}{1-\beta_1-\beta_2}}\left(\Gamma\right)^{\frac{\alpha_2}{1-\beta_1-\beta_2}}.$$

Note that since $z^U(s,\Gamma) = \Gamma^{\frac{\alpha_2}{1-\beta_1-\beta_2}} \cdot z^U(s,1) = \Gamma^{\frac{\alpha_2}{1-\beta_1-\beta_2}} \cdot z^J(s)$, we have

$$\pi_i(s,\Gamma) = \Gamma^{\frac{\alpha_2}{1-\beta_1-\beta_2}} \cdot \pi_i(s,1), \quad i = 1,2. \tag{9}$$

While upgrading, the foreign firm's chooses Γ to maximize

$$\underset{\Gamma}{Max} \ \ \pi_2(s,\Gamma) - F(\Gamma),$$

yielding the first order condition $\frac{\partial \pi_2(s,\Gamma)}{\partial \Gamma} = F'(\Gamma)$ that defines the extent of optimal upgrading $\Gamma(s)$ as a function of s. Differentiating the first order condition with respect to s, we get

$$\frac{d\Gamma}{ds} = \frac{\frac{\partial^2 \pi_2}{\partial \Gamma \partial s}}{F'' - \frac{\partial^2 \pi_2}{\partial \Gamma^2}}.$$

The denominator of the fraction on the right hand side of the above equation is positive by the second order condition of the maximization problem.[12] It is easy to show that

$$\frac{\partial^2 \pi_2}{\partial \Gamma \partial s} = \frac{\alpha_2 \Gamma^{-1}}{1-\beta_1-\beta_2} \frac{\partial \pi_2(s,\Gamma)}{\partial s}.$$

Thus, $\frac{d\Gamma}{ds}$ has the same sign as $\frac{\partial \pi_2(s,\Gamma)}{\partial s}$: the optimal amount of upgrading by the foreign firm varies with s in the same way as does its profit (for given Γ). From equation (9), we know that $\frac{\partial \pi_2(s,\Gamma)}{\partial s}$ has the same sign as $\frac{\partial \pi_2(s,1)}{\partial s}$. Given that $s^*(0)$ is the maximizer of $\pi_2(s,1)$, we thus have the following:[13]

Lemma 1: *The optimal level of upgrading by the foreign firm $\Gamma(s)$ increases with s if $s < s^*(0)$, reaches the maximum at $s = s^*(0)$, and then decreases afterwards.*

The intuition for this result is as follows. For s smaller than $s^*(0)$, an increase in s induces the local firm to provide more input to the joint venture and thus increases the foreign firm's profit, π_2. This makes upgrading more attractive to the foreign firm. However, if s exceeds $s^*(0)$, then giving an even larger share to the local firm hurts the foreign firm profit π_2, thereby weakening its incentive for upgrading.

Let $s^U(\sigma)$ denote the solution to the following maximization problem:

$$s^U(\sigma) \equiv Arg\max \ \sigma \cdot \pi_1 \left(s, \Gamma(s)\right) + (1-\sigma) \cdot \left[\pi_2 \left(s, \Gamma(s)\right) - F\left(\Gamma(s)\right)\right]. \qquad (10)$$

The problem specified in (10) is analogous to the problem specified in (8) except that now we need to take into account the costs and benefits of upgrading by the foreign firm.

The local firm's most preferred share under upgrading

Given the upgrading function of the foreign firm, $\Gamma(s)$, the sharing rule that is most preferred by the local firm, $s^U(1)$, is the solution to

$$\max \ \pi_1 \left(s, \Gamma(s)\right)$$

where $\pi_1 \left(s, \Gamma(s)\right)$ is specified in (0.1). The first order condition is

$$\frac{\partial \pi_1(s, \Gamma(s))}{\partial s} + \frac{\partial \pi_1(s, \Gamma(s))}{\partial \Gamma} \frac{d\Gamma}{ds} = 0. \qquad (11)$$

The first term of the above equation is the direct effect of a change in s on the local firm's profit. The second term represents the indirect effect which says that a change in s influences the upgrading decision of the foreign firm which in turn affects the local firm's profit via its effect on productivity of the joint venture. Note that $\frac{\partial \pi_1(s,\Gamma)}{\partial \Gamma} > 0$, i.e., given a fixed share s, upgrading by the foreign firm benefits the local firm.

>From (9) and the definition of $s^*(1)$, for any $s \geq s^*(1)$, the direct effect is negative or zero, whereas $\frac{d\Gamma}{ds}$ is negative (by Lemma 1 and because $s^*(1) > s^*(0)$). As a result, the above first order condition cannot hold for $s \geq s^*(1)$. We can thus conclude that $s^U(1) < s^*(1)$. That is, the local firm should give the foreign firm a share larger than the one it receives in the absence of upgrading. A small decrease in s from $s^*(1)$ lowers the local firm's profit for a given Γ, but it induces the foreign firm to invest more in upgrading. As a result, the local firm is better

off by reducing its share below $s^*(1)$ when the foreign firm can upgrade. By the definition of $s^U(1)$, under upgrading, the local firm receives greater profit at $s^U(1)$ than at $s^*(1)$.

The efficient sharing arrangement under one-sided upgrading

The efficient sharing arrangement in the presence of one-sided upgrading is the solution $s^U(\sigma)$ when $\sigma = 1/2$. One can similarly show that $s^U(1/2)$ is smaller than the share the local firm receives in the absence of upgrading. The intuition is exactly the same as in the case above. We summarize the above results, and the case $\sigma = 0$, in the following proposition.

Proposition 2: *(i) For both $\sigma = 1/2$ and $\sigma = 1$, $s^*(0) < s^U(\sigma) < s^*(\sigma)$. That is, the local firm's receives a smaller share under one-sided upgrading than under no upgrading, but its share is still greater than the one it receives when the foreign firm gets to determine their shares (in the case of no-upgrading).*

(ii) $s^U(0) = s^*(0)$. That is, the foreign firm's most preferred share under one-sided upgrading is the same as that under no upgrading.

Proof: Since $\Gamma(s)$ is chosen optimally by the foreign firm for given s, the Envelope Theorem implies that the first order condition for $s^U(\sigma)$ is

$$\sigma\frac{\partial\pi_1(s,\Gamma)}{\partial s} + (1-\sigma)\frac{\partial\pi_2(s,\Gamma)}{\partial s} = -\sigma\frac{\partial\pi_1(s,\Gamma)}{\partial\Gamma}\frac{d\Gamma}{ds}. \tag{12}$$

Note that $\frac{\partial\pi_1}{\partial\Gamma}$ is always positive. Since $\frac{d\Gamma}{ds}$ has the same sign as $\frac{\partial\pi_2(s,\Gamma)}{\partial s}$ (Lemma 1), it must be that $\frac{\partial(\sigma\cdot\pi_1+(1-\sigma)\cdot\pi_2)}{\partial s}$ and $\frac{\partial\pi_2(s,\Gamma)}{\partial s}$ have opposite signs at the optimum $s^U(\sigma)$. From equation (9) the signs of these partial derivatives when $\Gamma > 1$ are the same as when $\Gamma = 1$ (no upgrading). Since $\pi_2(s,1)$ is maximized at $s = s^*(0)$ and $\sigma\cdot\pi_1(s,1)+(1-\sigma)\cdot\pi_2(s,1)$ at $s = s^*(\sigma)$ (with $s^*(0) < s^*(\sigma)$), both $\frac{\partial(\sigma\cdot\pi_1+(1-\sigma)\cdot\pi_2)}{\partial s}$ and $\frac{\partial\pi_2(s,\Gamma)}{\partial s}$ are positive for $s < s^*(0)$ and both are negative for $s > s^*(\sigma)$. Thus, s^U must fall in the range $(s^*(0),\ s^*(\sigma))$ over which $\frac{\partial\pi_2(s,\Gamma)}{\partial s}$ is negative while $\frac{\partial(\sigma\cdot\pi_1+(1-\sigma)\cdot\pi_2)}{\partial s}$ is positive. This proves the first part of the proposition. At

$\sigma = 0$, equation (12) is satisfied at $\frac{\partial \pi_2(s,\Gamma)}{\partial s} = 0$, which implies that $\frac{\partial \pi_2(s,1)}{\partial s} = 0$. So $s^U(0) = s^*(0)$. ■

Despite the need to give the foreign firm a larger share under upgrading, the share it receives is still smaller than its most preferred share. That is, for both $\sigma = 1/2$ and $\sigma = 1$, it is still the case that $s^U(\sigma) > s^*(0) = \beta_1$. Thus, our results imply that while upgrading creates an argument for granting the foreign firm a larger share, it does *not* justify giving the foreign firm its most preferred one (i.e., $1 - s^*(0)$), or even a majority share, since the local firm's incentive for supplying its input in production would be severely undermined. If $\sigma = 0$, we have $s^U(0) = s^*(0) = \beta_1$: i.e. when the local firm's profits are immaterial, firms receive the same shares as they do in the absence of upgrading. This is because when $\sigma = 0$ the foreign firm already chooses the optimal level of upgrading (given s). Thus, the indirect effect of a change in s is zero for the case of $\sigma = 0$.[14]

Upgrading and double moral hazard

One can measure the degree of DMH by the ratio of the total profit of the joint venture when firms behave non-cooperatively to when they coordinate their decisions. Let this ratio be denoted by $R(s)$ when there is no upgrading and by $R_U(s)$ when there is upgrading. By definition $R(s)$ is maximized at $s = s^*(1/2)$ and $R_U(s)$ at $s = s^U(1/2)$. Since the presence of upgrading requires a change in the sharing arrangement, one may ask how upgrading affects the degree of DMH. In general, the presence of upgrading worsens the potential for DMH because it adds another dimension along which there can be under-provision of effort. Specifically, when firms cannot engage in upgrading, DMH only exists in the provision of inputs of x_i to the joint venture. With upgrading there arises a new source of DMH: the upgrading firm only captures a fraction of the benefit of its investment and thus upgrades to a level that is below the one that maximizes the total profits of the joint venture. While analytical progress is not possible, simulations confirm that $R(s^*(1/2)) > R_U(s^U(1/2))$.

5. Upgrading by both firms

Suppose the local firm can also upgrade its input to the joint venture, say in the form of expanding its local network of connections or consumer base. In this section, we focus on the efficient ownership arrangement when both firms can upgrade their inputs and compare it with the case where neither firm can upgrade. Although complete results cannot be obtained due to algebraic complexity, some additional insights can be derived.

Suppose the local firm can improve its efficiency of providing input x_1 to the level $\Delta > 1$ while the foreign firm can increase is efficiency of providing input x_2 to $\Gamma > 1$. The production function of the joint venture after upgrading is thus

$$z(x_1, x_2; \Delta, \Gamma) = A\,(\Delta x_1)^{\alpha_1}\,(\Gamma x_2)^{\alpha_2}\,.$$

Let the cost of upgrading for the local firm be given by $\Delta^\varepsilon/\varepsilon$ and for the foreign firm be given by $\Gamma^\varepsilon/\varepsilon$. Assume $\varepsilon \geq 1$ (so that the upgrading technologies exhibit decreasing returns to scale).

At the output stage, the efficiency parameters Δ and Γ are given and the choices of input provision are essentially the same as those described in section 2. Using equation (2) we obtain the total output of the joint venture, for any given efficiency levels Δ and Γ:

$$z^{BU}(s, \Delta, \Gamma) = (A\Delta^{\alpha_1}\Gamma^{\alpha_2})^{\frac{1}{1-\beta_1-\beta_2}}\,(\alpha_1 s)^{\frac{\beta_1}{1-\beta_1-\beta_2}}\,(\alpha_2(1-s))^{\frac{\beta_2}{1-\beta_1-\beta_2}}.$$

Profits, gross of upgrading costs, are

$$\pi_1(s, \Delta, \Gamma) = s(1-\beta_1)z^{BU}(s, \Delta, \Gamma) \quad \text{and} \quad \pi_2(s, \Delta, \Gamma) = (1-s)(1-\beta_2)z^{BU}(s, \Delta, \Gamma).$$

Incentive to upgrade

At the upgrading stage, taking the foreign firm's choice of Γ as given, the local firm chooses Δ ($\Delta \geq 1$) to maximize its profit net of its investment cost:

$$\underset{\Delta}{Max}\ \pi_1(s, \Delta, \Gamma) - \Delta^{\varepsilon}/\varepsilon$$

The first order condition for the above problem is

$$\frac{\alpha_1}{1-\beta_1-\beta_2} s(1-\beta_1) z^{BU}(s, \Delta, \Gamma) = \Delta^{\varepsilon}. \tag{13}$$

Similarly, the foreign firm chooses Γ ($\Gamma \geq 1$) to maximize:

$$\underset{\Gamma}{Max}\ \ \pi_2(s, \Delta, \Gamma) - \Gamma^{\varepsilon}/\varepsilon$$

with an analogous first order condition

$$\frac{\alpha_2}{1-\beta_1-\beta_2}(1-s)(1-\beta_2) z^{BU}(s, \Delta, \Gamma) = \Gamma^{\varepsilon}. \tag{14}$$

The above first order conditions explicitly define the reaction functions of the two firms. It is easy to show that these reaction functions are upward sloping. Due to the complementary nature of the two firms inputs, an increase in investment by one firm increases the marginal benefit of the other firm's investment and, hence, its optimal investment.

Let $(\Delta^{BU}(s), \Gamma^{BU}(s))$ denote the Nash equilibrium upgrading levels of the two firms, given their respective revenue shares $(s,\ 1-s)$.[15] From the first order conditions, we have:

$$\frac{\Delta^{BU}}{\Gamma^{BU}} = \left[\frac{s}{1-s}\frac{(1-\beta_1)\alpha_1}{(1-\beta_2)\alpha_2}\right]^{1/\varepsilon}. \tag{15}$$

Intuitively, and as is clear from the above formula, three crucial factors determine the investment incentives of firms: the productivity of their inputs, their joint venture shares, and the cost parameters for upgrading. The larger a firm's productivity, the more rewarding is its investment to itself and the higher its incentive to upgrade (everything else constant). Likewise, the larger a firm's share of the joint venture, the more it benefits from upgrading, and the higher its investment in upgrading. Suppose that $k_1 = k_2$ (i.e. the costs of both inputs are equal), so that $\frac{\alpha_1}{\alpha_2} = \frac{\beta_1}{\beta_2}$. Equation (15) immediately implies the following result.

Lemma 2: *Suppose $k_1 = k_2$. Then, the local firm upgrades more than the foreign firm ($\Delta^{BU} > \Gamma^{BU}$) if and only if $s > s_c$ where $s_c = \frac{1}{1+b}$ and $b \equiv \frac{\beta_1(1-\beta_1)}{\beta_2(1-\beta_2)}$.*

The above result implies that the local firm upgrades more than the foreign firm *even if* $\beta_1 < \beta_2$ (and hence $b < 1$), provided that $s > 1/(1+b)$.[16] Suppose the local firm receives a minority share of the joint venture (i.e. $s < 1/2$). Then, the condition $s > s_c$ holds if the local firm is sufficiently more productive than the foreign firm (i.e. β_1 is sufficiently large relative to β_2). For the case where the two firms are equally productive ($\beta_1 = \beta_2$), the local firm invests more than the foreign firm if and only if its share of the joint venture exceeds 50%.

Suppose that the optimal share $s^*(1/2)$ in the absence of upgrading as given in Proposition 1 is chosen, which can be either greater, equal to, or less than 50%, depending on the relative sizes of the productivity parameters β_1 and β_2. It is easy to show that

$$s^*(1/2) > s_c \quad \text{if and only if} \quad \sqrt{\frac{(1-\beta_1)\beta_2}{(1-\beta_2)\beta_1}} < \frac{\beta_1(1-\beta_1)}{\beta_2(1-\beta_2)},$$

which is the same as

$$s^*(1/2) > s_c \quad \text{if and only if} \quad (1-\beta_2)\beta_2^3 < (1-\beta_1)\beta_1^3,$$

which holds if and only if $\beta_1 > \beta_2$. Thus, if the sharing arrangement that is efficient under *no* upgrading is in place, the more productive firm upgrades more.

Efficient ownership structure under upgrading by both firms

Let s^{BU} denote the local firm's share that maximizes the joint venture's total profits:

$$s^{BU} = Arg\max_{s} \ \pi_1(s, \Delta^{BU}, \Gamma^{BU}) + \pi_2(s, \Delta^{BU}, \Gamma^{BU}) - \left(\Delta^{BU}\right)^{\varepsilon}/\varepsilon - \left(\Gamma^{BU}\right)^{\varepsilon}/\varepsilon$$

How does the solution to the above problem compare to the efficient sharing scheme under no upgrading by either firm, $s^*(1/2)$? Intuitively, if a firm's input is more important to the joint venture than that of its partner then it should be in the joint venture's interest to give this a firm a larger share than what it gets in the complete absence of upgrading. Suppose $\beta_1 > \beta_2$ and that the shares are currently given by $s^*(1/2)$. Consider what happens to the joint venture's total profit if the local firm's share is raised beyond $s^*(1/2)$. Such an increase in s, in general, increases the local firm's incentive to upgrade and at the same time reduces the foreign firm's incentive to upgrade. Increased upgrading by the local firm tends to increase the joint venture's productivity, while reduced upgrading by the foreign firm tends to lower it. Since $\beta_1 > \beta_2$, the increase in the local firm's upgrading more than offsets the negative effect of reduced upgrading by the foreign firm. This implies that if $\beta_1 > \beta_2$ then the original optimal share $s^*(1/2)$ is *below* what is optimal when both firms can upgrade. For the Cobb-Douglas production function used in our analysis with $k_i = 1$ and $\varepsilon = 1$, we can show that if $\beta_1 + 2\beta_2 < 1$ and $2\beta_1 + \beta_2 < 1$, then[17]

$$s^{BU} > s^*(1/2) \ \text{ if and only if } \ \beta_1 > \beta_2$$

Due to algebraic complexity, we are unable to prove the result for a more general setting, although we believe that it continues to hold.

6. Conclusion

Joint ventures in developing countries frequently face restrictions on foreign ownership. Evidence also indicates that such joint ventures are frequently based on complementary strengths of firms, and technological upgrading by foreign partners often surfaces as an important issue during joint venture negotiations. Taking these two stylized facts as motivation, the paper develops a model in which a foreign and a local firm provide complementary inputs to a jointly owned venture. In the model, each firm's incentive to provide its input, as well as its incentive to upgrade that input, depends upon its share of the joint venture. This trade-off is used to examine the local firm's most preferred sharing rule and the efficient sharing arrangement for the joint venture. The paper provides an analysis of optimal ownership patterns for different sharing rules and explores their dependence on the possibility of technological upgrading in an environment of complementarity.

Our results have direct implications for joint venture policies in developing countries. They show that local policy should take into account the importance of foreign firm's productivity and not grant the local firm a controlling share of the joint venture under all circumstances. This is especially so when the foreign firm can upgrade its input, in which case the foreign firm's share should be increased in order to induce it to upgrade. While restrictions on foreign ownership of joint ventures can sometime improve local welfare (especially when the foreign firm has considerable bargaining power), a blanket policy of prohibiting majority foreign ownership is difficult to justify and may have serious consequences for the performance of joint ventures.

The Cobb-Douglas production function specification we use captures the notion of complementarity of inputs between joint venture partners. It also enables us to parameterize the importance of inputs in a straightforward way. We believe that our model captures some fundamental issues regarding input provision and incentives for technological upgrading within joint ventures, and expect our main results to hold under more general circumstances. In particular, the most preferred sharing arrangement by each firm, as well as the efficient ownership arrangement, should depend crucially on the importance of both firms' inputs to the joint venture; there should exist a upper limit to each firm's share even when the firm gets to choose its most preferred share; and this upper limit must be negatively related, thought not necessarily exclusively, to the other firm's productivity parameter. Our analysis of the direct effect and indirect effect of a share adjustment in the presence of upgrading is based on general profit functions (section 4.2). Thus, the result that the upgrading firm should be given a larger share relative to the case of no-upgrading is not specific to the Cobb-Douglas production formulation.

Appendix

Proof of Proposition 1

It is easily seen that maximizing $\pi_1(s)$ is equivalent to

$$\max\ s \cdot (s)^{\frac{\beta_1}{1-\beta_1-\beta_2}} (1-s)^{\frac{\beta_2}{1-\beta_1-\beta_2}}, \tag{A1}$$

which is equivalent to maximizing $(1-\beta_2)\ln(s) + \beta_2 \ln(1-s)$. The solution to this problem is $s^*(1) = 1-\beta_2$. Similarly, it can be derived that $s^*(0) = \beta_1$. Next we derive the solution $s^*(1/2)$.

$$\begin{aligned} \max\ \pi(s) &= [s(1-\beta_1) + (1-s)(1-\beta_2)]\, z^J(s) \\ \text{subject to}\ &:\ z^J(s) = \left(A^J\right)^{\frac{1}{1-\beta_1-\beta_2}} (\alpha_1 s)^{\frac{\beta_1}{1-\beta_1-\beta_2}} (\alpha_2(1-s))^{\frac{\beta_2}{1-\beta_1-\beta_2}} \end{aligned} \tag{A2}$$

This maximization problem is equivalent to

$$\begin{aligned} \max\ \pi(s) &= (1-\beta_1) s^{\frac{\beta_1}{1-\beta_1-\beta_2}+1} [1-s]^{\frac{\beta_2}{1-\beta_1-\beta_2}} \\ &\quad + (1-\beta_2) s^{\frac{\beta_1}{1-\beta_1-\beta_2}} [1-s]^{\frac{\beta_2}{1-\beta_1-\beta_2}+1} \end{aligned} \tag{A3}$$

The first order condition for the above problem is

$$-(1-\beta_1)\beta_2 s^{\frac{1-\beta_2}{1-\beta_1-\beta_2}} (1-s)^{\frac{2\beta_2+\beta_1-1}{1-\beta_1-\beta_2}} + (1-\beta_2)\beta_1 s^{\frac{2\beta_1+\beta_2-1}{1-\beta_1-\beta_2}} (1-s)^{\frac{1-\beta_1}{1-\beta_1-\beta_2}} = 0 \tag{A4}$$

which yields

$$\left(\frac{1-s}{s}\right)^2 = \frac{(1-\beta_1)\beta_2}{(1-\beta_2)\beta_1} \implies s^*(1/2) = \frac{1}{1+\sqrt{\frac{(1-\beta_1)\beta_2}{(1-\beta_2)\beta_1}}}. \tag{A5}$$

To show $s^*(0) < s^*(1/2) < s^*(1)$, note that the first order condition for the problem specified in (8) is

$$\frac{\partial \pi_2}{\partial s} + \sigma \left[\frac{\partial \pi_1}{\partial s} - \frac{\partial \pi_2}{\partial s}\right] = 0. \tag{A6}$$

Totally differentiating the first order condition with respect to σ yields

$$\frac{ds^*(\sigma)}{d\sigma} = -\frac{\frac{\partial \pi_1}{\partial s} - \frac{\partial \pi_2}{\partial s}}{\frac{\partial^2 \pi_2}{\partial s^2} + \sigma \left[\frac{\partial^2 \pi_1}{\partial s^2} - \frac{\partial^2 \pi_2}{\partial s^2}\right]}. \tag{A7}$$

By the second order condition, the denominator is negative. So $\frac{ds_1^*(\sigma)}{d\sigma}$ has the same sign as $\frac{\partial \pi_1}{\partial s} - \frac{\partial \pi_2}{\partial s}$. Since $s^*(0) < s^*(1)$, it must be that $\frac{\partial \pi_1}{\partial s} > 0$ and $\frac{\partial \pi_2}{\partial s} < 0$ only for $s \in (s^*(0),\ s^*(1))$.[18] This implies that $\frac{ds^*(\sigma)}{d\sigma} > 0$. ■

References

[1] Al-Saadon, Youssef and Satya P. Das, "Host Country Policy, Transfer Pricing and Ownership Distribution in International Joint Ventures: A Theoretical Analysis." *International Journal of Industrial Organization* 14 (1996): 345-364.

[2] Beamish, Paul W., "Joint Ventures in LDCs: Partner Selection and Performance." *Management International Review* 1 (1987): 23-37.

[3] Chan, Raissa and Michael Hoy, "East-West Joint Ventures and Buyback Contracts." *Journal of International Economics* 30 (1991): 331-343.

[4] Child, John, "PRC Investment Control: Exploding the Myths." *China Direct Investor* August (1998): 10-15.

[5] *China Joint Venturer*, "Case Study: BOC's First Foothold in Shanghai." September (1995): 14-16.

[6] *China Joint Venturer*, "Case Study: Pepsi Takes the China Challenge." October (1996): 16-20.

[7] Dinopoulos, Elias and Constantinos Syropoulos, "International Diffusion and Appropriability of Technological Expertise," in Michael R. Baye, ed., *Advances in Applied Microeconomics*, volume 7 (1998): 115-137.

[8] Lee, Frank C. and Oz Shy, "A Welfare Evaluation of Technology Transfer to Joint Ventures in the Developing Countries." *International Trade Journal* 7 (1992): 205-220.

[9] Lin, Ping and Kamal Saggi, "Notes on Ownership Structure and Performance of Joint Ventures," 2001, mimeo.

[10] Luo, Yadong, "Guanxi and Performance of Foreign-Invested Enterprises in China: An Empirical Enquiry." *Management International Review* 37 (1997): 51-70.

[11] Mattoo, Aaditya, "Financial Services and the WTO: Liberalization Commitments of the Developing and Transition Economies." World Bank Policy Research Working Paper No. 2184, 1998.

[12] Miller, Robert R, Jack D. Glen, Frederick Z. Jaspersen, and Yannis Karmokolias, "International Joint Ventures in Developing Countries: Happy Marriages?" IFC Discussion Paper 29, 1997.

[13] Mogi, Yuzaburo, "Joint Venturing in Taiwan." *The Columbia Journal of World Business* Summer (1996): 54-59.

[14] Selassie, Habte Gebre, *International Joint Venture Formation in the Agribusiness Sector: The Case of Sub-Saharan African Countries*, Brookfield, Vt., USA, 1995.

[15] Svejnar, Jan and Stephen Smith, "The Economics of Joint Ventures in Less Developed Countries," *The Quarterly Journal of Economics*, November (1984): 149-167.

Notes

1. See Mattoo (1998) for details regarding financial services.

2. Of course, as noted in the paper, analogous effects also exist in the case where there is no upgrading: increasing a firm's share carries the indirect cost of lowering its partner's incentive for input provision. However, in the dynamic case, it is worth emphasizing the indirect effect that arises due to upgrading.

3. A devious implication is that local firms will benefit from preventing such economic liberalization in order to retain the value of their contributions to international joint ventures. Alternatively, as an anonymous referee has noted, an indirect benefit to the local economy of having a lot of red tape is that local firms become more valuable partners in joint ventures.

4. Similar findings for other countries have been reported in Beamish (1987) and Selassie (1995). See also Mogi (1996) for a CEO's overview of the joint venture between Kikkoman Coporation of Japan and President Enterprises of Japan. One strong motivation for this joint venture was the complentary strengths of the two firms.

5. See Svejnar and Smith (1984) for an earlier study of the optimal ownership pattern of a joint venture.

6. Chan and Hoy (1991) note that joint ventures between foreign firms and enterprises in Socialist countries such as China frequently involve a linear sharing rule (as the one employed in our model) along with minimum standards requirements. They argue that the two features together produce an arrangement that minimizes shirking by partners regarding the quality levels of their respective inputs.

7. Their model considers two scenarios: one in which firms expend resources that influence the probability that the leader's technology spills over to the follower and another in which they contest the transfer associated with technology licensing. By contrast, in our model firms spend resources in technological upgrading that improve the value of their respective inputs. More importantly, each firm's investment benefits the other firm since it increases the productivity of the joint venture.

8. Cooperation in joint ventures is difficult because the two partners' efforts may be unobservable and/or unverifiable. For example, the effort exerted by the local firm in dealing with the local government and bureaucracy, as well as the foreign firm's contribution in terms of management and international marketing, may be hard to verify and contract upon. Our results remain valid if the joint venture's production is given by $z = Ax_1^{\alpha_1}x_2^{\alpha_2} + \eta$ where η is a random variable (with zero mean) whose realization cannot be observed by the firms. Due to the random element η, partners are unable contract upon their input choices.

9. The first best solution requires that inputs be also chosen to maximize total profits of the joint venture.

10. If expenditures by both firms were payments to some local factors of production then local welfare would equal the joint venture's *revenue* (or output z^J since price is normalized to 1). This is because private costs of the firms would be factor payments and while considering total local welfare, costs of the firms

would cancel out with factor payments. It is easy to show that to maximize the joint venture's revenue, the local firm's share should be $\frac{\beta_1}{\beta_1+\beta_2}$ so that the foreign firm still gets a majority share if $\beta_1 < \beta_2$.

11. More generally, one can model complementarity of inputs by employing the following production function for the joint venture:

$$z = A\left(\delta_1 x_{11} + \delta_2 x_{12}\right)^{\alpha_1}\left(\gamma_1 x_{21} + \gamma_2 x_{22}\right)^{\alpha_2}, \quad \alpha_1 + \alpha_2 < 1$$

where x_{ij} is the amount of input i provided by firm j, $\delta_1 > \delta_2$, and $\gamma_1 < \gamma_2$. Under this specification, the local firm is more efficient in providing input 1 and the foreign firm in input 2, and the efficient output for the joint venture is $z = A\left(\delta_1 x_{11}\right)^{\alpha_1}\left(\gamma_2 x_{22}\right)^{\alpha_2}$. In this context, technological upgrading by the foreign firm amounts to an increase in the value of $\gamma_{2.}$

12. A sufficient condition for the second order condition to hold is $\beta_1+\beta_2+\alpha_2 < 1$.

13. This result obtains due to the Cobb-Douglas production specification of our model.

14. This last result is due to the Cobb-Douglas production assimption, and in particular to the fact that the alternative sharing arrangements do not depend on the parameter A of the production function.

15. Straightforward algebraic manipulations show that this equilibrium exists and is unique. Due to algebraic complexity, however, explicit solutions cannot be derived.

16. We assume that $\max\{\beta_1, \beta_2\} < 1/2$.

17. The proof, contained in Lin and Saggi (2001), is lengthy and thus omitted here.

18. These profits functions are quasi-concave in s.