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# Core Competencies, Matching, and the Structure of Foreign Direct Investment

Federico J. Díez and Alan C. Spearot

## Abstract:

We develop a matching model of foreign direct investment to study how multinational firms choose between Greenfield investment, acquisitions, and joint ventures. For all entry modes, firms must invest in a continuum of tasks to bring a product to market. Each firm possesses a core competency in the task space, though firms are otherwise identical. For acquisitions and joint ventures, a multinational enterprise (MNE) must match with a local partner, where the local partner may provide complementary expertise within the task space. However, for joint ventures, investment in tasks is shared by multiple owners, and hence is subject to a holdup problem. In equilibrium, ex-ante identical multinational enter the local matching market, and ex post, three different types of ownership within a heterogeneous group of firms arise. Specifically, the worst matches dissolve and the MNEs invest greenfield, the middle matches form joint ventures, and the best matches integrate via mergers and acquisitions. We also show that joint ventures are more common when the host country produces products that are inferior to those produced in the source country, which explains why MNEs use joint ventures more frequently in less-developed countries. Finally, we extend the model to a simple two-period context to provide a rationale for one of the more salient features of joint ventures, namely, their instability.

## JEL Classifications: F12, F23

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This paper presents preliminary analysis and results intended to stimulate discussion and critical comment. The views expressed herein are those of the authors and do not indicate concurrence by other members of the research staff or principals of the Board of Governors, the Federal Reserve Bank of Boston, or the Federal Reserve System.

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# 1 Introduction

The decision of whether or not to invest in a foreign market is the first of many decisions facing a multinational enterprise (MNE). Once the MNE decides to operate directly in a foreign market, the firm chooses from a number of different options regarding *how* to operate in the foreign market: greenfield investment, acquisition, or joint ventures. Each type of investment seems to have a comparative advantage in different host country and industrial environments. For instance, developing economies tend to attract more greenfield investment than acquisitions, while the opposite pattern holds in developed economies.<sup>1</sup> Moreover, joint ventures are a usual form of foreign investment into developing countries, but they are quite rare in developed countries where wholly owned subsidiaries are the norm.<sup>2</sup> Further, joint ventures tend to be very unstable entities, most lasting only a few years.<sup>3</sup> Finally, direct investment (greenfield or acquisition) tends to involve more-capable firms in terms of their technological abilities than do joint ventures.<sup>4</sup>

How do firms choose between these investment options? A crucial distinction between greenfield investment and the latter two options is that both acquisitions and joint ventures involve the MNE matching with a local partner before production takes place. If the matching takes place, the MNE must then choose the type of ownership structure that best utilizes the assets of both firms in the local market. Indeed, the quality of the match itself is likely to have a profound impact on the nature of the relationship that is chosen *ex post*. For example, an MNE may choose to bring a match under full ownership to eliminate any possibility that agency issues might ruin the potential of a good match. Of course, if the quality of the match itself is uncertain, the MNE may instead choose to “test” the match under a loose contractual relationship prior to making costly integration decisions.

In this paper, we develop a model of foreign direct investment (FDI) in which MNEs choose whether to match with a local partner, and, if they do, whether to bring the match

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<sup>1</sup>UNCTAD (2000, 2011) reports that over two-thirds of greenfield investment is directed to developing economies, while only 25 percent of the cross-border merger and acquisitions take place there. Moreover, cross-border merger and acquisitions in manufacturing industries are concentrated in automobiles, pharmaceuticals and chemicals, and food, beverages, and tobacco.

<sup>2</sup>Desai et al. (2004) find that almost 60 percent of U.S. affiliates in developing countries are partially owned, whereas this figure drops to 15.5 percent in the case of the richest countries.

<sup>3</sup>For example, Inkpen and Ross (2001) report that the failure rate is around 50 percent, and over a third of the joint ventures in Kogut (1989) failed within seven years. Other studies on joint venture instability or failures include Hamel et al. (1989), and Gomes-Casseres (1987). Moreover, there is also evidence about *international* joint ventures being particularly unstable. For example, see Steensma et al. (2007), Inkpen and Beamish (1997), Miller et al. (1997), and Killing (1982).

<sup>4</sup>See Javorcik and Saggi (2010) for a discussion of this issue along with empirical support.

under common ownership. The elements of the investment model are twofold. First, we view production as a set of tasks that must be completed to produce a product in the foreign market, where each firm, local and MNE, possesses a unique core competency within the task space. Indeed, entering the market for corporate control is a way to increase efficiency by finding a local partner that can improve upon the MNE’s deficiencies. However, as each task requires investment, an ownership structure involving multiple independent parties may bring about agency issues within the investment process. Hence, we also allow the MNE to choose the contractual arrangement that governs the new foreign affiliate. Depending on the quality of the match with the local partner, the MNE may be compelled to complete the match through mergers and acquisitions rather than operate under a joint venture with multiple owners sharing revenues of a final product.

In equilibrium, all ex-ante identical firms will enter the foreign matching market to find a local partner. The result is an ex-post group of heterogeneous firms that have sorted into three forms of ownership. In particular, we find that the least efficient of these matches are forgone, the mid-efficiency matches form joint ventures, and the most efficient matches involve mergers and acquisitions. The intuition for this sorting is straightforward. The least-efficient matches are forgone since the match does not offer joint profits sufficient to compensate the MNE for forgoing the outside option of greenfield investment for the MNE and provide profits for the local firm. However, for matches that reach a threshold level of efficiency, firms sort into either joint ventures, or if superior in efficiency, into acquisitions. Indeed, the incomplete contracts associated with a joint venture cause a holdup problem in coordinating joint investments in the final product. When match potential is high, the loss of profits due to holdup is quite severe, and the MNE instead chooses to buy out the local firm, pay a fixed integration cost, and bring all investment responsibilities under one owner.

To examine the stability of joint ventures—a theoretical consideration mostly absent in the literature—we offer a simple two-period model based on our static framework. There are two major differences from the setting described above: first, MNEs are heterogeneous in the quality of the product that they produce; second, they enter the foreign market under match uncertainty in the first period and learn about their matches before the second. Through this simple framework of uncertainty, we find that while the high-quality MNEs choose wholly owned investment from the beginning, low-quality firms use joint ventures to test the match prior to (potentially) paying fixed costs to integrate through acquisitions.<sup>5</sup> Further, we offer

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<sup>5</sup>This is consistent with Javorcik and Saggi (2010), who find, using data on FDI in Eastern Europe, that the more technologically advanced MNEs are less likely to enter a foreign market through a joint venture.

a unique prediction about which firms are more likely to break a joint venture after it is formed. Indeed, we find that high-quality firms are more likely than low-quality firms to break joint ventures in favor of wholly owned investment.

This paper relates to three strands in the literature. First, our results share a resemblance with those presented in Rauch and Trindade (2003) and Grossman and Helpman (2005), both of which examine matching around a unit circle. In contrast with the former, which focuses on the role of information in the matching process, we allow for a varying degree of common ownership within the match. Hence, as discussed above, we are able to distinguish between joint ventures and acquisitions as different forms of foreign investment. In terms of the latter, our contributions are complementary, in that we focus on the choice of foreign investment type rather than on the outsourcing vs. integration decision in developing a product. In contrast with both papers, we offer greenfield investment as an option when matches fail.

Second, two other papers offer related contributions in terms of the optimal mode of foreign investment. Volker and Yeaple (2007) examine the choice between greenfield FDI and mergers and acquisitions as a function of whether capabilities are transferrable across borders. Their work shows that the optimal sorting of firms is critically dependent on the degree to which capabilities are internationally mobile. Raff et al. (2009) examine the three-way decision between joint ventures, acquisitions, and greenfield investment in an oligopoly setting, where they find that the profits from greenfield investment are a crucial threat-point in the choice between mergers and acquisitions and joint ventures.

Lastly, there are two related models about joint venture instability. Sinha (2001) presents a two-period model where joint ventures are formed in the first period as a result of governmental restrictions on foreign ownership. In the second period, these are lifted, and the MNE may opt for a wholly owned affiliate, dissolving the joint venture. Roy Chowdhury and Roy Chowdhury (2001) link joint venture formation to synergies between the parent firms; since there is learning through time, these synergies are weakened, leading to the breakup of the joint venture.

The rest of the paper is organized as follows. In Section 2, we present the basic setup of the model, detailing the production processes under the different modes of entry. In Section 3, we describe the equilibrium and the resulting organizational choices resulting from different matches. In Section 4, we extend our model to a two-period setting. We conclude in Section 5.

## 2 Basic Setup

The focus of the model is an MNE that is deciding how to enter a foreign market and, where applicable, how to organize with a local partner. Specifically, the MNE has three possible ways to enter the market: greenfield investment, forming a joint venture with a local firm, and acquiring a local firm. The key to the model is how an MNE may divide the tasks required for production with the local firm and how the choice of organizational form incentivizes investment in each task. Shortly, we detail further particulars about each entry type, although the crucial distinction for the model will be that joint ventures are formed under a less “complete” contract than are the other forms of direct investment. While there may be fixed cost savings from not fully integrating the local partner, there may also be inefficiencies due to the standard holdup problem.

### 2.1 Production

Production in the model is defined over a continuum of tasks in which firms must invest to execute production of a final product, similar to the approach taken by Antràs and Helpman (2008). Specifically, we assume that all firms produce subject to the following revenue function:

$$R = A\theta^{1-\beta}Y^\beta, \quad \beta \in (0, 1). \quad (1)$$

In (1),  $\theta$  is a measure of the quality of an idea, and  $Y$  is a measure of the execution of the idea (marketing, quality control, R&D, etc.). The intuition for this framework is that a high-quality idea is worth nothing if poorly executed, and executing a bad idea well is also worthless.

We assume that  $\theta$  is specific to the MNE, and, for the moment, is held fixed in order to focus on how the execution of ideas affects organizational choice. Later, we will allow  $\theta$  to vary by MNE to evaluate how organizational choice may vary across firms of heterogeneous profitability.

As mentioned above,  $Y$  will be a function of how the final firm invests in a continuum of tasks. Specifically, we assume that  $Y$  is characterized by the following constant returns function over a continuum of tasks,  $T$ :

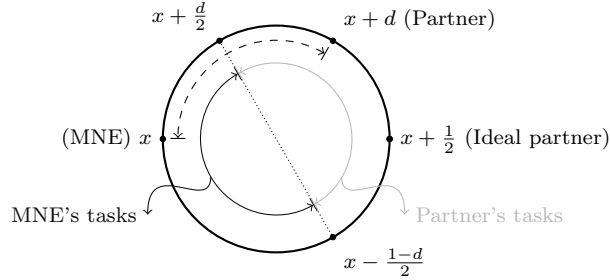
$$Y = \exp \left( \int_{t \in T} \log(y_t) dt \right). \quad (2)$$

Here,  $y_t$  is investment in task  $t$ . We assume that tasks are uniformly distributed around a unit circle, where every firm, whether local or multinational, has a unique position around the circle. This is the location of a firm's *core competency*, where tasks farther away from the firm around the outside of the circle are more costly. A standalone firm cannot change its position around the circle to improve the efficiency of production. However, a firm may match with a partner in order to divide tasks in a way that minimizes costs, and, if it chooses to do so, may operate the combined firm under joint or full ownership.

Figure 1 provides a graphical representation of the division of tasks around the circle. The MNE is positioned at point  $x$ , making  $x$  its core competency. Ideally, the MNE would like to form a match with a partner located exactly halfway around the circle, at point  $x + \frac{1}{2}$ . Generally, the partner will be located at a distance  $d \in [0, \frac{1}{2}]$  from  $x$ , with the MNE taking care of the tasks closest to  $x$ , and the partner those closest to  $x + d$  (as we explain below).

We now consider production under all three cases of entry into the host country.

Figure 1: Allocation of Tasks Around the Circle



### Standalone Firms (Greenfield Investment)

In the model, there are two types of standalone firms: MNEs that invested greenfield, and local firms that operate independently. We introduce the profits for each in order.

Denote the cost of investing in each task  $t$  as  $c_t$ . The optimization problem of a standalone MNE that has invested greenfield is the following:

$$\pi_G = \max_{y_t \forall t \in T} \left\{ A(\theta)^{1-\beta} \left( \exp \left( \int_{t \in T} \log(y_t) dt \right) \right)^\beta - \int_{t \in T} c_t y_t dt \right\}. \quad (3)$$

Differentiating with respect to  $y_t$  yields the following for all  $t$ :

$$y_t = \frac{\beta A \theta^{1-\beta} Y^\beta}{c_t}. \quad (4)$$

Naturally, higher-cost tasks receive less investment. Tasks are defined around a unit circle. Specifically, we assume that task  $t$ , which is at a distance  $s_t$  from the firm's core competency  $x$ , costs  $c_t = e^{|s_t-x|}$  per unit to complete. Hence, a unit of investment in the task precisely at  $x$  requires one unit of labor to complete, and the unit labor requirement rises with distance around the circle from the firm's core competency. With this parameterization, optimal investment in task  $t$  is written as:

$$y_t = \frac{\beta A \theta^{1-\beta} Y^\beta}{e^{|s_t-x|}}. \quad (5)$$

Taking into account the uniform location of tasks around the unit circle, the equation for  $Y$  can be written as

$$Y = \exp \left( \int_x^{x+1/2} \log \left( \frac{\beta A \theta^{1-\beta} Y^\beta}{e^{s_t-x}} \right) ds + \int_{x-1/2}^x \log \left( \frac{\beta A \theta^{1-\beta} Y^\beta}{e^{x-s_t}} \right) ds \right), \quad (6)$$

which is simplified as:

$$Y = \beta^{\frac{1}{1-\beta}} A^{\frac{1}{1-\beta}} \theta \exp \left( -\frac{1}{1-\beta} \left( \frac{1}{4} \right) \right). \quad (7)$$

Using (2), after some simplification we can rewrite operating profits in the following way:

$$\begin{aligned} \pi_G &= (1-\beta) \beta^{\frac{\beta}{1-\beta}} A^{\frac{1}{1-\beta}} \theta \exp \left( -\frac{\beta}{4(1-\beta)} \right) \\ &= \Gamma \theta \\ &\equiv \pi_0, \end{aligned} \quad (8)$$

where  $\Gamma \equiv (1-\beta) \beta^{\frac{\beta}{1-\beta}} A^{\frac{1}{1-\beta}} \exp \left( -\frac{\beta}{4(1-\beta)} \right)$ .

The operating profits of greenfield investment for the MNE are labeled  $\pi_0$ . The operating profits of all other options will be measured against this “numeraire.”

With respect to total profits, the MNE must also pay a fixed cost  $F_G$  under greenfield investment. This is meant to embody the costs of new facilities and management associated with new investment in a foreign market. Hence, total profits under greenfield investment



are labeled as:

$$\Pi_G = \pi_0 - F_G. \quad (9)$$

Moving on to the local firms in the host country, we assume that these firms differ from MNEs in two dimensions. First, local firms may differ from MNEs in the quality of the product that they are able to produce absent a match with an MNE. Second, local firms may differ from MNEs in the fixed costs (or lack thereof) that must be incurred to produce. We assume that when an MNE can produce a product at quality  $\theta$ , the local firm can produce the product at quality  $\delta\theta$ , where  $\delta \in [0, 1]$ . Hence, the local firm can produce the product, but only a lower-quality variety that earns lower profits. Therefore, the operating profits for the local firm are written as follows:

$$\begin{aligned} \pi_L &= (1 - \beta) \beta^{\frac{\beta}{1-\beta}} A^{\frac{1}{1-\beta}} \delta \theta \exp \left( -\frac{\beta}{4(1-\beta)} \right) \\ &= \delta \pi_0. \end{aligned} \quad (10)$$

The second dimension on which the local firm differs from the MNE is that, as an established firm in the local market, the local firm incurs no fixed costs. Hence, total profits of the local firm are written as:

$$\Pi_L = \delta \pi_0. \quad (11)$$

## Acquisition

The difference between a greenfield investment and an acquisition is that in the latter case the MNE is matched with a local partner and purchases the capabilities of the local partner. Hence, the MNE decides which capabilities, MNE or local, are best suited to invest in each of the tasks required for production. The MNE then chooses the investment level in each task, using whichever capabilities are closer in the task space (the MNE's or the acquired firm's).

Since only one firm controls the investment levels in tasks, the optimal investment in task  $t$  as a function of  $c_t$  is the same as for the standalone firm. However, the marginal costs may differ because some of the tasks are being performed by capabilities acquired from the local partner. Within the circle context discussed above, assume (without loss of generality) that the core competency of the matched local firm is at a distance  $d \leq \frac{1}{2}$  away from the MNE. Hence, via cost minimization, the MNE, which is located at  $x$ , performs tasks between  $(x - \frac{1-d}{2}, x + \frac{d}{2})$ . The assets acquired from the local partner perform all other tasks. This is

also depicted in Figure 1. With this parameterization, the equation for  $Y$  can be written as:

$$Y = \exp \left( 2 \int_x^{x+d/2} \log \left( \frac{\beta A \theta^{1-\beta} Y^\beta}{e^{s-x}} \right) ds + 2 \int_{x-\frac{1-d}{2}}^x \log \left( \frac{\beta A \theta^{1-\beta} Y^\beta}{e^{x-s}} \right) ds \right). \quad (12)$$

Simplifying yields the optimal level of production for the merged firm,  $Y_A$ :

$$Y = \beta^{\frac{1}{1-\beta}} A^{\frac{1}{1-\beta}} \theta \exp \left( -\frac{1}{1-\beta} \left( \frac{d^2 - d + 1/2}{2} \right) \right). \quad (13)$$

Using the equation for  $Y_A$  and simplifying yields the following equation for operational profits of the merged firm:

$$\begin{aligned} \pi_A(d) &= (1-\beta) \beta^{\frac{\beta}{1-\beta}} A^{\frac{1}{1-\beta}} \theta \exp \left( -\frac{\beta}{1-\beta} \left( \frac{d^2 - d + 1/2}{2} \right) \right) \\ &= \phi(d) \pi_0, \end{aligned} \quad (14)$$

where  $\phi(d) \equiv \exp \left( \frac{\beta}{1-\beta} \frac{d(1-d)}{2} \right) \geq 1, \forall d \in [0, \frac{1}{2}]$ .

We think of  $\phi(d)$  as a measure of the quality of the match between the MNE and the domestic firm:  $\phi(d)$  measures the improvement from splitting tasks with a partner (as opposed of being in charge of all tasks). Since  $\phi(d) \geq 1$ , an acquisition (weakly) increases the efficiency of production relative to a standalone firm. Additionally, since  $\phi$  is increasing in  $d$ , and is maximized at  $d = \frac{1}{2}$ , this implies that better matches (that is, matches where the partners are farther away and are better complements) enjoy higher profits.

In terms of total profits, the MNE must pay two fixed costs associated with an acquisition. The first,  $F_A$ , is a simple integration cost that is required to “solve” the holdup problem. The second,  $T_A$ , is a transfer from the MNE to the local firm as payment for the local firm’s assets. Overall, total profits of the acquisition are written as:

$$\Pi_A(d) = \phi(d) \pi_0 - F_A - T_A. \quad (15)$$

## Joint Venture

Having detailed the (polar) options of establishing a wholly owned subsidiary in the local market via greenfield investment and via acquisitions, we now turn to the option of a joint venture. Under this mode of FDI, the MNE forms a match with a local partner, but without buying out the local firm’s capabilities. This option may provide advantages in terms of

the costs of market entry—no new facilities are built, and there is no cost of buying out the local firm. However, because there are two owners jointly investing in the combined product, agency issues may arise when contracts are incomplete. Indeed, we adopt the assumption that contracts are incomplete under the joint venture and focus on these issues in this section.

For simplicity, assume that the parties each receive one half of the total revenue earned from the joint investment. Under this assumption, investments in tasks by the MNE are defined by the following maximization problem:

$$\tilde{\pi}_{JV} = \max_{y_t \forall t \in T_{MNE}} \left\{ \frac{1}{2} A(\theta)^{1-\beta} \left( \exp \left( \int_{t \in T_{MNE}} \log(y_t) dt + \int_{t \in T_P} \log(y_t) dt \right) \right)^\beta \right\} - \int_{t \in T_{MNE}} c_t y_t dt \quad (16)$$

where  $T_{MNE}$  is the set of tasks that are performed by the MNE within the total set of tasks  $T$ . The maximization problem of the local partner is identical to that of the MNE, shown above, with the exception that  $T_P$ , the set of tasks undertaken by the local firm, and  $T_{MNE}$  are switched. In (16),  $\frac{1}{2}$  represents the fact that the MNE and the local partner each receive one half of the ex-post profits. Note that while the parties agree to share the revenue generated by the joint venture, the revenue itself depends on the investments undertaken by both parties. Given the environment of incomplete contracts, the parties cannot commit to an investment level (the maximization takes the other tasks as given) despite the fact that each party must incur the full costs of the tasks for which it has responsibility.

Differentiating with respect to  $y_t$  yields the following for all  $t$ :

$$y_t = \frac{\beta \frac{A}{2} \theta^{1-\beta} Y^\beta}{c_t}. \quad (17)$$

Hence, investment levels in each task are exactly one half of what they were under acquisition or greenfield investment. Plugging into the equation for  $Y$ , we get:

$$Y = \beta^{\frac{1}{1-\beta}} \left( \frac{1}{2} A \right)^{\frac{1}{1-\beta}} \theta \exp \left( -\frac{1}{1-\beta} \left( \frac{d^2 - d + 1/2}{2} \right) \right). \quad (18)$$

Using the equation for  $Y$  and simplifying yields the following equation for the MNE's profits under a joint venture:

$$\tilde{\pi}_{JV}(d) = \left( 1 - \frac{\beta}{2} \right) \left( \frac{1}{2} \right)^{\frac{1}{1-\beta}} \beta^{\frac{\beta}{1-\beta}} A^{\frac{1}{1-\beta}} \theta \exp \left( -\frac{\beta}{1-\beta} \left( \frac{d^2 - d + 1/2}{2} \right) \right). \quad (19)$$

We assume that the MNE and the local firm, if they choose a joint venture, can engage in side payments so that the primary measure relevant for each is the total profits earned under the venture, which is compared with the total profits earned from other the organizational options (the motivation for this will become clear below). Since there are no fixed costs under the joint venture, the total profits accruing to both parties under the joint venture can be written as follows:

$$\Pi_{JV}(d) = \lambda \phi(d) \pi_0, \quad (20)$$

where  $\lambda \equiv \frac{(1-\frac{\beta}{2})}{1-\beta} (\frac{1}{2})^{\frac{\beta}{1-\beta}} \in [0, 1]$ . The term  $\lambda$  measures the inefficiency generated by contractual incompleteness (the holdup problem). Therefore, although the MNE benefits from matching with a partner that is more efficient at some tasks—there is an efficiency gain through  $\phi(d)$ —there is also an inefficiency in investment due to the loose contractual relationship. Finally, note that  $\lambda$  is decreasing in  $\beta$  (recall that  $\beta$  is the coefficient on  $Y$ , the execution of the idea performed by both partners). Intuitively, this means that the more important the execution of the idea, the greater the holdup problem.

### 3 Organizational Choice

In this section we characterize the optimal organizational choice as a function of the quality of the matches that occur and prove that a parameter space exists such that all three types of FDI occur after ex-ante identical firms enter the matching market for corporate control.

#### 3.1 Equilibrium

First, consider the choice between a joint venture and declining the match. The MNE can compensate the local firm for its outside option and also make additional profit for itself, if the following holds:

$$\begin{aligned} \Pi_{JV}(d) &\geq \Pi_G + \Pi_L \\ \lambda \phi(d) \pi_0 &\geq \pi_0 - F_G + \delta \pi_0. \end{aligned} \quad (21)$$

Simplifying, this condition can be written as:

$$\phi(d) \geq \frac{1}{\lambda} \frac{(1 + \delta) \pi_0 - F_G}{\pi_0} \equiv \phi_{JV}. \quad (22)$$

In (22), only matches of relatively high productivity form joint ventures rather than declining the match and operating as standalone entities.

An interesting polar case to study is one in which local firms and MNEs are identical:  $\delta = 1$  and  $F_G = 0$ . Under these restrictions, (22) is simplified to:

$$\lambda\phi(d) \geq 2. \quad (23)$$

Using numerical simulations, it can be shown that (23) is *never* satisfied when  $d = \frac{1}{2}$ . Since  $\frac{\partial\phi(d)}{\partial d} > 0$ , this suggests that (23) is never satisfied for any  $d \leq \frac{1}{2}$ . This implies that the best match is never able to overcome the holdup problem by doubling the profits available under greenfield. This suggests a reason why relatively few joint ventures occur within developed economies, whereas, in contrast, many joint ventures occur between developed and developing countries. Intuitively, developing country firms lag in quality  $\delta < 1$  and can be easily bought, and, outside of a joint venture or acquisition, it is costly to obtain the needed local knowledge as a foreign entrant that the local firm already possesses ( $F_G > 0$ ).

Consider next the choice between an acquisition of a local firm by the MNE and a joint venture, where an acquisition is preferred if the profits earned under acquisition are larger than the combined profits of the MNE and the local firm under the joint venture (note that this guarantees that there exists a value of  $T_A$  such that total profits are positive for both the MNE and the local firm). This is characterized in the following condition:

$$\phi(d)\pi_0 - F_A \geq \lambda\phi(d)\pi_0.$$

Simplifying, this condition is written as:

$$\phi(d) \geq \frac{F_A}{(1 - \lambda)\pi_0} \equiv \phi_A. \quad (24)$$

In (24), a matched party prefers an acquisition to a joint venture when the match is of relatively high quality. In this case, the additional rents earned from the match are sufficient to overcome the fixed costs of integrating the local firm into the MNE.

Again, consider a polar case in which the fixed costs of integration are equal to zero. In this case, all matches that provide a non-zero benefit of specialization take the form of acquisitions rather than joint ventures. In this case, there are no additional fixed costs, and an acquisition provides the benefits of a match without the agency issues of two parties splitting revenues but making independent investments.

Finally, consider the choice between acquisition and greenfield investment. The former organizational form will be preferred over the latter if and only if:

$$\begin{aligned}\phi\pi_0 - F_A &> (1 + \delta)\pi_0 - F_G \\ \phi &> \frac{(1 + \delta)\pi_0 - F_G + F_A}{\pi_0} \equiv \phi'_A.\end{aligned}\tag{25}$$

Note that a high  $\delta$ , low  $F_G$ , or high  $F_A$  requires a better match to make acquisition preferred over greenfield investment. However, as we show below, this choice is redundant in our baseline equilibrium.

### 3.2 Equilibrium Sorting of Matches

In this subsection, we prove that there exists a range of exogenous parameters such that the least efficient matches are declined, mid-efficiency matches become joint ventures, and the most efficient matches result in acquisitions. Given the preference conditions above, this occurs if the following condition holds:

$$1 < \phi_{JV} < \phi_A < \hat{\phi},\tag{26}$$

where  $\hat{\phi} \equiv \phi|_{d=1/2}$  is the maximum possible benefit from a match.

To begin, consider the condition  $1 < \phi_{JV} < \hat{\phi}$ . As a function of the model's parameters, this condition can be simplified as:

$$\lambda\pi_0 < (1 + \delta)\pi_0 - F_G < \lambda\pi_0\hat{\phi}\tag{27}$$

$$\Leftrightarrow$$

$$\left(1 + \delta - \lambda\hat{\phi}\right)\pi_0 < F_G < (1 + \delta - \lambda)\pi_0.\tag{28}$$

Since  $\lambda\hat{\phi} \in (0, 1)$ ,  $F_G$  is bounded away from 0.

Next, consider  $\phi_{JV} < \phi_A < \hat{\phi}$ , which implies the following condition:

$$\frac{1 - \lambda}{\lambda}((1 + \delta)\pi_0 - F_G) < F_A < \frac{1 - \lambda}{\lambda}\lambda\hat{\phi}\pi_0.\tag{29}$$

Note that  $((1 + \delta)\pi_0 - F_G) < \lambda\hat{\phi}\pi_0$  is equivalent to (27) being satisfied. Hence, if joint ventures are chosen at all over greenfield investment, then there exists a range of  $F_A$  such that acquisitions also occur, but only for matches of the highest quality. This is intuitive, as

$F_A$  simply shifts up and down  $\Pi_A$ , where the slope of  $\Pi_A$  is fixed given match quality and is steeper than  $\Pi_{JV}$ . Hence, there exists a value of  $F_A$  such that  $\phi_{JV} < \phi_A < \hat{\phi}$ .

Finally, the above expressions imply that  $\phi_{JV} < \phi'_A$  and that  $\phi'_A < \phi_A$ . Indeed, substituting in the expressions for the cutoffs, we find that

$$\frac{(1-\lambda)}{\lambda} [(1+\delta)\pi_0 - F_G] < F_A, \quad (30)$$

which is precisely the left-hand side of expression (29).

Overall, we have the following proposition:

**Proposition 1** *Suppose that  $F_G$  and  $F_A$  satisfy (28) and (29). Then, for  $\phi \in (1, \phi_{JV})$  matches are immediately declined (and firms operate independently); for  $\phi \in (\phi_{JV}, \phi_A)$ , matches form joint ventures; and for  $\phi \in (\phi_A, \hat{\phi})$ , matches form acquisitions.*

Figure 2 provides a graphical representation of the equilibrium, and the shaded area in Figure 3 represents all the possible combinations of fixed costs  $F_G$  and  $F_A$  such that the equilibrium is the one described in Figure 2. We see that the marginal value of a high-quality match is higher for acquisitions than for joint ventures. This is due to the holdup problem that is present with joint ventures, and is key to understanding the equilibrium sorting of matches into entry modes. Specifically, the forgone profits due to the holdup problem are largest when the potential profits of the match are large. Hence, the MNE is willing to pay a fixed cost to solve the holdup problem and integrate the local firm into one entity that controls investment in all tasks.

Figure 2: Profits as a Function of Match Quality,  $\phi$

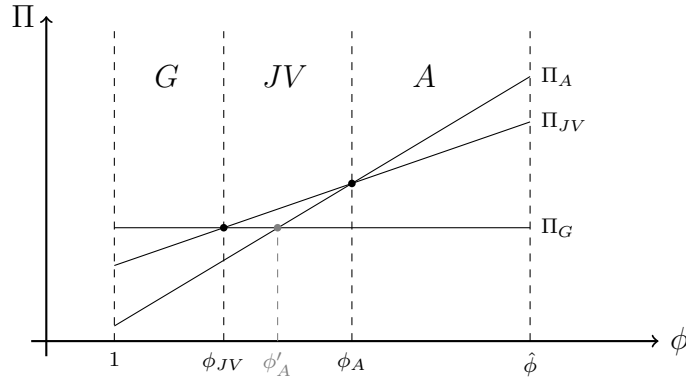
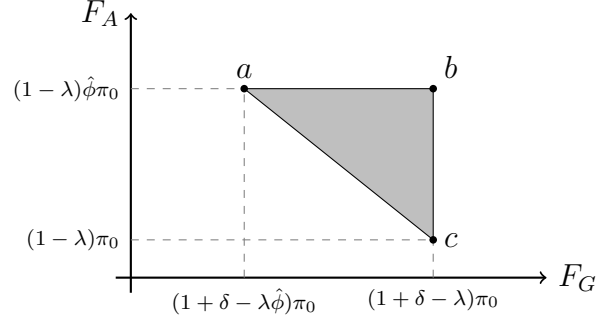


Figure 3: Conditions for  $F_G$  and  $F_A$



### 3.3 Comparison with Complete Contracts Setting

It is worth comparing the results above with the ones obtained in a complete contracts setting.

First, note that the profits under greenfield investment and acquisition will not change. However, the resulting profits of a joint venture will be:

$$\Pi_{JV}^{cc}(d) = \phi(d) \pi_0 > \lambda \phi(d) \pi_0 = \Pi_{JV}^{ic}(d). \quad (31)$$

Therefore, when both parties are able to agree to all contingencies in a contract, the resulting joint venture will receive higher profits than under incomplete contracts.

Additionally, note that  $\Pi_{JV}^{cc} = \pi_A$ . It follows that if  $F_A > 0$ , then  $JV$  dominates  $A$ . Therefore, with complete contracts, we need only compare  $G$  with  $JV$ . It is straightforward to check that  $JV$  is preferred to  $G$  if and only if

$$\begin{aligned} \phi(d) \pi_0 &> \pi_0 - F_G + \delta \pi_0 \\ \phi(d) &> \frac{(1 + \delta) \pi_0 - F_G}{\pi_0} \equiv \phi_{JV}^{cc}. \end{aligned} \quad (32)$$

Note that even though joint ventures entail no fixed costs and there are complete contracts, it is possible that greenfield investment may dominate  $JV$ . First, this may occur when the match is poor. Since the MNE must share profits with the local firm in a  $JV$ , the less-efficient greenfield investment may still provide greater total profits in equilibrium. Second, greenfield investment may dominate  $JV$  for all matches when the revenue function is sufficiently inelastic with respect to the execution of the idea. That is, even if the match



is exceptional, splitting profits after a match may not compensate the MNE for the forgone profits of operating independently when the efficiency boost from a match is constrained by an inelastic revenue function.

Further, note that in the special case of  $\delta = 1$  and  $F_G = 0$ , the inequality above needs  $\phi > 2$ , something that is feasible for a combination of high values of  $\beta$  and  $d$ . This is another difference from the incomplete contracts case, where  $\delta = 1$  and  $F_G = 0$  imply that greenfield investment dominates joint ventures.

We can find conditions for  $F_G$  such that both  $G$  and  $JV$  will be observed in equilibrium. In particular, this will be the case whenever

$$\begin{aligned} 1 &< \phi_{JV}^{cc} < \hat{\phi} \\ (1 + \delta - \hat{\phi}) \pi_o &< F_G < \delta \pi_0. \end{aligned} \tag{33}$$

These conditions are analogous to the incomplete contracts case (for  $\lambda = 1$ ). Comparing both conditions, we see that the interval range for  $F_G$  in the case of complete contracts is moved leftward relative to the incomplete contracts case.

Finally, note that  $\phi_{JV}^{cc} = \lambda \phi_{JV}^{ic}$ , so the cutoff at which joint ventures become profitable is smaller in the case of complete contracts. That is, some matches that form joint ventures under complete contracts would not be sustained under incomplete contracts.

## 4 Two-Period Model

In this section we present a simple two-period model to provide a theoretical rationale for one of the most salient features of international joint ventures, namely, their instability.<sup>6</sup>

Consider a two-period setting where the MNE faces options similar to the ones described in the previous section, but with two major differences. First, the MNEs differ in their  $\theta_i$ , that is, different MNEs have ideas of different qualities. Second, while choosing a mode of entry in the first period, the MNE does not know the quality of the match. Consequently, all MNEs make their first choice based only on their firm-specific  $\theta_i$ , assuming they have a match of “average” quality (that is,  $E_\phi \equiv \bar{\phi}$ ).

After the first period, the quality of the matches is revealed and firms take this into consideration to make their decisions for the final period. If an MNE chose  $JV$ , then it is

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<sup>6</sup>For example, Bleeke and Ernst (1995) find that nearly 80 percent of joint ventures end in a sale by one of the partners.

allowed to re-evaluate its strategy and, conditional on  $\theta_i$  and  $\phi(d)$ , it can choose to remain as a joint venture, to acquire the domestic partner, or to dissolve the match (and either become a standalone firm or exit the host country). We assume that if in the first period an MNE chose either  $A$  or  $G$ , it cannot switch later on. Implicitly, we are assuming that: (1) if the MNE chose to be a standalone firm rather than to have an “average” domestic partner, it would do so again in the second period under the same circumstances; (2) if the MNE chose to acquire a domestic firm, the internalization costs  $F_A$  are sufficiently large to make it unprofitable to seek a new partner.<sup>7</sup>

## 4.1 First Period

Let us first consider the profits that an MNE would earn under the different organizational choices. To simplify the algebra, assume that there is no discount factor, although this assumption does not affect the results.

If the MNE chooses to do greenfield investment, then the expected operational profit for the first period will be the following:

$$\pi_G = \theta_i \Gamma, \quad (34)$$

and the overall profit for the two periods will be:

$$\Pi_G = 2\theta_i \Gamma - F_G. \quad (35)$$

Similarly, the equivalent expressions for an acquisition will be the following:

$$\begin{aligned} \pi_A &= \theta_i \Gamma \bar{\phi}, \\ \Pi_A &= 2\theta_i \Gamma \bar{\phi} - F_A. \end{aligned} \quad (36)$$

Note that (35) and (36) imply that if  $F_G > F_A$ , then  $A$  will dominate  $G$  for any  $\theta$  value (so in this section we assume  $F_A > F_G$ ).

Finally, in the case of a joint venture, the expected overall profits can be written as:

$$\Pi_{JV} = \theta_i \Gamma \bar{\phi} \lambda + E \max \{JV, A, G, exit\}. \quad (37)$$

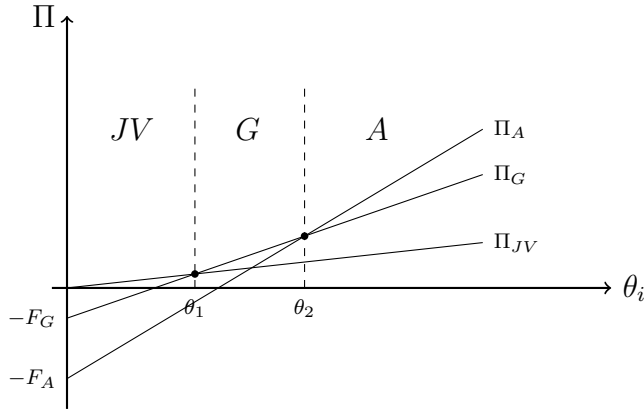
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<sup>7</sup>The setting presented next assumes a zero outside option for the domestic firm ( $\delta = 0$ ).

It is readily verifiable that the product  $\bar{\phi}\lambda \in (0, 1)$  and is decreasing in  $\beta$ . In the appendix we show that the slope of  $\Pi_{JV}$  is always smaller than the slope of  $\Pi_A$ . We also show that  $\Pi_{JV}$  is flatter than  $\Pi_G$ , provided that  $\beta$  is not too close to 1, that is, in terms of the profit function (1), provided that the quality of the idea ( $\theta$ ) is not irrelevant compared with its execution ( $Y$ ). We assume this to be the case throughout the section—otherwise, it could be the case that  $\Pi_{JV}$  is steeper than  $\Pi_G$ , in which case no MNEs would choose  $G$  in the first period.

With these characteristics, it follows that in the first period the MNEs with the low-quality ideas will enter the country as a joint venture, those with intermediate-quality ideas will enter through greenfield investment, and those with high-quality ideas will enter by acquiring a domestic firm.<sup>8</sup> Figure 4 provides the graphical representation of the outcome of the first period.

Figure 4: Profit Functions at  $t = 1$



We summarize these results in the following proposition.

**Proposition 2** *In the first period, provided that the above conditions are satisfied, multinationals with  $\theta \in (0, \theta_1]$  will form joint ventures, those with  $\theta \in (\theta_1, \theta_2]$  will pursue greenfield investment, and those with  $\theta > \theta_2$  will pursue acquisitions.*

<sup>8</sup>This prediction is consistent with the pattern that Javorcik and Saggi (2010) find in their data.

## 4.2 Second Period

After the first period, the quality of the matches is revealed and those firms that chose to form a joint venture can choose to reorganize or to remain in the joint venture.

The analysis at this point is fairly simple given that there is no uncertainty. Specifically, the profits from remaining in the joint venture are the following:

$$\pi_{JV} = \theta\Gamma\phi\lambda. \quad (38)$$

The profits from reorganizing by acquiring the domestic partner are:

$$\pi_A = \theta\Gamma\phi - F_A, \quad (39)$$

and the profits from leaving the partner and setting up as a standalone firm are the following:

$$\pi_G = \theta\Gamma - F_G. \quad (40)$$

It could also be the case that none of the alternatives is profitable, in which case, the MNE can abandon the joint venture and exit the country, making zero profits.

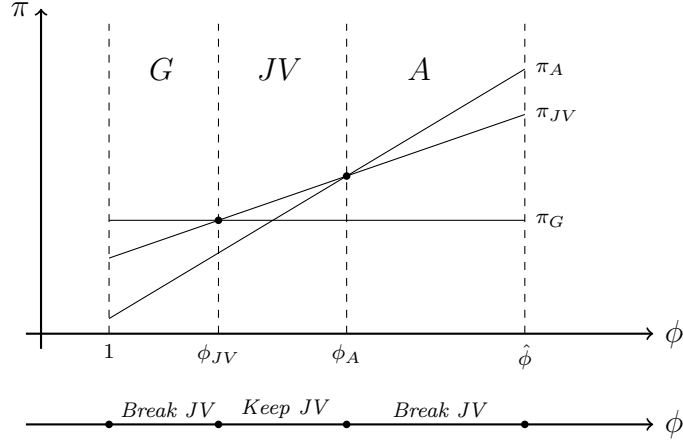
At this stage, the relevant parameter to look at is the product  $\theta\phi$ —that is, the combination of the quality of the idea,  $\theta_i$ , and the quality of the match between the MNE and the domestic partner,  $\phi(d)$ .

From the first-period analysis, we know that the  $\theta$ s of the MNEs that chose to form joint ventures will be relatively low. Let us fix the value of  $\theta$  and analyze what happens when the uncertainty about the match is lifted. Then, we can also study how these changes will vary depending on the specific value taken by  $\theta$ .

An MNE organized as joint venture faces a situation analogous to the one-period setting described in the previous section: upon observing the actual quality of the match, the firm can decide to remain in the joint venture or to reorganize the business, either through acquisition or as a standalone firm. This situation is represented by Figure 5.

From Figure 5 we learn that some of the joint ventures formed in the first period will be dissolved. In particular, if the match was of much greater quality than expected, then the MNE will find it profitable to acquire the domestic partner. If the quality of the match was well below expectations, the MNE will prefer to dissolve the joint venture and become a standalone firm.

Figure 5: Profit Functions at  $t = 2$



Formally, we have the following proposition.<sup>9</sup>

**Proposition 3 (JV Instability)** *Those MNEs that chose to form a joint venture in the first period will reorganize in the second period in one of the following ways.*

1. *If the actual quality of the match is  $\phi \in [1, \phi_{JV}]$ , the MNE will dissolve the joint venture and establish as a standalone firm.*
2. *If the actual quality of the match is  $\phi \in (\phi_{JV}, \phi_A]$ , the MNE will remain in the joint venture.*
3. *If the actual quality of the match is  $\phi \in (\phi_A, \hat{\phi}]$ , the MNE will dissolve the joint venture and acquire the domestic partner.*

The cutoffs  $\phi_{JV}$  and  $\phi_A$  are essentially the same as in the one-period model:

$$\phi_{JV} = \frac{\theta\Gamma - F_G}{\theta\Gamma\lambda}, \quad \phi_A = \frac{F_A}{\theta\Gamma(1 - \lambda)}.$$

It can be easily verified that  $\phi_{JV}$  depends positively on  $\theta$ , while  $\phi_A$  depends negatively on  $\theta$ . This is very interesting because it implies that, within the set of MNEs that chose a joint

<sup>9</sup>In Proposition 3 and Figure 5 we implicitly assume that the one-period profits obtained under greenfield investment are positive. If this were not the case, then joint ventures with bad matches would remain throughout the second period. Similarly, while we assume that the profits under an acquisition are positive for any match quality, this may not be the case.

venture, those with the best ideas (high  $\theta$ ) will dissolve the joint venture for a larger range of quality matches  $\phi$ . In contrast, those MNEs with worse ideas (low  $\theta$ ) will decide to keep the joint venture for a larger interval of match qualities.

**Proposition 4** *The most unstable joint ventures (those most likely to be dissolved) are those formed by MNEs with relatively high-quality ideas. The most stable joint ventures (the least likely to be dissolved) are those formed by MNEs with low-quality ideas.*

## 5 Conclusion

We have presented a model of foreign investment in which MNEs try to match up with firms in a local market. When the MNEs match, they choose between incomplete contractual relationships with no fixed costs (joint ventures) or common ownership with integration costs (acquisitions). When they fail to find a sufficiently good match, they instead undertake greenfield investment. In equilibrium, ex-ante identical multinationals enter the local matching market, and, ex post, three different types of ownership within a heterogeneous group of firms arise. In particular, the worst matches dissolve and the MNEs invest greenfield, the middle matches form joint ventures, and the best matches integrate via mergers and acquisitions.

We have also shown that joint ventures are more common when the host country produces products that are of inferior quality to those produced in the source country, which explains why MNEs use joint ventures more frequently in less-developed countries than in developed countries.

Finally, we extended the model to a simple two-period context to provide a rationale for one of the more salient features of joint ventures, namely, their instability. Indeed, we find that in the first period the MNEs with high-quality products choose whole ownership, while those with low-quality products choose joint ventures. In the second period, however, upon observing the quality of their matches, some MNEs will optimally choose to dissolve the joint venture. Moreover, we find that joint ventures are more unstable for MNEs that produce products of high quality than for those that produce low-quality products.

In future work, we intend to focus on the endogenous choice of the type of products that a firm brings to a local market as a function of the investment mode. Indeed, since many policies restrict the types of foreign investments that are permissible, this focus may elucidate the ramifications of such policies when technology transfer depends on the type of products that a firm brings into a local market.

## References

- Antràs, Pol, and Elhanan Helpman. 2008. “Contractual Frictions and Global Sourcing.” In *The Organization of Firms in a Global Economy*, eds. E. Helpman, D. Marin, and T. Verdier. Cambridge: Harvard University Press.
- Bleeke, Joel, and David Ernst. 1995. “Is Your Strategic Alliance Really a Sale?” *Harvard Business Review* 73(1): 97–105.
- Desai, Mihir A., C. Fritz Foley, and James R. Hines. 2004. “The Costs of Shared Ownership: Evidence from International Joint Ventures.” *Journal of Financial Economics* 73(2): 323–374.
- Gomes-Casseres, Benjamin. 1987. “Joint Venture Instability: Is It A Problem?” *Columbia Journal of World Business* 22(2): 97–102.
- Grossman, Gene, and Elhanan Helpman. 2005. “Outsourcing in a Global Economy.” *Review of Economic Studies* 72(1): 135–159.
- Hamel, Gary, Yves L. Doz, and C. K. Prahalad. 1989. “Collaborate with Your Competitors—And Win.” *Harvard Business Review* 67(1): 226–232.
- Inkpen, Andrew, and Paul W. Beamish. 1997. “Knowledge, Bargaining Power, and the Instability of International Joint Ventures.” *Academy of Management Review* 22(1): 177–202.
- Inkpen, Andrew, and J. Ross. 2001. “Why Do Some Strategic Alliances Persist Beyond Their Useful Life?” *California Management Review* 44(1): 132–148.
- Javorcik, Beata, and Kamal Saggi. 2010. “Technological Asymmetry Among Foreign Investors and Mode of Entry.” *Economic Inquiry* 48(2): 415–433.
- Killing, J.P. 1982. “How to Make a Global Joint Venture Work.” *Harvard Business Review* 60(3): 120–127.
- Kogut, Bruce. 1989. “The Stability of Joint Ventures: Reciprocity and Competitive Rivalry.” *Journal of Industrial Economics* 38(2): 183–198.
- Miller, Robert, Jack Glen, Fred Jaspersen, and Yannis Karmokolias. 1997. “International Joint Ventures in Developing Countries.” *Finance and Development* 34(1): 26–29.
- Raff, Horst, Michael Ryan, and Frank Stähler. 2009. “The choice of market entry mode: Greenfield investment, M&A and joint venture.” *International Review of Economics & Finance* 18(1): 3–10.
- Rauch, James E., and Vitor Trindade. 2003. “Information, International Substitutability, and Globalization.” *American Economic Review* 93(3): 775–791.

- Roy Chowdhury, Indrani, and Prabal Roy Chowdhury. 2001. "A Theory of Joint Venture Life-Cycles." *International Journal of Industrial Organization* 19(3-4): 319–343.
- Sinha, Uday Bhanu. 2001. "International Joint Venture, Licensing and Buy-Out under Asymmetric Information." *Journal of Development Economics* 66(1): 127–151.
- Steensma, H. Kevin, Jeffrey Q. Barden, Charles Dhanaraj, Marjorie Lyles, and Laszlo Tihanyi. 2008. "The Evolution and Internalization of International Joint Ventures in a Transitioning Economy." *Journal of International Business Studies* 39(3): 491–507.
- Volker, Nocke, and Stephen Yeaple. 2007. "Cross-border mergers and acquisitions vs. green-field foreign direct investment: The role of firm heterogeneity." *Journal of International Economics* 72(2): 336–365.



# Appendix

In this appendix we show that the slopes of the first-period profit functions are indeed as represented in Figure 4.

First, from equations (35) and (36) it is straightforward to check that the slopes of  $\Pi_G$  and  $\Pi_A$  are  $2\Gamma$  and  $2\Gamma\bar{\phi}$ , respectively.

Next, the slope of  $\Pi_{JV}$  is equal to

$$\frac{\partial}{\partial\theta}\Pi_{JV} = \Gamma\bar{\phi}\lambda + \frac{\partial}{\partial\theta}E_{\phi}\max\{\pi_{JV}, \pi_A, \pi_G\}. \quad (\text{A-1})$$

We are interested in finding an upper bound for the last term of the above expression.

We know that:

1. The derivative of the expectation is equal to the expectation of the derivative:

$$\frac{\partial}{\partial\theta}E_{\phi}[\max\{\cdot\}] = E_{\phi}\left[\frac{\partial\max\{\cdot\}}{\partial\theta}\right], \quad (\text{A-2})$$

2. The derivative of the maximum is bounded by the maximum of the derivatives:

$$\frac{\partial\max\{\pi_{JV}, \pi_A, \pi_G\}}{\partial\theta} \leq \max\left\{\frac{\partial\pi_{JV}}{\partial\theta}, \frac{\partial\pi_A}{\partial\theta}, \frac{\partial\pi_G}{\partial\theta}\right\} = \max\{\Gamma\phi\lambda, \Gamma\phi, \Gamma\} = \Gamma\phi, \quad \forall\phi. \quad (\text{A-3})$$

After taking expectations, we can rewrite the last expression as follows:

$$E_{\phi}\left[\frac{\partial\max\{\pi_{JV}, \pi_A, \pi_G\}}{\partial\theta}\right] \leq \Gamma\bar{\phi}.$$

Combining this expression with (A-2) we obtain the desired bound:

$$\frac{\partial}{\partial\theta}E_{\phi}\max\{\pi_{JV}, \pi_A, \pi_G\} \leq \Gamma\bar{\phi}. \quad (\text{A-4})$$

Therefore, combining equations (A-1) and (A-4), we conclude that the slope of  $\Pi_{JV}$  is bounded above by  $\Gamma\bar{\phi}(1 + \lambda)$ .

Given that  $\lambda \in (0, 1)$ ,  $\Pi_{JV}$  is always flatter than  $\Pi_A$ . Moreover, given that  $\bar{\phi}\lambda \in (0, 1)$  and is decreasing in  $\beta$ , it is readily verifiable that if  $\beta \leq 0.88$ , then  $\bar{\phi}(1 + \lambda) < 2$ , guaranteeing that  $\Pi_G$  is steeper than  $\Pi_{JV}$ .