

# International Joint Venture under Asymmetric Information: Technology vis-à-vis Information Advantage

By

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## Abstract

We study the relationship between a multinational corporation (MNC) and a domestic firm under demand uncertainty. The MNC possesses a superior production technology, but the domestic firm is better at predicting market demand. We examine how the MNC's preference for, and the ownership structure of, a joint venture depend on the credit market, demand uncertainty, the domestic firm's ability to gather demand information, the MNC's technology advantage, and the efficiency of technology transfer. We also consider a dynamic setting with technology spillover and show that whether technology spillover hinders or facilitates joint venture depends on the nature of the credit market.

**JEL Classification:** F23, L24, D86.

**Keywords:** International joint venture, MNC, demand uncertainty, technology spillover, credit market, principal-agent.

# 1 Introduction

International joint ventures (IJV) between companies in developing and industrialized countries have been an increasingly important business phenomenon. Miller et al. (1997) studied 76 IJVs in six developing countries. They found that more than 65% of the foreign companies chose domestic partners because of their knowledge of local politics, government regulations, local custom, and local markets, and more than 70% of the domestic firms in developing countries sought IJV with multinationals for their superior technology. However, it is frequently argued that the risk of technology spillover in developing countries hinders foreign direct investment and causes multinational corporations to prefer wholly-owned subsidiaries to IJVs in developing countries (Mansfield, 1994). In this paper, we formally study the effect of production technology, market information, and technology spillover on the formation of IJVs in developing countries.

We consider a simple model consisting of two firms: a multinational corporation (MNC) and a domestic firm. The firms produce a homogeneous product with uncertain market demand. The MNC possesses a superior production technology as compared to the technology of the domestic firm. However, the domestic firm can imperfectly predict the market demand through costly and non-contractable information gathering. We study the MNC's preference between forming an IJV with the domestic firm and establishing its own subsidiary to compete with the domestic firm. We show that the MNC's preference depends on the nature of domestic credit market, demand uncertainty, the domestic firm's ability to gather demand information, the MNC's technology advantage, and the efficiency of technology transfer. We also consider a dynamic setting where the domestic firm can improve its production technology in the second period through forming an IJV with the MNC in the first period. We study the effect of technology spillover on firms' profits under duopoly competition and joint venture, and on the MNC's preference.

When the credit market in the developing country is perfect, the MNC's decision

depends on the production technology of the IJV, i.e., the efficiency of technology transfer. When the technology transfer is perfect, the MNC always prefers IJV to duopoly competition. However, when technology transfer is imperfect, the MNC may prefer duopoly competition when the domestic firm's production technology is significantly inferior. In a joint venture, the MNC charges the domestic firm a lump-sum payment but offers it the entire profits of the IJV.<sup>1</sup> The domestic firm's ability to gather information increases its expected profits in the IJV but has no effect on the MNC's profits.

When the credit market in the developing country is imperfect, the MNC's preference for IJV depends on demand uncertainty, the domestic firm's access to credit and its ability to gather demand information. When the domestic firm's access to credit is severely constrained, the MNC prefers an IJV if the market uncertainty and the domestic firm's ability to gather information are either sufficiently low or sufficiently high. Otherwise, the MNC may prefer duopoly competition even if the technology transfer is perfect. In an IJV, the MNC charges the domestic firm a lump-sum payment and offers it a share of the IJV's profits. The domestic firm's share in the IJV profits increase as its ability to gather information increases. However, the MNC's expected profits can either increase or decrease in the domestic firm's ability to gather information.

When the domestic firm can improve its production technology in the second period through forming an IJV with the MNC in the first period, we show that this technology spillover raises the domestic firm's reservation profits in the second period but reduces it in the first period. Consequently, it has no effect on the MNC's expected profits in an IJV when the credit market is perfect. When the domestic firm's access to credit is constrained in both periods, the technology spillover reduces the MNC's expected profits in an IJV. However, the technology spillover raises the MNC's expected profits when the domestic firm's access to credit is constrained in the second period but not in the first period. Thus, our finding

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<sup>1</sup>This outcome is sometimes called licensing or franchising.

suggests that technology spillover in developing countries may not always hinder foreign investments, and can in fact facilitate it.

The importance of IJVs in today's globalized world has influenced substantial academic research on this issue, and a large theoretical literature has developed. Das (1999) considers a setting where a risk-neutral MNC and a risk-averse host firm expend efforts to produce a good in a competitive market. He analyzes the role of moral hazard, differences in attitude toward cost uncertainty, and the host country's policy toward the IJV in determining the MNC's optimal choice among joint venture, subsidiary and licensing. In contrast, we analyze a risk-neutral MNC's preference between IJV and duopoly competition with a risk-neutral domestic firm. We study the impact of moral hazard as well as demand uncertainty, the domestic firm's ability to gather demand information, the MNC's cost advantage, the efficiency of technology transfer, and the efficiency of domestic credit market on the MNC's decision. Sinha (2001) considers a dynamic setting where the host government imposes a restriction on foreign equity holdings in the first period but removes the restriction in the second period. It analyzes the role of the MNC's setup cost and its private information about its second period technology on its choice among joint venture, licensing, and wholly-owned subsidiary. Unlike Sinha (2001) where the firms' profits are exogenous under all situations, we analyze the effect of the domestic firm's information advantage and the MNC's technology advantage on firms' profits, and consequently on the MNC's preference between duopoly competition and joint venture without government intervention.<sup>2</sup> In the dynamic setting, we analyze the effect of technology spillover on firms' profits under duopoly competition and joint venture.

Asiedu and Esfahani (2001), Chan and Hoy (1991) and Lin and Saggi (2004) analyze the ownership structure of IJV where a MNC and a domestic firm possess complementary

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<sup>2</sup>In the past countries such as China and India used to allow foreign direct investments only in the form of IJV, and then put restrictions on foreign equity holdings. This regime has changed quite dramatically with these countries competing for foreign direct investments with many others. In China, for example, restrictions on foreign equity holding now applies only to a limited number of industries, and these too, under WTO rules, will need to be liberalized in the coming years.

inputs. In Chan and Hoy (1991) and Lin and Saggi (2004), firms cannot directly contract on their inputs, and they provide inputs non-cooperatively based on the profit-sharing arrangement. These studies show that, in equilibrium, the foreign equity share rises with the importance of foreign investor assets and declines with the contribution of local assets toward the project. Government policies and the institutional structure of the country also affect ownership structure.

Svejnar and Smith (1984) examine the microeconomic behavior of joint ventures established between MNCs and domestic partners in less developed countries. It focuses on the role of bargain power, transfer pricing, stock ownership and profit shares of the parties, and the responsiveness of IJVs to national development goals.<sup>3</sup> Darrough and Stoughton (1989) analyze the profit-sharing arrangement in joint ventures as a Bayesian bargaining game between two parents with incomplete information about each other's cost functions. They show that the outcomes call for equal allocation of realized joint venture net profit. Lee (2004) studies the foreign equity share of international joint ventures in a setting where a MNC and a domestic firm simultaneously decide their respective equity share and the time to exercise an irreversible investment project via Nash-bargaining.

In contrast to these studies, we analyze the international joint venture in a principal-agent framework. Furthermore, we do not presume the existence of a joint venture. Instead, our study emphasizes the role of the demand uncertainty, the domestic firm's information acquisition, efficiency of technology transfer, domestic credit market, and technology spillover on the MNC's preference for joint venture and the ownership structure of joint venture.

Our model also relates to some work on the impact of technology spillover on ownership structure in IJVs. Ethier and Markusen (1996) study a firm's choice between exporting, licensing, and acquiring a subsidiary abroad. They show that the firm may prefer costly exporting because of the technology spillover associated with producing abroad. Nakamura

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<sup>3</sup>Welfare implications of, and government policies toward, IJVs are analyzed in, for example, Farge and Wells, 1982; Katrak, 1983; Al-Saadon and Das, 1996; Roy Chowdhury and Roy Chowdhury, 2002; Das and Katayama, 2003; and Tomoda and Kurata, 2004.

and Xie (1998) study how technology-based firms utilize the ownership share in their foreign subsidiary as a mechanism to mitigate technology spillover. Consequently, the ownership share in their foreign subsidiary generally depends on the conditions under which their intangible assets are transferred to IJV as well as on their bargaining power relative to their domestic partners'. Muller and Schnitzer (2006) analyze the effects of a potential spillover on technology transfer of a multinational enterprise and on the host country policy. The potential of technology spillover induces the host country to attract the multinational enterprise with more favorable taxation and infrastructure. Consequently, spillovers must not always have negative effects on technology transfer and can be efficiency-improving under certain situation. In contrast to these studies, we show that technology spillover in developing countries may not hinder the formation of IJV, even in the absence of host-government policy interventions.

Our analysis also relates to several studies on the value of information in agency problems. Sobel (1993) and Dai et al. (2006) study the principal's preference regarding the agent's access to private information in agency models. In their models, the principal faces a fundamental trade-off between efficiency and rent extraction: the agent's better information improves efficiency but demands more information rents. They show that the principal always prefers a better informed agent if the agent acquires information after contracting but may prefer an uninformed agent if the agent acquires information before contracting. In contrast, we show that the MNC may prefer a less informed domestic firm even though the information is acquired after contracting.

Lewis and Sappington (1994) study a producer's preference regarding its buyers' private information about their tastes. The buyers' private information enables the producer to segment the market and charge higher prices to higher-value buyers, but can also provide rent to buyers. They find the producer prefers buyers to have either the best information or no information. In our model, improved information for the domestic firm increases the joint venture's profits but also increases its reservation profits. Similarly, we show that,

when the credit market is imperfect, the MNC prefers the domestic firm to have either best information or no information. Lewis and Sappington (1997) and Cremer et al. (1998) study how supply contracts are modified to motivate suppliers' acquisition of private information. In contrast, we analyze the impact of information acquisition on the ownership structure of joint ventures.

The remainder of the paper is organized as follows. Section 2 describes the central elements of our model. Section 3 discusses the outcome in duopoly competition. Section 4 analyzes the MNC's preference between joint venture and duopoly competition. Section 5 investigates the impact of technology spillover in a dynamic setting. Section 6 summarizes the results and concludes with future research directions.

## 2 Technology and Information

A multi-national corporation (MNC) and a domestic firm (firm D) produces a homogeneous product with an inverse demand function

$$p = \tilde{a} - bq,$$

where the demand parameter  $\tilde{a}$  is a binary random variable defined as:

$$\tilde{a} = \begin{cases} a_0 & \text{with probability } \phi \\ a_1 & \text{with probability } 1 - \phi. \end{cases} \quad (1)$$

Without loss of generality, we assume that  $a_0 < a_1$ .

Both firms are risk neutral. The foreign firm has a technology advantage in the sense that its constant marginal/average cost  $c_m$  is lower than that of the domestic firm which is denoted by  $c_d$ , i.e.,  $c_m < c_d$ . At the beginning of each period, both the MNC and the domestic firm know the distribution of  $\tilde{a}$ . However, the domestic firm has an information advantage in the sense that with efforts it can gather information to update its knowledge

on  $\tilde{a}$  before production actually takes place. To be more specific, if the domestic firm puts in an effort level of  $e$ , with probability  $\mu(e) = \alpha e$ , it discovers the realization of  $\tilde{a}$ ; but, with probability  $1 - \mu(e)$ , it obtains no further information on  $\tilde{a}$ .  $\alpha$  is a parameter measuring the domestic firm's efficiency in collecting information. The cost of the domestic firm's information gathering is  $C = e^2/2$ . However, the effort in gathering information is not observable and is a private information.

Having described the two firms and their relative advantages in costs and information, we shall now, before describing the joint-venture equilibrium, describe the benchmark model which will give us the reservation profit levels for the two firms.

### 3 The Benchmark: Duopoly Competition

Suppose the two firms engage in a two-stage Cournot competition. In the first stage, the domestic firm gathers demand information, and then in the second stage, the two firms compete on outputs, given their information on the demand condition.

In order to obtain a sub-game perfect equilibrium, we work with backward induction, starting with the second stage. In the second stage, the domestic firm's output strategy depends on its information on the demand parameter. First, when it fails to discover the realization of the demand parameter which has a probability of  $1 - \mu(e)$ , it makes its output decision based upon its prior belief on  $\tilde{a}$  and on the MNC's output strategy. In this case, the domestic firm's optimization problem is the following:

$$\underset{\bar{q}_d}{Max} \bar{\pi}_d = [\bar{a} - b(\bar{q}_d + \bar{q}_m) - c_d] \bar{q}_d, \quad (2)$$

where  $\bar{a} = E[\tilde{a}] = \phi a_0 + (1 - \phi)a_1$ , and  $\bar{q}_d$  and  $\bar{q}_m$  are the output levels of the domestic and the multi-national firm respectively. This optimization problem gives us the domestic firm's optimal output response function as  $\bar{q}_d = (\bar{a} - b\bar{q}_m - c_d)/(2b)$ .

Second, when the domestic firm discovers the realization of  $\tilde{a}$ , its optimization problem is the following:

$$Max_{q_d^i} \pi_{di} = [a_i - b(q_d^i + \bar{q}_m) - c_d] q_d^i, \quad (3)$$

where  $i = 0, 1$  denotes the realization of the demand parameter –  $a_0$  and  $a_1$  respectively. In this case, the domestic firm's optimal output response is  $q_d^i = (a_i - b\bar{q}_m - c_d)/(2b)$  for  $i = 0, 1$ .

The MNC chooses an output level to maximize its expected profits based upon its prior belief on  $\tilde{a}$  and on the domestic firm's output strategy. In particular, its optimization problem is the following:

$$Max_{\bar{q}_m} \bar{\pi}_m = \{\bar{a} - b[\bar{q}_m + (1 - \mu(e))\bar{q}_d + \mu(e)(\phi q_{d0} + (1 - \phi)q_{d1})] - c_m\} \bar{q}_m, \quad (4)$$

where  $\bar{q}_m + (1 - \mu(e))\bar{q}_d + \mu(e)(\phi q_{d0} + (1 - \phi)q_{d1})$  is the expected value of the domestic firm's output.

Consequently, the MNC's optimal output response is  $\bar{q}_m = \{\bar{a} - b[(1 - \mu(e))\bar{q}_d + \mu(e)(\phi q_d^0 + (1 - \phi)q_d^1)] - c_m\}/(2b)$ .

Therefore, at the equilibrium, both firms' output levels (under different scenarios) are the following:

$$\bar{q}_d = \frac{\bar{a} - 2c_d + c_m}{3b}, \quad (5)$$

$$q_d^0 = \frac{3a_0 - \bar{a} - 4c_d + 2c_m}{6b}, \quad (6)$$

$$q_d^1 = \frac{3a_1 - \bar{a} - 4c_d + 2c_m}{6b}, \text{ and} \quad (7)$$

$$\bar{q}_m = \frac{\bar{a} - 2c_m + c_d}{3b}. \quad (8)$$

At the equilibrium, both firms' outputs increase in (expected) demand condition and their competitors' marginal costs, but decrease in their own marginal costs. The domestic

firm's output depends on the expected demand condition when it fails to discover the demand condition, but varies with the demand condition when it successfully discovers the demand condition. Without loss of generality, we assume  $c_d \leq (3a_0 - \bar{a} + 2c_m)/4$  so that both firms will produce under all demand conditions. Formally,

**Assumption 1**  $c_d \leq (3a_0 - \bar{a} + 2c_m)/4$ .

The domestic firm's equilibrium profits depend on its information and the demand conditions. First, when it fails to discover the demand condition, its expected equilibrium profit is

$$\bar{\pi}_d = \frac{(\bar{a} - 2c_d + c_m)^2}{9b}. \quad (9)$$

Second, when it discovers the realization of demand parameter to be  $\tilde{a} = a_0$ , its profit is

$$\pi_d^0 = \frac{(3a_0 - \bar{a} - 4c_d + 2c_m)^2}{36b}, \quad (10)$$

and finally when it discovers the realization of demand parameter to be  $\tilde{a} = a_1$ , its profit is:

$$\pi_d^1 = \frac{(3a_1 - \bar{a} - 4c_d + 2c_m)^2}{36b}. \quad (11)$$

The expected equilibrium profit for the MNC is

$$\bar{\pi}_m = \frac{(\bar{a} - 2c_m + c_d)^2}{9b}. \quad (12)$$

This completes the second stage. In the first stage, the domestic firm chooses its effort level in information gathering based upon its expectation of equilibrium profits in the second stage. Its optimization problem is as follows:

$$\underset{e}{Max} \pi_d = \mu(e)(\phi\pi_d^0 + (1 - \phi)\pi_d^1) + (1 - \mu(e))\bar{\pi}_d - e^2/2, \quad (13)$$

where  $\bar{\pi}_d$ ,  $\pi_d^0$  and  $\pi_d^1$  are given in (9), (10) and (11) respectively and  $\mu(e) = \alpha e$ .

The solution of the optimal level of effort in the above problem is given by:

$$\begin{aligned} e &= \frac{\alpha \text{Var}(\tilde{a})}{4b}, \quad \text{where} \\ \text{Var}(\tilde{a}) &= \phi a_0^2 + (1 - \phi)a_1^2 - \bar{a}^2. \end{aligned} \quad (14)$$

We define the value of information,  $V$ , as the difference between the domestic firm's profits when information gathering is successful and when it is unsuccessful. Hence,

$$V = (\phi\pi_{d0} + (1 - \phi)\pi_{d1}) - \bar{\pi}_d = \text{Var}(\tilde{a})/(4b). \quad (15)$$

The domestic firm's maximum profit under duopoly competition, therefore, is

$$\begin{aligned} \pi_d &= \bar{\pi}_d + \alpha^2[\phi a_0^2 + (1 - \phi)a_1^2 - \bar{a}^2]^2/(32b^2), \\ \text{or, } \pi_d &= \bar{\pi}_d + \alpha^2 V^2/2. \end{aligned} \quad (16)$$

Therefore, the benefit of the domestic firm's superior information on demand condition is increasing in  $\alpha$  and  $\text{Var}(\tilde{a})$ .

**Proposition 1** *Under duopoly competition, the domestic firm's expected profit increases as the demand condition becomes more uncertain or the firm becomes more efficient in gathering information; however, the MNC's expected profit depends on neither the demand uncertainty nor the domestic firm's ability to gather information.*

The intuition is the following. The domestic firm's information on demand condition enables it to adjust its output downward when demand is low and upward when demand is high. Consequently, the domestic firm's gain in profit when the demand is high more than compensates its loss in profit when demand is low. Therefore, the domestic firm's profit is increasing and convex in the realization of demand condition., and its expected profit increases as the demand becomes more uncertain. As the domestic firm becomes more efficient in gathering information, it obtains the demand information more often for any given level of effort, which increases its expected profit. On the other hand, the MNC's

output decision is based on its expectation of demand condition and cannot vary with the realization of demand condition.. Consequently, its profit is increasing and linear with respect to the realization of demand condition. The domestic firm's information has two opposite effects on the MNC's expected profit: the domestic firm softens the competition by reducing output when demand is low and toughens the competition by raising output when demand is high. These two opposing effects turn out to offset each other. Moreover, as the demand uncertainty increases, so does the magnitude of these two effects. Consequently, the demand uncertainty and the domestic firm's information have no effect on the MNC's expected profit.<sup>4</sup>

## 4 Joint Venture

Having described the duopoly equilibrium, we are now in a position develop the international joint venture (IJV) equilibrium. We shall set it up in a principal-agent framework, with the MNC being the principal and the domestic firm as the agent.

As for the technology, we assume that in the joint venture, the marginal cost of production is a linear combination of the MNC's and the domestic firm's original marginal costs, i.e.,

$$c_j = \theta c_m + (1 - \theta)c_d,$$

where  $\theta \in [0, 1]$  measures the efficiency of technology transfer.

Since the domestic firm's effort in information gathering is unobservable to the MNC, the two firms cannot contract on the domestic firm's effort in gathering information. Consequently, the MNC must offer the domestic firm a contract to induce the latter's effort in information gathering. The timing of the model is the following:

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<sup>4</sup>Basar and Ho (1976), Ponssard (1979), Novshek and Sonnenschein (1982), Vives (1984), and Hwang (1993) study firms' incentives to acquire and disclose information on the demand function in an oligopolistic market. They show that the acquisition of such information is always beneficial to the firms and not disclosing information is a dominant strategy for each firm in Cournot competition when the goods are substitutes.

1. The MNC offers a contract  $\{T, s\}$  to the domestic firm, specifying the domestic firm's ex ante lump-sum payment to the MNC  $T$  (which can be negative) and the MNC's share of profit  $s$ .
2. The domestic firm decides whether to accept or reject the contract.
3. The nature determines the demand condition in the market.
4. The domestic firm gathers information on demand conditions.
5. The IJV determines the output level and production takes place.
6. Profits of the IJV are distributed between the two parties based on the contract.

The optimization problem for the IJV depends whether the domestic firm succeeds or fails to discover the demand condition. When the domestic firm fails to discover the demand condition, the IJV's optimization problem is

$$\underset{\bar{q}_j}{Max} \bar{\pi}_j = (\bar{a} - b\bar{q}_j + c_j)\bar{q}_j, \quad (17)$$

and in this case it can be shown that the joint venture's maximum profit is  $\bar{\pi}_j = (\bar{a} - c_j)^2 / (4b)$ .

When the domestic firm discovers the realization of the demand condition, the IJV's optimization problem is

$$\underset{q_j^i}{Max} \pi_j^i = [a_i - bq_{ji} - c_j]q_{ji}, \quad (18)$$

where  $i = 0, 1$ . In this case, the joint venture's maximum profit is  $\pi_j^0 = (a_0 - c_j)^2 / (4b)$  if  $\tilde{a} = a_0$ , and  $\pi_j^1 = (a_1 - c_j)^2 / (4b)$  if  $\tilde{a} = a_1$ .

Before establishing the optimal contract, it may be useful to derive the first best, and this we do in the next subsection.

## 4.1 The first-best solution

As a reference point, we first consider the optimal solution when the MNC can observe and contract on the domestic firm's effort in information gathering. In this case, the MNC can specify the amount of effort in information gathering in the contract. The MNC's optimization problem is

$$\underset{T,s,e}{Max} \Pi_m = s[\mu(e)(\phi\pi_{j0} + (1 - \phi)\pi_{j1}) + (1 - \mu(e))\bar{\pi}_j] + T \quad (19)$$

subject to

$$(1 - s)[\mu(e)(\phi\pi_{j0} + (1 - \phi)\pi_{j1}) + (1 - \mu(e))\bar{\pi}_j] - T - e^2/2 \geq \pi_d, \quad (20)$$

where  $\pi_d$  is defined in (16).

Constraint (20), which requires the domestic firm's expected profits in the IJV to be no less than its maximum expected profit under duopoly competition, guarantees the domestic firm's participation in the contract.

In the optimal solution we must have:

$$e^* = \alpha[(\phi\pi_{j0} + (1 - \phi)\pi_{j1}) - \bar{\pi}_j] = \alpha V. \quad (21)$$

The MNC offers the domestic firm a combination of  $s$  and  $T$  which drives the latter's profit to its reservation level. Substituting  $T$  from (20) (with equality) into (19) and using (21), we can obtain the MNC's maximum profits to be  $\bar{\pi}_j + \mu(e^*)[(\phi\pi_{j0} + (1 - \phi)\pi_{j1}) - \bar{\pi}_j] - \alpha^2 V^2/2 - \pi_d = \bar{\pi}_j + \alpha^2 V^2/2 - \pi_d$ . Thus, the domestic firm's and the MNC's profits, respectively, are

$$\Pi_d^* = \pi_d = \bar{\pi}_d + \alpha^2 V^2/2, \text{ and} \quad (22)$$

$$\Pi_m^* = \bar{\pi}_j + \alpha^2 V^2/2 - \pi_d = \bar{\pi}_j - \bar{\pi}_d. \quad (23)$$

## 4.2 The Optimal Contract

We now describe the optimal contract when the MNC cannot observe the domestic firm's effort in information gathering. Since the MNC cannot observe and contract on the domestic firm's effort in information gathering, it can no longer specify the effort level in a contract. The MNC's optimization is

$$\underset{T,s,e}{Max} \Pi_m = s[\mu(e)(\phi\pi_j^0 + (1-\phi)\pi_j^1) + (1-\mu(e))\bar{\pi}_j] + T \quad (24)$$

subject to

$$(1-s)[\mu(e)(\phi\pi_j^0 + (1-\phi)\pi_j^1) + (1-\mu(e))\bar{\pi}_j] - T - e^2/2 \geq \pi_d, \quad (25)$$

$$e = \arg \max_e \{(1-s)[\mu(e)(\phi\pi_j^0 + (1-\phi)\pi_j^1) + (1-\mu(e))\bar{\pi}_j] - T - e^2/2\}, \quad (26)$$

$$T \leq W, \quad (27)$$

where  $\bar{\pi}$  is defined after (17),  $\pi_j^0$  and  $\pi_j^1$  after (18), and  $W$  is the domestic firm wealth level including what it can borrow.

Constraint (25) guarantees the domestic firm's participation in the contract. Constraint (26) determines the domestic firm's effort in information gathering for a given contract. The third constraint (27) states the fact that the amount of *ex ante* payment is limited by the domestic firm's borrowing/wealth constraint.

From constraint (26), we get

$$e = \alpha(1-s)[(\phi\pi_j^0 + (1-\phi)\pi_j^1) - \bar{\pi}_j] = (1-s)\alpha V. \quad (28)$$

Substituting the above solution for  $e$  into the MNC's optimization problem, the MNC's optimization problem can be reduced to:

$$\underset{T,s}{Max} \Pi_m = s[\bar{\pi}_j + (1-s)\alpha^2 V^2] + T \quad (29)$$

subject to

$$(1 - s)[\bar{\pi}_j + (1 - s)\alpha^2 V^2] - T - (1 - s)^2 \alpha^2 V^2 / 2 \geq \pi_d, \quad (30)$$

$$T \leq W. \quad (31)$$

The properties of the optimal contract would depend on whether the domestic firm's borrowing constraint is binding or not. We shall now consider these two cases in turn

#### 4.2.1 Case 1: Perfect Credit Market

First, we consider the case where the domestic firm has unrestricted access to the credit market, i.e., constraint (31) is not binding. In this case, the optimal contract is given by

$$s = 0; \quad \text{and} \quad (32)$$

$$T = \bar{\pi}_j - \bar{\pi}_d. \quad (33)$$

In the optimal contract, the MNC maximizes its profit by charging the domestic firm an *ex ante* payment which equals the MNC's profits under the first-best, but offering the domestic firm the entire profits of the joint venture.<sup>5</sup> The domestic firm's effort level is  $e = (1 - s)\alpha V = \alpha V = e^*$ . Therefore, the domestic firm delivers the first-best level of effort in information gathering and achieves the first-best profits for the IJV.

The MNC's and the domestic firm's profits in this case are respectively:

$$\Pi_m = \bar{\pi}_j - \bar{\pi}_d, \quad \text{and} \quad (34)$$

$$\Pi_d = \pi_d = \bar{\pi}_d + \alpha^2 V^2 / 2. \quad (35)$$

Under the optimal contract, the domestic firm receives its reservation profits – its profits under duopoly competition, and the MNC receives the first-best profits of the joint venture minus the domestic firm's reservation profits.

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<sup>5</sup>This contract can be called licensing or franchising.

We now examine how the contract changes as the efficiency level of the domestic firm's information gathering — represented by the parameter  $\alpha$  — increases. Since  $\pi_d = \bar{\pi}_d + \alpha^2 V^2/2$  (see (16)) where  $\bar{\pi}_d$  is given in (9), it should be clear that an increase in  $\alpha$  increases the domestic firm's profits, but has no effect on the MNC's profits. This is because the domestic firm's ability to gather information increases the joint venture's profits and the domestic firm's reservation profits by the same amount. Consequently, the MNC's profits does not depend on the domestic firm's ability to gather information. We summarize these results in Proposition 2 (the formal proof is given in appendix A).

**Proposition 2** *When the credit market is perfect, the MNC charges the domestic firm a fixed payment only and the domestic firm receives the entire profit of the joint venture. The domestic firm's ability to gather information increases its own profit but has no effect on the MNC's profit.*

The MNC however may not take part in the IJV if its profits under IJV is lower than that under duopoly. In Proposition 3 we show that when the technology transfer is perfect, i.e.,  $\theta = 1$ , the MNC would prefer IJV to duopoly (appendix B has the proof). Formally:

**Proposition 3** *Under perfect credit markets, the MNC always prefers a joint venture to duopoly competition when the technology transfer is perfect.*

Next we derive a sufficient condition under which the MNC would still prefer IJV over duopoly even when technology transfer is completely absent, i.e.,  $\theta = 0$ . This sufficient condition also guarantees that IJV is the preferred option for the MNC for all values of  $\theta$ . However, if this sufficient condition is not satisfied, there exists a critical value of  $c_d$ , say  $\tilde{c}_d$ , such IJV is preferable to the MNC if  $c_d \leq \tilde{c}_d$ , and duopoly is preferable if  $\tilde{c}_d \leq c_d$  ( $\leq (3a_0 - \bar{a} + 2c_m)/4$ , because of assumption 1). These results are formally stated in proposition 4 below (the proof is given in appendix C).

**Proposition 4** *Under perfect credit markets and inefficient technology transfer, the MNC always prefers IJV to duopoly competition for all values of  $\theta$  if  $\Delta \equiv [\bar{a} + a_0 - 2c_m]^2 + [\bar{a} - a_0]^2 - [5\bar{a} - 3a_0 - 2c_m]^2/4 < 0$ . If  $\Delta \geq 0$ , then there exists a critical value of  $c_d$ ,  $\tilde{c}_d(\leq (3a_0 - \bar{a} + 2c_m)/4)$ , such that the MNC prefers IJV to duopoly when  $c_d < \tilde{c}_d$ , and duopoly to IJV when  $\tilde{c}_d \leq c_d$ . Furthermore, the critical value of  $c_d$ ,  $\tilde{c}_d$ , is an increasing function of the technology transfer parameter  $\theta$ .*

Note that when  $c_m \simeq 0$ ,  $4\Delta = -17\bar{a}^2 - (a_0)^2 + 30\bar{a}a_0$  which is positive when the difference between  $\bar{a}$  and  $a_0$  is small ( $p \simeq 1$ ), and is negative when the difference between  $\bar{a}$  and  $a_0$  is large, say  $\bar{a} = 2a_0$ .

The intuition behind Propositions 3 and 4 is the following. The formation of a joint venture eliminates the competition under duopoly. Therefore, the MNC always prefers joint venture to duopoly competition if the technology transfer is perfect. However, when the technology transfer is imperfect, the MNC faces the trade-off between less competition and higher cost of production. When the domestic firm's production cost increases, the MNC's benefit from less competition reduces and the IJV's cost of production increases. Consequently, the MNC prefers duopoly competition to joint venture if the domestic firm's production cost is sufficiently large.

#### 4.2.2 Case 2: Binding Borrowing Constraint

When the credit constraint is binding, the domestic firm's ability to make an *ex ante* payment is constrained by its access to credits,  $W$ , and the MNC cannot charge the domestic firm the same amount of *ex ante* payment as in the case perfect credit market. In this case, the MNC's optimal offer to the domestic firm a mixed contract: it charges the domestic firm an *ex ante* payment and it also offers the domestic firm a share of the joint venture's profits.

Under the optimal contract:

$$s = 1 - \frac{\sqrt{(\bar{\pi}_j)^2 + 2\alpha^2 V^2 (W + \pi_d)} - \bar{\pi}_j}{\alpha^2 V^2} > 0; \quad \text{and} \quad (36)$$

$$T = W. \quad (37)$$

Note that  $s$  in (36) is positive since  $W < \bar{\pi}_j - \bar{\pi}_d$ . Note that  $\bar{\pi}_j - \bar{\pi}_d$  is the amount of payment in the case of perfect credit markets (see (33)), i.e., a binding borrowing constraint implies that the maximum level of borrowing is less than the amount the domestic firm borrowed in the case of perfect credit markets.

The MNC's and the domestic firm's profits are respectively

$$\Pi_m = s[\bar{\pi}_j + (1-s)\alpha^2 V^2] + W; \quad \text{and} \quad (38)$$

$$\Pi_d = \pi_d = \bar{\pi}_d + \alpha^2 V^2 / 2. \quad (39)$$

Thus, under the optimal contract, the domestic firm still receives its reservation profits — its profits under duopoly competition, as was the case under perfect credit markets and the first best. However, under profit-sharing, the domestic firm's effort is  $e = (1-s)\alpha V < \alpha V = e^*$ , i.e., the domestic firm delivers less than the first-best level of efforts in information gathering.<sup>6</sup> Consequently, the profit of the joint venture is below the first-best level and the MNC receives a smaller profits than in the case of perfect credit markets.

Since  $\partial s / \partial W < 0$  according to (36), it follows that the MNC gives a smaller share of the joint venture profits to the domestic firm, and receives a smaller *ex ante* lump-sum payment from it, as the domestic firm's access to credits worsens, i.e., as  $W$  decreases. A smaller share of profits for the domestic firm further reduces the domestic firm's efforts in gathering information and therefore further reduces the joint venture's profits. Consequently, the MNC's profit declines as the domestic firm's access to credits worsens. We summarize these findings in Proposition 5 (a formal proof can be found in appendix D).

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<sup>6</sup>Note that the optimum effort level under perfect credit markets is the first-best level.

**Proposition 5** *When borrowing constraint is binding, the MNC receives an ex ante lump-sum payment plus a share of the joint venture's profit. The domestic firm receives its reservation profits and delivers less than the first-best level of efforts. The MNC receives a smaller profits as compared to the case of perfect credit markets, and its profits decline as the domestic firm's access to credit worsens.*

When the borrowing constraint is not binding, an increase in the efficiency level of the domestic firm's information gathering — represented by the parameter  $\alpha$  — increases its reservation profits and the joint venture's profits by the same amount. Consequently, the MNC's profits do not depend on the parameter  $\alpha$  (see proposition 2). However in the present case where the MNC receives a positive share of the IJV profits, an increase in  $\alpha$  has two opposite effects on the MNC's profits. On one hand, it increases the domestic firm's reservation profits, and this reduces the MNC's share of profits. On the other hand, a higher efficiency of information gathering together with a resultant larger share of profits for the domestic firms, provides it with more incentive to gather information and therefore to raise the joint venture's profits. When  $\alpha^2 V^2 < \bar{\pi}_j$ , the value of information, and consequently the domestic firm's share of profits, is relatively small, the former effect dominates the latter and the MNC's profit decreases as the domestic firm becomes more efficient in gathering information; however, when  $\alpha^2 V^2 > \bar{\pi}_j$ , the value of information, and therefore the domestic firm's share of profits, is relatively large, the latter effect dominates the former and the MNC's profit increases as the domestic firm becomes more efficient in gathering information.<sup>7</sup> We present this result in Proposition 6 (proof in appendix E).

**Proposition 6** *As the domestic firm's ability to gather information increases, the MNC's profit increases when  $\alpha^2 V^2 > \bar{\pi}_j$  but decreases when  $\alpha^2 V^2 < \bar{\pi}_j$ .*

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<sup>7</sup>Lewis and Sappington (1994) study a producer's preference regarding its buyers' private information about their tastes. Similarly, they show that the producer prefers buyers to have either the best information or no information.

Since the MNC receives a smaller profit when the credit constraint for the domestic firm is binding, it is no longer true that the MNC always prefers a joint venture to duopoly competition even when the technology transfer is perfect ( $\theta = 1$ ). The MNC's preference depends on the domestic firm's access to credit, its ability to gather information, and the market uncertainty. Proposition 7 presents a condition under which the MNC prefers a joint venture to duopoly competition when the technology transfer is perfect (proof is in appendix F).

**Proposition 7** *With binding borrowing constraint and perfect technology transfer, there exist  $0 < \beta_L \leq \beta_H$  such that the MNC always prefers joint venture if  $\alpha^2 V^2 \leq \beta_L$  or  $\alpha^2 V^2 \geq \beta_H$  but may prefer duopoly competition if  $\beta_L < \alpha^2 V^2 < \beta_H$ . Moreover,  $\beta_L$  and  $\beta_H$  converge as the domestic firm's access to credit increases.*

The intuition behind Proposition 7 is the following. When  $\alpha^2 V^2 \leq \beta_L$ , the domestic firm's reservation profits as well as its share of IVJ profits are small. In this case, even though the domestic firm does not have much incentive to gather information, the MNC prefers a joint venture to duopoly competition simply because the former eliminates competition. However, when  $\beta_L < \alpha^2 V^2 < \beta_H$ , the domestic firm's ability to gather information and therefore its reservation profits are bigger than those in the previous case ( $\alpha^2 V^2 \leq \beta_L$ ). However, the share of the domestic firm in IJV profits and thus its incentive to gather information are still relatively small. Consequently, the domestic firm's contributions to the joint venture via information gathering plus the benefit of less competition cannot compensate for the negative effect of the domestic firm's high reservation profits on the MNC's profits. Therefore, the MNC prefers duopoly competition to a joint venture in this case. When  $\alpha^2 V^2 \geq \beta_H$ , the domestic firm's ability to gather information and thus its reservation profits are even higher than those in the previous case ( $\beta_L < \alpha^2 V^2 < \beta_H$ ), but this time the domestic firm's share in IJV profits is also higher, provides it greater incentive to gather

information. In this case, the domestic firm's contribution to the joint venture plus the benefit of less competition more than compensates for the negative effect of the domestic firm's high reservation profits on MNC profits, and the MNC prefers a joint venture to duopoly competition.

## 5 Technology Spillover

In this section we extend the analysis of the preceding sections by considering a dynamic setting where the MNC interacts with the domestic firm in two consecutive periods. The link between the two periods is via possible spillover of technology within a joint venture. In particular, we assume that the domestic firm can improve its production technology and reduce its production cost in the second period through forming a joint venture with the MNC in the first period. This may give rise to the possibility that the domestic firm breaks away from the IJV at the beginning of the second period and compete with the MNC with an improved technology. We consider the effect of this type of technology spillover on the nature of the joint venture.

The domestic firm's marginal cost of production in the second period is  $c_d - \tau\Delta c$ , where  $\Delta c = c_d - c_m$  and  $0 \leq \tau \leq 1$ , when it forms a joint venture with the MNC in the first period. Therefore,  $\tau$  measures the rate of technology spillover. For simplicity, we assume the discount rate for both firms to be unity.<sup>8</sup>

In the absence of technology spillover, the MNC's overall inter-temporal optimization problem can be split into two identical optimization problems: one for each period.<sup>9</sup> However, when technology spillover occurs in the joint venture, the MNC's overall inter-temporal

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<sup>8</sup>When the discount rates of the two firms are higher than unity, but are the same, all our qualitative results will hold although the magnitude of the effect of technology spillover on the MNC's profits will be smaller. When the domestic firm discounts future profits by more (or less) than what the MNC does, the spillover, however, will become more costly (or beneficial) for the MNC and therefore the possibility of a IJV occurring will be lower (higher).

<sup>9</sup>Implicitly, we assume that profits of the domestic firm is spent by the end of the first period, and it does not add to its wealth ( $W$ ).

optimization problem can no longer be split into two identical problems, and we shall now describe the optimal contract.

First of all note that in the presence of technology spillover, in the second period, the domestic firm's reservation profits, i.e., maximum profits under duopoly competition is

$$\pi_{d2} = [\bar{a} - 2(c_d - \tau \Delta c) + c_m]^2 / 9b + \alpha^2 V^2 / 2. \quad (40)$$

The inter-temporal optimization problem facing the MNC is

$$\underset{T_1, s_1}{Max} \Pi_m = s_1[\bar{\pi}_j + (1 - s_1)\alpha^2 V^2] + T_1 + \Pi_{m2} \quad (41)$$

subject to

$$(1 - s_1)[\bar{\pi}_j + (1 - s_1)\alpha^2 V^2] - T_1 - (1 - S_1)^2 \alpha^2 V^2 / 2 + \pi_{d2} \geq 2\pi_d, \quad (42)$$

$$\text{and} \quad T_1 \leq W_1, \quad (43)$$

where  $\Pi_{m2}$  is the maximum value of the MNC's profits in second period, and is obtained from the following optimization problem:

$$\underset{T_2, s_2}{Max} \Pi_{m2} = s_2[\bar{\pi}_j + (1 - s_2)\alpha^2 V^2] + T_2 \quad (44)$$

subject to

$$(1 - s_2)[\bar{\pi}_j + (1 - s_2)\alpha^2 V^2] - T_2 - (1 - s_2)^2 \alpha^2 V^2 / 2 \geq \pi_{d2}, \text{ and} \quad (45)$$

$$T_2 \leq W_2. \quad (46)$$

Equation (45) is the no-breaking-away or continued-participation constraint. That is, with this constraint the MNC makes sure that the domestic firm has no incentive to break away from the IJV. Equation (42) is the overall or inter-temporal participation constraint: it says that the sum of profits in the two periods for the domestic firm is larger than or equal to what it would make in the two periods in the absence of IJV, which is two times

the duopoly profits with no technology spillover. Note that equation (42) can be rewritten as

$$(1 - s_1)[\bar{\pi}_j + (1 - s_1)\alpha^2V^2] - T_1 - (1 - S_1)^2\alpha^2V^2/2 \geq \pi_d - [\pi_{d2} - \pi_d],$$

which states that the reservation profits in the first period is  $\pi_d - [\pi_{d2} - \pi_d]$ , which is less than  $\pi_d$  since  $\pi_{d2} > \pi_d$ . That is, technology spillover raises the domestic firm's reservation profit in the second period, but lowers it in the first period.

The credit or wealth constraints (43) and (46) needs further explanations. Here we assume that any credit is taken at the beginning of a period and needs to be repaid at the end of that period. This is different from the usual treatment of credits in two-period macroeconomic models where credits are typically taken in the first period and is repaid out of second period's income.

As in the one-period setting, the MNC's optimal contract depends on the domestic firm's access to credit. When the credit market is perfect the MNC charges an *ex ante* payment but offers the domestic firm entire share of the joint venture's profit. This is true for both periods. If the credit market is perfect in period 2, then the profits of the MNC and the domestic firm in period 2 are  $\bar{\pi}_j + \alpha^2V^2/2 - \pi_{d2}$  and  $\pi_{d2}$  respectively. If the credit market is perfect in period 1, then the two profits in period 1 are  $\bar{\pi}_j + \alpha^2V^2/2 - [2\pi_d - \pi_{d2}]$  and  $2\pi_d - \pi_{d2}$  respectively.

When the credit constraint is binding, the situation vis-à-vis the domestic firm's profits in the two periods do not change. As for the MNC, if the credit constraint is binding in period 2, its profits are  $s_2^*[\bar{\pi}_j + (1 - s_2^*)\alpha^2V^2] + W_2$  where  $s_2^* = 1 - (\sqrt{\bar{\pi}_j + 2\alpha^2V^2(W_2 + \pi_{d2})} - \bar{\pi}_j)/(\alpha^2V^2)$ . Similarly, if the credit constraint is binding in period 1, it is  $s_1^*[\bar{\pi}_j + (1 - s_1^*)\alpha^2V^2] + W_1$  where  $s_1^* = 1 - (\sqrt{\bar{\pi}_j + 2\alpha^2V^2[W_1 + (2\pi_d - \pi_{d2})]} - \bar{\pi}_j)/(\alpha^2V^2)$ .

Therefore, the overall effect of technology spillover on the contract depends on the nature of the domestic firm's access to credits. We shall consider a number of scenarios in

relation to the credit market and examine the effect of technology spillover on the MNC's total profits.

## 5.1 Case 1: Perfect Credit Market in Both Periods

In this case, the MNC and the domestic firm's maximum total profit are  $\Pi_m = 2[\bar{\pi}_j + \alpha^2 V^2/2] - 2\pi_d$  and  $\Pi_d = 2\pi_d$ , respectively. The technology spillover raises the domestic firm's reservation profit in the second period but lowers it in the first period. Overall, it does not affect the domestic firm's reservation profits for the two periods. Therefore, the technology spillover has no effect on the MNC's total profits either.

## 5.2 Case 2: Binding Credit Constraint in at Least One Period

Suppose the credit market is inefficient in period  $i$ ,  $i = 1, 2$ . Then profits of the MNC in period  $i$ ,  $\Pi_{mi}$ , is  $s_i^*[\bar{\pi}_j + (1 - s_i^*)\alpha^2 V^2] + W_i$  where  $s_i^* = 1 - (\sqrt{\bar{\pi}_j + 2\alpha^2 V^2[W_i + Z_i]} - \bar{\pi}_j)/(\alpha^2 V^2)$  and  $Z_i$  represents the domestic firm's reservation profit in period  $i$ .

From the above expression for  $s_i^*$  and using the participation constraints, we get

$$\frac{ds_i^*}{dZ_i} = -\frac{1}{\bar{\pi}_j + (1 - S_i^*)\alpha^2 V^2}.$$

Then,

$$\frac{d\Pi_{mi}}{dZ_i} = [\bar{\pi}_j + (1 - 2S_i^*)\alpha^2 V^2] \frac{ds_i^*}{dZ_i} \quad (47)$$

$$= -\frac{[\bar{\pi}_j + (1 - 2S_i^*)\alpha^2 V^2]}{\bar{\pi}_j + (1 - S_i^*)\alpha^2 V^2}. \quad (48)$$

Therefore,

$$-1 < \frac{d\Pi_{mi}}{dZ_i} < 0, \quad (49)$$

as  $\bar{\pi}_j + (1 - 2S_i^*)\alpha^2 V^2 > 0$ .

Thus, one unit increase in the domestic firm's reservation profits in a period reduces the MNC's profit by less than one unit in that period in the presence of binding credit constraint, and by one unit if the credit market is perfect.

Furthermore,

$$\frac{d^2\Pi_{mi}}{dZ_i^2} = -\frac{\alpha^2 V^2 [\bar{\pi}_j + \alpha^2 V^2]}{[\bar{\pi}_j + (1 - S_i^*)\alpha^2 V^2]^2} < 0, \quad (50)$$

i.e., the MNC's profit in period  $i$  is convex in  $Z_i$ . It suggests that the MNC prefers the domestic firm's reservation profit to be consistent overtime when the credit constraint is binding in both periods.

When the credit constraint is binding in period  $j$  but not in period  $i \neq j$ , given the domestic firm's overall reservation profits, the MNC prefers the domestic firm to have a smaller reservation profit in period  $i$  but a larger reservation profit in period  $j$ . This is because a higher reservation profit for the domestic firm helps relax the credit constraint in period  $j$ . As a result, one unit increase in the domestic firm's reservation profit reduces the MNC's profit by one unit in period  $i$  but by less than one unit in period  $j$ . Therefore, the technology spillover benefits the MNC when the credit market is perfect in period 1 but not in period 2, but harms the MNC when the credit market is perfect in period 2 but not so in period 1. We summarize these finding in Proposition 8.

**Proposition 8** *Technology spillover has no effect on the MNC's profits when the credit markets are perfect in both periods, but reduces the MNC's profit when the credit constraint is binding in both periods. Furthermore, the technology spillover increases the MNC's profit when the credit market is perfect in period 1 but not so in period 2; and reduces its profit when the credit constraint is binding in period 1 but not so in period 2.*

## 6 Conclusion

International joint venture (IJV) is an important and significant mode of foreign direct investment. Why should a multinational corporation (MNC) seek a joint venture with an inefficient firm in a developing country? This question is at the heart of the present paper. The knowledge of local markets by domestic firms and superior technology of the MNE is thought to be important factors that bring about collaboration between the two parties, with both parties gaining from each others' advantages. However, in the theoretical literature, these two factors have not been considered together to explain the existence of IJVs. This paper fills this void in the literature.

We do so in the context of a principal-agent framework in which the principal (MNC) has technology advantage and the agent (the domestic firm) can predict, with some probability, uncertain market demand by spending efforts in non-contractable information gathering, which the MNE cannot. The levels of reservation profits for both firms are given by their profits in a duopoly competition. Under this framework, we examine under what scenarios the MNC would prefer an IJV rather than greenfield foreign direct investment (i.e., duopoly competition), and when an IJV does take place, we characterize the nature of the IJV contract, under different credit market scenarios.

When the credit market is perfect and the IJV technology is the same as the MNC technology (the case of perfect technology transfer), the MNC will always prefer IJV to greenfield investment. When the credit market is perfect, but the IJV technology is significant inferior to the MNC technology, the MNC may prefer duopoly competition to IJV. When IJV does take place, the IJV contract would involve a lump-sum payment by the domestic firm who in turn receives the entire profits of the IJV. In this case, domestic firm's efficiency in gathering information has no effect on the MNC's profits.

When the credit constraint is binding, the domestic firm would pay a smaller lump-

sum payment, but will not receive the entire IJV profits. In this case, the MNC may prefer duopoly even when the IJV technology is the same as the MNC technology. But, the MNC would prefer IJV to duopoly competition when the domestic firm's efficiency in information gathering is either sufficiently high or sufficiently low. Also, the MNC's profits may decrease as the domestic firm becomes more efficient in gathering information.

We also consider a dynamic setting, in which there is spillover of technology and there is a threat that the domestic firm may break away from the IJV in the second period. We find that this possibility may not always hinder the formation of an IJV, and sometimes can even facilitate it.

To summarize, we have found that whether or not IJV takes place, and when it does, the nature of the IJV contract, would depend on the nature of credit markets and on a number parameters such as the domestic firm's efficiency level in information gathering, demand uncertainty, and the extent of technology transfer in an IJV.

In this paper, we have left out government policies altogether. However, in a future work we plan to extend the the present analysis by considering government policy interventions.

## Appendix A: Proof of Proposition 2

The Lagrangian of the MNC's problem is the following:

$$\mathcal{L} = s[\bar{\pi}_j + (1-s)\alpha^2 V^2] + T + \lambda_1\{(1-s)\bar{\pi}_j + (1-s)^2\alpha^2 V^2/2 - T - \pi_d\} + \lambda_2\{W - T\}, \quad (\text{A.1})$$

where  $\lambda_1$  and  $\lambda_2$  are the Lagrangian multipliers for constraints (30) and (31), respectively.

Then the first order conditions are the following:

$$\mathcal{L}_s = [\bar{\pi}_j + (1-2s)\alpha^2 V^2] - \lambda_1[\bar{\pi}_j + (1-s)\alpha^2 V^2] = 0, \quad \text{and} \quad (\text{A.2})$$

$$\mathcal{L}_T = 1 - \lambda_1 - \lambda_2 = 0. \quad (\text{A.3})$$

When constraint (31) is not binding, (A.3) indicates that  $\lambda_1 = 1$  and  $\lambda_2 = 0$ . Then solving (A.2) we get  $s = 0$ . From constraint (30), we also find that  $T = \bar{\pi}_j + \alpha^2 V^2/2 - \pi_d$ . Finally, constraint (31) being not binding requires  $W \geq T = \bar{\pi}_j + \alpha^2 V^2/2 - \pi_d$ .

## Appendix B: Proof of Proposition 3

The MNC strictly prefers joint venture to duopoly competition if

$$\Pi_m = \bar{\pi}_j + \alpha^2 V^2/2 - \pi_d > \bar{\pi}_m, \quad \text{or} \quad (\text{B.1})$$

$$\frac{(\bar{a} - c_j)^2}{4b} > \frac{(\bar{a} - 2c_m + c_d)^2}{9b} + \frac{(\bar{a} - 2c_d + c_m)^2}{9b}. \quad (\text{B.2})$$

When the technology transfer is perfect,  $c_j = c_m$  and the above condition simplifies to

$$\frac{(\bar{a} - c_m)^2}{4} > \frac{(\bar{a} - 2c_m + c_d)^2 + (\bar{a} - 2c_d + c_m)^2}{9}. \quad (\text{B.3})$$

Define  $\varphi(c_d) \equiv [(\bar{a} - 2c_m + c_d)^2 + (\bar{a} - 2c_d + c_m)^2]/9$ . Since  $\varphi'(c_d) = (10c_d - 2\bar{a} - 8c_m)/9$  and  $\varphi''(c_d) \equiv 10/9 > 0$ ,  $\varphi(c_d)$  is strictly convex in  $c_d$  and is U-shaped. Furthermore,  $\varphi'|_{c_d=c_m} = 2(c_d - \bar{a})/9 < 0$  and  $\varphi|_{c_d=c_m} = 2(\bar{a} - c_m)^2/9 < (\bar{a} - c_m)^2/4$ . Thus, the inequality (B.3) is satisfied at  $c_d = c_m$ .

It can also be shown that,  $\varphi'|_{c_d=(\bar{a}+c_m)/2} = (\bar{a} - c_m)/3 > 0$  and  $\varphi|_{c_d=(\bar{a}+c_m)/2} = (\bar{a} - c_m)^2/4$ , which is the left hand side of (B.3). However, from assumption 1 and since  $a_0 < a_1$ , we have  $c_m < c_d \leq (3a_0 - \bar{a} + 2c_m)/4 < (\bar{a} + c_m)/2$ . Thus from the shape of the  $\varphi(c_d)$  function it follows that  $\varphi < (\bar{a} - c_m)^2/4$  for all  $c_d \in [c_m, (3a_0 - \bar{a} + 2c_m)/4]$ .  $\square$

## Appendix C: Proof of Proposition 4

Define  $\phi(c_d) \equiv (\bar{a} - 2c_m + c_d)^2/9 + (\bar{a} - 2c_d + c_m)^2/9 - (\bar{a} - c_j)^2/4$ . Following the proof of proposition 3, it follows from (B.2) that the MNC would prefer IJV to duopoly competition if and only if  $\phi(c_d) < 0$ .

It is easy to verify that  $\phi(c_d)|_{c_m=c_d} = 2(\bar{a} - c_d)^2/9 - (\bar{a} - c_j)^2/4 < 0$ . Moreover, the function also has the following property:

$$18\phi'(c_d) = [-4 + 9(1 - \theta)]\bar{a} - [16 + 9\theta(1 - \theta)]c_m + [20 - 9(1 - \theta)]c_d, \quad (\text{C.1})$$

$$18\phi''(c_d) = [20 - 9(1 - \theta)] > 0. \quad (\text{C.2})$$

Thus, the function  $\phi(c_d)$  is strictly convex and is either monotonically increasing or U-shaped. Moreover, since the maximum possible value for  $c_d$  is  $(3a_0 - \bar{a} + 2c_m)/4$  and an increase in the value of  $\theta$  decreases the value of  $\phi(c_d)$  for every level of  $c_d$ , if we can show that  $\phi(c_d)|_{c_d=(3a_0-\bar{a}+2c_m)/4, \theta=0} < 0$ , then  $\phi < 0$  for all admissible values of  $\theta$  and  $c_d$  and we can say that the MNC will always prefer IJV to duopoly competition. In fact, we have

$$\phi(c_d)|_{c_d=(3a_0-\bar{a}+2c_m)/4, \theta=0} = [\bar{a} + a_0 - 2c_m]^2 + [\bar{a} - a_0]^2 - [5\bar{a} - 3a_0 - 2c_m]^2/4 \equiv \Delta.$$

Thus,  $\Delta < 0$  is a sufficient condition for the MNC to prefer IJV over duopoly competition always. If  $\Delta > 0$ , then by continuity, there must a critical value of  $c_d$ ,  $\tilde{c}_d$ , such that IJV is preferable to the MNC if  $c_d \leq \tilde{c}_d$ , and duopoly is preferable if  $\tilde{c}_d \leq c_d \leq (3a_0 - \bar{a} + 2c_m)/4$ . Moreover, since  $\phi(c_d)$  decreases with  $\theta$  for every  $c_d$ ,  $\tilde{c}_d$  increases with  $\theta$  and as  $\theta$  is sufficiently large  $\tilde{c}_d$  becomes inadmissible (greater than  $(3a_0 - \bar{a} + 2c_m)/4$ ).  $\square$

## Appendix D: Proof of Proposition 5

When the credit constraint is binding,  $\lambda_2 > 0$ . From constraint (31), we then get  $T = W$ . It can be shown that constraint (30) is always binding in an optimal contract. As a result, the domestic firm always receives its reservation profit. Further, from constraint (30) it follows that

$$s = 1 - \frac{\sqrt{(\bar{\pi}_j)^2 + 2\alpha^2 V^2(W + \pi_d)} - \bar{\pi}_j}{\alpha^2 V^2}.$$

Since  $\sqrt{(\bar{\pi}_j)^2 + 2\alpha^2 V^2(W + \pi_d)} - \bar{\pi}_j > 0$ ,  $s < 1$ . Further,  $s > 0$  if  $W < \bar{\pi}_j + \alpha^2 V^2/2 - \pi_d$ . Finally,  $d\mathcal{L}/dW = \lambda_2 > 0$  by use of the Envelope theorem.  $\square$

## Appendix E: Proof of Proposition 6

From (38), we find

$$\frac{d\Pi_m}{d\alpha^2 V^2} = [\bar{\pi}_j + (1-s)\alpha^2 V^2] \frac{ds}{d\alpha^2 V^2} + s[(1-s) - \alpha^2 V^2 \frac{ds}{d\alpha^2 V^2}], \quad (\text{E.1})$$

from (36) we have,

$$\frac{ds}{d\alpha^2 V^2} = \frac{(1-s)^2 - 1}{2[\bar{\pi}_j + (1-s)\alpha^2 V^2]} < 0. \quad (\text{E.2})$$

Therefore,

$$\frac{d\Pi_m}{d\alpha^2 V^2} = -\frac{s^2[\bar{\pi}_j - \alpha^2 V^2]}{2[\bar{\pi}_j + (1-s)\alpha^2 V^2]}. \quad (\text{E.3})$$

Hence,

$$\frac{d\Pi_m}{d\alpha^2 V^2} \geq 0 \quad \text{according as} \quad \bar{\pi}_j \leq \alpha^2 V^2.$$

$\square$

## Appendix F: Proof of Proposition 7

Suppose the technology transfer is perfect, i.e.,  $\theta = 1$ . Given that the MNC always prefers a joint venture to duopoly competition when  $W \geq \bar{\pi}_j - \bar{\pi}_d$  (the case of perfect credit markets), by continuity, it also prefers a joint venture to duopoly competition when  $W$  is close to  $\bar{\pi}_j - \bar{\pi}_d$ .

Let us now consider another extreme value for  $W$ , viz.,  $W = 0$ . At this value of  $W$ , the MNC prefers joint venture if and only if

$$\Pi_m = [\bar{\pi}_j + (1-s)\alpha^2V^2] - (1-s)^2\alpha^2V^2/2 - \pi_d \geq \bar{\pi}_m, \quad \text{or} \quad (\text{D.1})$$

$$\bar{\pi}_j - \bar{\pi}_d - \bar{\pi}_m \geq s^2\alpha^2V^2/2. \quad (\text{D.2})$$

When  $\alpha^2V^2 = 0$ , from Proposition 3, we know that (D.2) holds at  $\theta = 1$ , i.e.,  $\Pi_m - \bar{\pi}_m > 0$ .

Let us now look  $\Pi_m - \bar{\pi}_m$  when  $\alpha^2V^2$  is very large. Substituting (36) for  $s$  provides

$$s^2\alpha^2V^2/2 = \frac{s}{2} \left[ (\bar{\pi}_j + \alpha^2V^2) - \sqrt{(\bar{\pi}_j)^2 + 2\alpha^2V^2\bar{\pi}_d + \alpha^4V^4} \right]. \quad (\text{D.3})$$

Notice that  $(\bar{\pi}_j + \alpha^2V^2) - \sqrt{(\bar{\pi}_j)^2 + 2\alpha^2V^2\bar{\pi}_d + \alpha^4V^4} < \bar{\pi}_j - \bar{\pi}_d$  since  $(\bar{\pi}_j)^2 + 2\alpha^2V^2\bar{\pi}_d + \alpha^4V^4 > (\bar{\pi}_d + \alpha^2V^2)^2$ . That is, the coefficient  $s$  on the right hand side of (D.3) is always a finite number. From (36) using (16), it can be shown that  $s$  converges to 0 as  $\alpha^2V^2$  converges to infinity. Thus the right hand side of (D.3) converges to 0 as  $\alpha^2V^2$  converges to infinity. It then follows that the left hand side of (D.3), viz.,  $s^2\alpha^2V^2/2$ , also converges to 0 as  $\alpha^2V^2$  converges to infinity. Hence, (D.2) holds when  $\alpha^2V^2$  converges to infinity.

From proposition 6, we know also that  $\Pi_m - \bar{\pi}_m$  is a U-shaped function of  $\alpha^2V^2 = 0$ . Thus, if  $\Pi_m - \bar{\pi}_m$  never takes a negative value, then of course joint venture is always preferred to duopoly (and  $\beta_L = \beta_H$ ). However, this cannot be guaranteed. Since  $\Pi_m$  is at its minimum

when  $\alpha^2 V^2 = \bar{\pi}_j$ . Condition (D.2) becomes

$$\bar{\pi}_j - \bar{\pi}_d - \bar{\pi}_m \geq s^2 \bar{\pi}_j / 2 \quad (\text{D.4})$$

at  $\alpha^2 V^2 = \bar{\pi}_j$ . From equation (36), we also know that  $s|_{W=0, \alpha^2 V^2 = \bar{\pi}_j} = 2 - (1 + 2\bar{\pi}_d / \bar{\pi}_j)^{1/2}$ . Substituting  $s|_{W=0, \alpha^2 V^2 = \bar{\pi}_j}$  into  $s^2 \bar{\pi}_j / 2$ , we can show that  $\bar{\pi}_j - \bar{\pi}_d - \bar{\pi}_m < s^2 \bar{\pi}_j / 2$  at  $c_d = c_m$  and  $c_d = (\bar{a} + c_m) / 2$ . That is, it is possible that for some parameter values there exists two values  $\beta_L$  and  $\beta_H$  where  $0 < \beta_L \leq \beta_H$  such that the MNC always prefer joint venture if  $\alpha^2 V^2 \leq \beta_L$  or  $\alpha^2 V^2 \geq \beta_H$  but prefer duopoly competition if  $\beta_L < \alpha^2 V^2 < \beta_H$ .<sup>10</sup> However, we cannot rule out the possibility that  $\beta_L = \beta_H$  so that duopoly is never preferred.

Since profits for the MNC is an increasing function of  $W$  (proposition 5),  $\beta_L$  and  $\beta_H$  converges to each other as  $W$  increases, and coincide when  $W$  is sufficiently close to  $\bar{\pi}_j - \bar{\pi}_d$ .  
□

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<sup>10</sup>It can be shown that  $\mu$  would still be less than 1 when  $\alpha^2 V^2 = \beta_H$  as long as either  $\alpha$  is sufficiently small or  $V$  is sufficiently large.

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