Joint Venture and Adoption of New Technology: The Effect of Bargaining, Control and Demand Shift*

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Abstract

We consider a joint venture between a local firm from a less developed country and a foreign multinational. In a dynamic two period model, we demonstrate that the availability of a new technology could trigger a joint venture breakdown. The outcome may also involve the new technology not being adopted at all. The possibility of joint venture breakdown is greater when the foreign firm has a large discount factor and the investment cost for the new technology is relatively small. Moreover, an upward shift of demand increases the likelihood of joint venture breakdown. On the other hand, neither control, nor bargaining power affects the incentive for joint venture breakdown. However, they do affect the pattern of technology adoption in case the JV survives. Finally, we show that an increase in the demand level could lead to the breakdown of the JV.

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1 Introduction

In recent years there has been a large increase in the number of international joint ventures (JVs from now on).[1] At the same time, however, joint ventures appear to be quite unstable. This instability has been documented in several works. Kogut (1989) finds that out of a sample of 92 US based JVs, about half had terminated their relation by the sixth year. In Killing (1982), out of the 37 international JVs surveyed, 36 were prone to breakdown. The average life span of a venture firm in Harrigan's (1988) study was only 3.5 years. The study by the McKinsey consultancy firm of more than 200 alliances show that the median life span of a venture firm is only seven years. Moreover, in more than 80% of the cases it ends with one partner selling its stake to the other (Bleake and Ernst, 1995). The survey by Miller et al. (1996) covers 70 JVs in six developing countries and finds that at least 27% of them were unlikely to survive. Cases of JV break down and instability in India are documented in Ghosh (1996) and Bhandari (1996-97), among others. Examples of such breakdown include the JVs between Procter & Gamble and Godrej, General Electric and Apar, Tata Sons and Unisys Corporation, to name a few.[2]

Joint venture instability could have several manifestations. It could take the form of renegotiating the existing contract, and even complete buyouts.[3] In this paper we study joint venture instability that takes the form of subsidiary formation by one of the partners.

This paper was motivated by some empirical facts regarding the linkage between the adoption of new technology, joint venture formation and joint venture instability. In their study Miller et al. (1996) find that acquisition of technology is one of the main motivations behind joint venture formation.[4] The technologically advanced partner firm transfers its superior technology to the JV. At the same time, however, technology transfer also seems to be a point of contention between the venture partners and often causes friction. The Miller et al. (1996) study points out that firms often cite conflict over technology as one of the main reasons behind joint venture instability. Lyles (1988) reports that adoption of new technologies by joint ventures led to conflicts later. In Ghosh (1996), it is shown that the MNC partners often open subsidiaries to

[1] Hergert and Morris (1988) and Pekar and Allio (1994) survey this phenomenon. The theoretical literature on international JVs includes, among others, Svejnar and Smith (1984), Marjit (1990), Chan and Hoy (1991), Singh and Bardhan (1991), Yu and Tang (1992), Al-Saadan and Das (1996), Das (1998) and Marjit and Mukherjee (2001).

[2] For a conceptual background and understanding of the problem of JV instability see, in particular, Gomes-casseres (1987), Dymsza (1988), Bleake and Ernst (1995), Miller et al. (1996) and Roy Chowdhury and Roy Chowdhury (2001a).

[3] Franco (1971) studies different forms of joint venture breakdown. He argues that in a broader sense, any unplanned changes in equity or profit shares, or a major reorganization of the venture structure, including a shift of control can also be interpreted as instability.

[4] See Marjit, Mukherjee and Kabiraj (2001) for a theoretical modelling of this idea.

safe guard their new technologies. For example, Unilever set up a wholly owned subsidiary even though it had controlling rights in Hindustan Lever. In case of adoption of a new technology, foreign firms often threaten to open a subsidiary using the new technology, rather than bring it to the JV. This indeed was the case in the joint venture between GEC and Alsthom (Ghosh, 1996). In this paper we try to model the idea that the adoption of new technology could lead to joint venture instability.

Another important objective of the paper is to study the impact of control and bargaining power on joint venture instability. Miller et al. (1996) suggest that control problems could lead to disputes regarding product lines, sourcing of raw materials, technology utilization etc. Geringer and Hebert (1989) study the effect of control structures on joint venture performances. Control, however, need not be necessarily identical with ownership. Beamish (1985) surveys several studies and finds that there is no tight connection between ownership and control. Thus in our study we assume that the control structure is exogenously determined. We study two extreme cases, one where there is MNC control regarding technology decisions, and the other where there is domestic firm control.

It has been argued that asymmetric bargaining power between partner firms can lead to joint venture instability (see, for example, Inkpen and Beamish, 1997). What determines the relative bargaining power of the two partner firms? While it may be argued that the foreign firms, with their superior technology and financial strength, have a greater bargaining power, several authors have argued that domestic firms sometimes have significant bargaining power since their contribution to the joint venture is important enough.[5] Moreover, with time, they have learnt how to negotiate with foreign MNCs. In this paper we consider two extreme cases, one where the MNC partner has all the bargaining power and the other where the domestic firm has all the bargaining power. Below we provide a summary of our main results.

We consider a dynamic two period model. There is an existing joint venture between an MNC and a local firm. Joint venture formation involves synergy whereby the MNC supplies the superior technology, whereas the domestic firm supplies a knowledge of local inputs.[6] We also assume that there is one-sided organizational learning by the local partner.[7] We show that depending on parameter values the outcome can be any one of the following: JV breakdown (i.e. subsidiary formation by the MNC), adoption of the new technology in the existing joint

[5]Among others Lall (1981), Bell and Scott-Kamiens (1985) and Desai (1985) have noted the growing bargaining power of the local firms. In the context of technology transfers in the Indian petrochemical industry, Ram (1990) mentions that licensing contracts are heavily biased in favor of the foreign firms.

[6]In a study of British joint ventures in India and Pakistan, Tomlinson (1970) finds that one of the main reasons behind such ventures is the local resources supplied by the domestic partner. See also Miller et al. (1996).

[7]On this issue, see Hamel et al. (1989), Hamel (1991), Mody (1993) and Beamish and Inkpen (1995).

venture and status quo. We find that JV breakdown is more likely when the discount factor is large and the cost of acquiring the new technology is small. If the investment cost is high, then adoption of the new technology in the existing JV is likely to occur, whereas status quo is the likely outcome if it is at an intermediate level.

The intuition behind subsidiary formation is as follows. In case the new technology is brought to the joint venture there is going to be one-sided learning, leading to the domestic firm appropriating all the surplus in the second period. The MNC, by subsidiary formation, can prevent this learning from taking place. Note that a higher discount factor increases the MNC's payoff from subsidiary formation. This, however, has no effect on the MNC's payoff from the joint venture, since the MNC gets no payoff in the second period. Hence an increase in the discount factor makes subsidiary formation more attractive.

As to the effect of bargaining power and control we find that the incentive for JV breakdown does not depend on either factor. The intuition is as follows. Whether a JV breaks up or not depends on the MNC's payoff from subsidiary formation and the JV's first period payoff. Since these are independent of control, or bargaining power, neither of these factors affect whether there is breakdown or not. However, in case a breakdown does not take place, these factors do affect whether the outcome involves status quo, or the adoption of the new technology by the JV. Suppose that adopting the new technology by the joint venture is the efficient outcome. In that case we find that the efficient outcome is more likely if the local firm has the bargaining power and the MNC has control, compared to the case where the MNC has both control, as well as bargaining power. Whereas if the local firm has control and the MNC has the bargaining power then the efficient outcome is less likely compared to the case where the MNC has both control, as well as bargaining power.

Finally, we study the impact of an increase in the demand level on joint venture instability. In the existing literature that explains the break down of JVs by means of synergy and learning, an increase in demand raises the chance of formation as well as the stability of JVs (e.g., Roy Chowdhury and Roy Chowdhury, 1999, 2001a, 2001b).[8] In contrast in our case under some parametric situations an increase in demand could lead to greater instability.[9]

Let us now briefly outline the theoretical literature on JV instability. The papers by Roy Chowdhury and Roy Chowdhury (1999, 2000, 2001b), Kabiraj (1999) and Lin and Saggi (2001) analyze JV instability in terms of synergy and learning. Roy Chowdhury and Roy Chowd-

[8]The empirical work by Hladik (1985) also shows a positive relation between stability and market demand. However, Hladik (1985) is in the context of R&D joint ventures.

[9]Marjit and Roy Chowdhury (2003) also finds that an increase in demand increases the incentives for subsidiary formation, but in equilibrium there is buy-out rather than subsidiary formation because the MNC can use subsidiary opening as a credible threat.

hury (1999) construct a two period model where in the first period firms simultaneously decide whether to form a JV, or compete in Cournot fashion. In case a JV forms, firms not only gain from complementary synergy and market concentration, but there is also organizational learning, whereby they also learn from each other. But learning reduces synergistic gains and hence increases the incentive for breakdown. The paper shows that the life-cycle of a JV depends on parameters like market size, the extent of learning and the discount factor. Roy Chowdhury and Roy Chowdhury (2000) extends the argument to the case where learning is one-sided rather than both sided. Roy Chowdhury and Roy Chowdhury (2001b) argue that joint venture formation leads to moral hazard problems. They show that JV breakdown occurs when the moral hazard cost of forming the JV outweighs the synergistic benefits. Kabiraj (1999), on the other hand, has constructed a model where initially a JV forms between a foreign firm and a local firm so as to combine the complementary strengths of each. He shows that if the JV competes with a third firm which acquires the knowledge embedded in the foreign input, then competitive pressure from this outside firm causes the JV to breakdown. The paper also determines the optimal timing of break down. Lin and Saggi (2001) assume that after forming a JV partners decide on the type of investment. If both invest in improving the supply of inputs, then synergy goes up and the JV is stable; if they invest in learning about each other's inputs, then synergy falls and there may be instability.

Sinha (2001a, 2001b) has constructed models of joint venture instability where instability is interpreted as payoff readjustments between the partners. Joint ventures form because of government restrictions on foreign equity holdings and government policy uncertainty. The subsequent instability is caused by both a change in government policy and the failure of the local firm to imitate its partner's knowledge. Finally, Kabiraj et al. (2001) develop a model where the source of instability lies in the incompatibility of the partners.

The paper is organized as follows. The second section defines the structure of the model. The third section solves the benchmark model where the foreign MNC has both control and bargaining power. Section 4 studies the effect of a change in control and bargaining power on the technology adoption and production organization. The demand shift effect is studied in the fifth section. The last section gives a summary of the results. Detailed proofs of some of the results are relegated to the appendix.

2 The Model

We consider a two period model, $t = 1, 2$. At $t = 1$ there is an existing joint venture (JV) between two firms, firm 1 and firm 2. Firm 1 is a foreign-based multinational company (MNC

from now on) and firm 2 is a local firm from a less developed country (LDC from now on). The MNC contributes a superior technology, better management practices, etc. to the joint venture, while the local firm provides access to the labor market and distribution channels, a knowledge of local conditions, etc. Hence joint venture formation leads to synergy whereby the two parent firms combine their efficiencies and produce more cheaply compared to either one of the parent firms.

We allow for lump sum transfer among the partner firms; hence the exact equity share holdings of the two parent firms in the JV is immaterial for our analysis.[10]

Let the marginal cost of production for the JV be $\overline{c}$. There is no other firm in the industry. Let $\pi(\overline{c})$ denote the monopoly profit of the JV.

The discount factor of the i-th firm is δ_i, where $0 \leq \delta_1, \delta_2 \leq 1$. We allow δ_1 and δ_2 to differ.[11]

There is organizational learning whereby the parent firms can acquire the skill level of its partner. In this paper we focus on the case where the local firm learns at a faster rate, that is, learning is asymmetric.[12] This assumption, however, is not too unrealistic. Note that many of the skills of the MNC firms, like better management practices etc. are transparent and codifiable. This makes imitation by the local firms easier. Much of the skills of the local firms, however, lie in local knowledge like access to local labor markets and distributional channels etc., which takes time to acquire. Sometimes cultural differences may make it difficult for the MNC managers to acquire such skills. Moreover, there are examples where the MNC partner makes a conscious decision not to acquire the skills of its local partner.[13] In our paper we focus on the extreme case where the domestic firm can acquire the skill of its MNC partner, but the MNC firm cannot acquire the skill of its local partner.

Since this is an existing JV, we assume that the old technology $\overline{c}$ has been in operation for

[10]The equity share may, however, play a role in determining which one of the parent firms controls the JV.

[11]That δ_1 and δ_2 could be different captures the idea that firms might differ about the valuation of future payoffs. For example, the LDC partners are often concerned about their immediate profits, whereas the foreign partners are more concerned about the long-term profits and hence they do not mind even if the immediate future profits are negative. Differing discount rates also capture the idea that the JV partners might have different attitudes regarding prospective future returns and different business cultures. Hofstede (1980), Harrigan (1988) and Kabiraj et al. (2001) study the relationship between joint venture instability, partner asymmetry and business cultural differences.

[12]There are a number of works that focus on asymmetric learning. See, for instance, Kumar and Nti (1988) and Larsson et al. (1998). The effect of one-sided learning on JV instability has been analyzed in Roy Chowdhury and Roy Chowdhury (2000).

[13]Of course, there can be cases where the MNC learns at a faster rate. For example, in the joint venture between Ralston Purina and Taiyo Fishing Corporation in Japan, Ralston Purina learned at a faster rate. The JV broke down when Ralston Purina decided that it had acquired a sufficient knowledge of local conditions (Beamish and Inkpen ,1995).

some time. Thus the local firm has already learnt the old technology. With a new technology learning by the local firm takes one period.

Firms are free to open subsidiaries using whatever technologies are available to them. For convenience we assume that there are no fixed costs of opening a subsidiary. However, our results go through qualitatively even if we allow for some fixed costs of subsidiary formation. We now describe the behavior of the firms when one of them decides to open a subsidiary.

First consider the hypothetical case where apart from the existing technology $\bar{c}$, no other technology is available. Since the local firm has already learnt the old technology, the marginal cost of the local firm in case of subsidiary formation will be $\bar{c}$. The marginal cost of the MNC will however be $\overline{d}$ ($> \bar{c}$) if it decides to open a subsidiary. This is because by assumption, the MNC cannot learn the skills of its local partner, and hence, in case of subsidiary formation has a higher marginal cost of production.

We assume that $\bar{c}$ is 'drastic' with respect to $\overline{d}$, in the sense that $\bar{c}$ is less than the monopoly price corresponding to $\overline{d}$.

Next we consider the situation where a new technology becomes available at $t = 1$ at a cost of $I > 0$. This cost includes the licensing fee of the new technology, as well as the fixed costs of installing the new technology. Moreover, because of its international connections, the MNC alone has access to this new technology and can open a subsidiary at $t = 1$ using the new technology.

The marginal cost after the adoption of the new technology depends on whether it is adopted by the MNC subsidiary, or by the JV. Since only the MNC has access to the new technology, the domestic firm cannot open a subsidiary using the new technology.[14] In case this technology is adopted by the MNC subsidiary, its marginal cost will be $\underline{d}$, where $\underline{d} < \bar{c}$. But if the new technology is adopted in the JV, then the JV's unit production cost is $\underline{c}$, where $\underline{c} < \underline{d}$. Note that $\underline{c} < \underline{d}$ reflects the fact that the skill specific to the local firm cannot be imitated by the MNC subsidiary. Moreover, $\underline{d}$ is drastic with respect to $\bar{c}$, which in turn is drastic with respect to $\overline{d}$. Since learning by the local firm requires one period, at the beginning of period $t = 2$ the local firm will have access to $\underline{c}$, whereas the MNC has access only to $\underline{d}$. Moreover, $\pi(\underline{c}) - I > 0$.

Assumption 1 below collects together our assumptions regarding the various cost parameters and allows us to abstract from the effect of product market competition if there are more than one firms in the market. Note that Assumption 1 goes through if we assume that there is price competition leading to limit pricing.

Assumption 1. *$\underline{c}$ is drastic with respect to $\underline{d}$, which again is drastic with respect to $\bar{c}$, which*

[14] Alternatively, it can do so but at a much higher fixed cost.

in turn is drastic with respect to $\overline{d}$.

Let us discuss some implications of this assumption.

First consider a situation where only the old technology $\overline{c}$ is available. Given that $\overline{c}$ is drastic with respect to $\overline{d}$ (Assumption 1), if the local firm opens a subsidiary with technology $\overline{c}$ and withdraws its knowledge from the JV, then it can reap the monopoly profit, $\pi(\overline{c})$. We assume that under this situation the existing JV will continue and the partners will not dismantle the structure, although the MNC will get nothing in this situation.

Next consider the situation where the new technology is adopted by the MNC subsidiary at $t = 1$. Given that $\underline{d}$ is drastic with respect to $\overline{c}$ (Assumption 1), the MNC subsidiary will become a monopoly with a payoff of $\pi(\underline{d})$. Moreover, since there is no organizational learning in case of subsidiary formation, the MNC will be a monopolist in the second period as well. Hence the JV and so the local firm will have a zero payoff in both the periods. Since the MNC can unilaterally decide to acquire the new technology and open a subsidiary, its reservation payoff is

$$V_s = \max\{(1 + \delta_1)\pi(\underline{d}) - I, 0\}. \tag{1}$$

Finally consider a situation where the new technology was adopted by the JV at $t = 1$. Given our assumption on learning at $t = 2$, the local firm can open a subsidiary using the technology $\underline{c}$. If the local firm withdraws its knowledge from the JV, then the JV will have a cost parameter of $\underline{d}$. Given that $\underline{c}$ is drastic with respect to $\underline{d}$ (Assumption 1), the local firm subsidiary can act as a monopolist.

We further assume that adopting the new technology (either by the MNC for its subsidiary or by the JV firm) in the second period is never profitable.

Assumption 2.
(i) $I > \pi(\underline{d})$.
(ii) $I > \pi(\underline{c}) - \pi(\overline{c})$.

Assumption 2(i) implies that adopting the new technology in the second period by the MNC for its subsidiary is not profitable, and assumption 2(ii) implies that adopting the technology in period 2 by the JV is not profitable. Hence we can restrict attention to the case where the technology is either adopted in period 1, or not at all.

The goal of the present paper is to examine the adoption pattern of the new technology, i.e. whether it will be adopted by the existing JV or by the MNC subsidiary, or not at all. We say that there is JV breakdown if the outcome involves subsidiary formation by the MNC. Henceforth the outcome where the new technology is adopted by the JV will be referred to as

JVN, and the outcome where the new technology is not adopted at all, either by the JV or by the MNC subsidiary, will be referred to as the status quo.

We also examine the sensitivity of the outcome to a change in 'control' and 'bargaining power' of the two firms.

We say that the MNC has control if it has the power to decide whether the new technology is to be adopted by the JV or not. Otherwise, we say that control lies with the local firm. Formally, if the MNC (respectively the local firm) has control, then in period 1 the MNC (respectively the local firm) decides whether to opt for the new technology or not.

We say that the MNC (respectively the local firm) has the bargaining power if, in the case of adoption of the new technology, the local firm (respectively the MNC) is pushed down to its reservation payoff. Formally, if the MNC (respectively the local firm) has bargaining power, then it can make a take-it-or-leave-it offer to the local firm (respectively the MNC). Thus in our analysis we de-link control and bargaining power of the parent firms.

Clearly, depending on which firm has control and bargaining power, several different scenarios are possible. In the benchmark model considered in the next section we assume that the MNC has control, as well as bargaining power. We shall also consider two variations of this benchmark model. We solve for subgame perfect Nash equilibrium of these games. Given the complexity of these games, the game forms will be described in the appropriate sections below.

Before we proceed any further let us introduce some further notations. We define I_1, I_2, I_3 and δ_1^* as follows:

$$\begin{aligned} I_1 &= \pi(\underline{c}) - \pi(\bar{c}), \\ I_2 &= (1+\delta_1)\pi(\underline{d}) - \pi(\bar{c}), \\ I_3 &= (1+\delta_1)\pi(\underline{d}), \\ \delta_1^* &= \begin{cases} \frac{\pi(\underline{c})}{\pi(\underline{d})} - 1, & \text{if } 2\pi(\underline{d}) > \pi(\underline{c}), \\ 1, & \text{otherwise.} \end{cases} \end{aligned} \tag{2}$$

Thus I_1 is the maximum (gross) surplus that could be generated in the JV in a single period by adopting the new technology. Similarly, I_3 is the (gross) present discounted value of the payoff to the MNC subsidiary and I_2 is the difference between I_3 and the one period JV payoff from status quo. Finally, δ_1^* defines the level of impatience of the MNC such that if δ_1, that is, the discount factor of the MNC, is greater than the critical level, then the JV cannot meet the MNC's reservation payoff from its single period payoff from the new technology.

The following observations are straightforward.

(a) Suppose $V_s > 0$. Then $I \geq I_2$ if and only if $\pi(\bar{c}) \geq V_s$.

(b) $I \geq I_3$ if and only if $V_s = 0$.

(c) $I_2 < I_3$.

(d) Finally, it is easy to check that

$$\begin{aligned} \delta_1 &\geq \delta_1^* \Rightarrow I_1 \leq I_2 < I_3, \\ \text{and } \delta_1 &< \delta_1^* \Rightarrow I_2 < I_1, I_3. \end{aligned} \tag{3}$$

Below we provide two examples where $\delta_1^* < 1$. This is important because later on we show that a necessary condition for the JV breakdown is that δ_1 be greater than δ_1^*, which is only possible if $\delta_1^* < 1$.

Example (i) Let the demand function be $q(p) = A - p$ and the cost function be $C(q) = cq^2$. Then the monopoly profit is $\pi_m(c) = \frac{A^2}{4(1+c)}$. Note that the condition $2\pi(\underline{d}) > \pi(\underline{c})$ reduces to the condition $1 + 2\underline{c} > \underline{d}$. Moreover, the condition that $\underline{c}$ is drastic vis-a-vis $\underline{d}$, simplifies to $A < \frac{2\underline{d}(1+\underline{c})}{1+2\underline{c}}$. Consider any $\underline{c}$ and $\underline{d}$ such that $1 + 2\underline{c} > \underline{d}$. Clearly, given these values we can find some A satisfying the condition that $A < \frac{2\underline{d}(1+\underline{c})}{1+2\underline{c}}$.

Example (ii) Let the demand and cost functions be respectively $q(p) = Ap^{-\alpha}$ and $C(q) = cq$, $A > 0,\ \alpha > 1,\ c > 0$. Then the monopoly profit is $\pi_m(c) = \frac{A}{\alpha^\alpha}[\frac{\alpha-1}{c}]^{\alpha-1}$. The condition that $\underline{c}$ is drastic relative to $\underline{d}$ means $p_m(\underline{c}) < \underline{d} \Leftrightarrow \frac{\underline{c}}{\underline{d}} < \frac{\alpha-1}{\alpha}$. On the other hand, the condition $2\pi(\underline{d}) > \pi(\underline{c})$ means $\frac{\underline{c}}{\underline{d}} > [\frac{1}{2}]^{1/(\alpha-1)}$. It is easy to check that both these conditions can hold for some parametric situations. For instance, $\alpha = 1.5$, $\underline{c} = 1$ and $\underline{d} = 3.5$ satisfy both these inequalities.

In what follows we assume that $2\pi(\underline{d}) > \pi(\underline{c})$, so that $\delta_1^* < 1$. This is for expositional reasons alone.

3 Both Control and Bargaining Power with the MNC

In this section we examine the benchmark model where the MNC has both control and bargaining power. MNC control is formalized by the assumption that it is the MNC which decides whether the new technology is to be adopted by the JV or not. The bargaining power assumption is formalized by assuming that in every period it is the MNC that offers a contract to the local firm. The local firm just decides whether to accept the contract or not.

We then describe the sequence of actions in this case. The game tree is portrayed in Figure 1 below.

(Figure 1 about here)

At $t = 1$ the MNC decides whether to acquire the new technology or not. In either case the MNC makes an offer to its local partner, where the offer specifies the sharing rule regarding

the split of the first period JV profits among the MNC and its local partner. If the offer is accepted, then production takes place, the payoffs are distributed according to the agreed upon sharing rule and the game goes to the next period. In case the offer is rejected, then the MNC decides whether to open a subsidiary or not. If there is subsidiary formation by the MNC, then it operates as a monopolist in both the periods with a marginal cost of $\underline{d}$. If it does not form a subsidiary, then the local firm decides whether to open a subsidiary or not. If there is subsidiary formation by the local firm, then it operates as a monopolist in both the periods with a marginal cost of $\overline{c}$.

If there is no subsidiary formation at $t = 1$, then, at $t = 2$, the MNC again makes an offer to the local firm. If it is accepted, then the offer is implemented, whereas if it is rejected then the local firm opens a subsidiary. Note that the game tree rules out the possibility that the new technology can be adopted at $t = 2$, either by the JV or by the MNC subsidiary. This is for expositional convenience since, given Assumption 2, the new technology is not going to be adopted at $t = 2$ anyway.

We then solve for the subgame perfect Nash equilibrium of this game. As usual the solution involves backwards induction.

To begin with recall that in case the MNC opens a subsidiary with the new technology, then it will have an aggregate profit of $(1 + \delta_1)\pi(\underline{d}) - I$.

There are two cases to consider.

Case 1. $I < I_3$, so that $V_s = (1 + \delta_1)\pi(\underline{d}) - I > 0$.

First consider the case where the MNC decides to opt for JVN. At $t = 1$ the MNC makes an offer of $(\pi(\underline{c}) - I, 0)$. The local firm accepts this offer, otherwise the MNC opens a subsidiary when the local firm has a payoff of zero.[15] At $t = 2$, however, there is complete learning by the local firm, so that it can open a subsidiary and obtain $\pi(\overline{c})$. Thus the local firm can use the threat of opening a subsidiary to appropriate the whole of the surplus at $t = 2$. Hence under JVN the MNC has an aggregate payoff of $\pi(\underline{c}) - I$. Note that for the MNC its aggregate payoff from JVN exceeds that under subsidiary formation (by the MNC at $t = 1$), provided $\pi(\underline{c}) - I \geq (1 + \delta_1)\pi(\underline{d}) - I$, i.e. $\delta_1 \leq \delta_1^*$.

We then consider the case where the MNC decides to opt for status quo. Again, the MNC can use the threat of opening a subsidiary to appropriate the whole of the payoff at $t = 1$. Similarly the local firm can appropriate the whole of the JV payoff at $t = 2$. Hence under status quo the MNC has a payoff of $\pi(\overline{c})$. For the MNC its aggregate payoff from status quo exceeds that under subsidiary formation at $t = 1$, provided $\pi(\overline{c}) \geq (1 + \delta_1)\pi(\underline{d}) - I$, i.e. $I \geq I_2$.

[15]Note that if the MNC does not open a subsidiary then in the continuation game the MNC has a payoff of zero.

The following observations are now straightforward:

(i) Suppose that $\delta_1 > \delta_1^*$ and $I_1 < I < I_2$. Then compared to MNC subsidiary, neither JVN, nor status quo is more profitable. Thus there will be subsidiary formation by the MNC at $t = 1$ when the MNC has an aggregate payoff of $(1 + \delta_1)\pi(\underline{d}) - I$ and the local firm has a payoff of zero.

(ii) Suppose $\delta_1 \leq \delta_1^*$ and $I_1 < I < I_2$. Here status quo is less profitable compared to subsidiary but JVN dominates subsidiary, since $I < I_2$. Therefore, in this case the MNC will opt for JVN. Under JVN the MNC has an aggregate payoff of $\pi(\underline{c}) - I$ and the local firm has an aggregate payoff of $\delta_2\pi(\underline{c})$.

(iii) If $\delta_1 > \delta_1^*$ and $I_3 > I \geq I_2$, then the outcome involves status quo because status quo dominates subsidiary which in turn dominates JVN. Under status quo the MNC has an aggregate payoff of $\pi(\overline{c})$, and the local firm has an aggregate payoff of $\delta_2\pi(\overline{c})$.

(iv) If $\delta_1 \leq \delta_1^*$ and $I_3 > I \geq I_2$, then the outcome involves status quo since, from Assumption 2(ii), the MNC's payoff under status quo (i.e. $\pi(\overline{c})$) is greater than its payoff under JVN (i.e. $\pi(\underline{c}) - I$). In this case the MNC has an aggregate payoff of $\pi(\overline{c})$, and the local firm has an aggregate payoff of $\delta_2\pi(\overline{c})$.

Case 2. $I \geq I_3$, so that $V_s = 0$.

Then the MNC is never going to open a subsidiary at $t = 1$. However, if the new technology is adopted for the JV, the same argument as in case 1 establishes that the MNC has a profit of $\pi(\underline{c}) - I$. In case of status quo, however, the MNC's payoff in period 1 is zero, since the threat of opening a subsidiary is not credible. Thus the aggregate payoff of the MNC is zero. Since $\pi(\underline{c}) - I > 0$, the MNC will adopt the new technology in the joint venture.

Summarizing the above analysis we obtain our first proposition.

Proposition 1. *Suppose that the MNC has both control and bargaining power.*

(a) Suppose that $\delta_1 > \delta_1^*$. Then the equilibrium involves subsidiary formation if $I_1 < I < I_2$, status quo if $I_2 \leq I < I_3$ and adoption of the new technology by the joint venture if $I \geq I_3$.

(b) Suppose that $\delta_1 \leq \delta_1^*$. Then the equilibrium involves status quo if $I < I_3$, otherwise there is adoption of the new technology by the joint venture.

Thus depending on the parameter configuration the outcome may or may not involve JV breakdown. Moreover, in case there is no breakdown, the new technology may or may not be adopted by the JV. Als0, note that JV breakdown is more likely if δ_1 is relatively large. The intuition is as follows. Since only the MNC has access to the new technology, it can always open a subsidiary by adopting the new technology for the subsidiary. This defines its reservation payoff, which is the present discounted value of the subsidiary's payoff. Moreover, the larger

is δ_1, the larger is the MNC's reservation payoff. JV breakdown occurs when the JV fails to meet the reservation payoff of the MNC from the first period JV profits. Hence the breakdown possibility arises only when δ_1 is large.

Interestingly, note that JVN is more likely if I is large. The intuition is as follows. For I large $V_s = 0$, so that the threat of subsidiary formation is absent. Thus the MNC's payoff from status quo decreases to zero since it cannot credibly threaten to open a subsidiary. This makes JVN more attractive to the MNC compared to status quo.

4 Effect of Control and Bargaining

In this section we study the effect of control and bargaining power on the pattern of technology adoption and JV instability.

4.1 MNC Control, Local Firm has Bargaining Power

In this subsection we consider the scenario where the MNC retains control over the JV firm, but the bargaining power lies with the local firm. This is formalized by considering a game tree where, in both the periods, the local firm makes a take-it-or-leave-it offer to the MNC. The full game tree has been presented in Figure 2 below.

(Figure 2 about here)

We then solve for the subgame perfect Nash equilibrium of this game. We can mimic the argument in Proposition 1 earlier to arrive at Proposition 2 below. The formal proof has been relegated to the Appendix.

Proposition 2. *Suppose that there is MNC control of the JV, but the bargaining power lies with the local firm.*

(a) Suppose that $\delta_1 > \delta_1^*$. If $I_1 < I < I_2$, then the outcome involves subsidiary formation, whereas if $I_2 \leq I < I_3$, then the outcome involves status quo. If $I \geq I_3$, then the outcome involves adoption of the new technology by the joint venture if $I \leq (1+\delta_2)[\pi(\underline{c}) - \pi(\overline{c})]$, it is status quo otherwise.

(b) Suppose that $\delta_1 \leq \delta_1^*$. Then the outcome involves adoption of the new technology by the joint venture provided $I_1 < I \leq (1+\delta_2)[\pi(\underline{c}) - \pi(\overline{c})]$; otherwise the outcome involves status quo.

In this case also the outcome can involve any one of status quo, JVN and subsidiary formation. Also as before, JV breakdown is more likely if δ_1 is large.

How does the outcome depend on which firm has the bargaining power? Comparing the

results in Propositions 1 and 2 we find that JV breakdown is not affected by this factor. The intuition is as follows. Whether a JV breaks up or not is dependent on three things, the MNC's payoff from subsidiary formation, and the first period payoffs under JVN and status quo. Since none of these three are affected by a change in the bargaining power of the two firms, the result goes through.

However, does a change in bargaining power affect the adoption of the new technology by the JV? Suppose that there is MNC control and that $\delta_1 \leq \delta_1^*$. A comparison of Propositions 1 and 2 shows that for low values of I, the outcome is likely to involve status quo if the MNC also has the bargaining power, whereas it is likely to involve JVN if the local firm has the bargaining power. On the other hand if I is large, then the outcome is likely to involve JVN if the MNC also has the bargaining power, whereas it is likely to involve status quo if the local firm has the bargaining power.

4.2 Local Firm Control, MNC has Bargaining Power

We then study the effect of local firm control on the outcome. Assume that the local firm controls the JV, but the bargaining power is with the MNC. The sequence of moves are given in Figure 3 below.

(Figure 3 about here)

We then solve for the subgame perfect Nash equilibrium of this game. We can again mimic the argument in Proposition 1 earlier to arrive at Proposition 3 below. Details of the proof are given in the Appendix.

Proposition 3. *Assume that there is local firm control of the JV, but the bargaining power lies with the MNC.*

(a) Suppose that $\delta_1 > \delta_1^*$. Then the equilibrium involves subsidiary formation if $I_1 < I < I_2$ and status quo if $I_2 \leq I < I_3$. When $I \geq I_3$, the outcome is adoption of the new technology by the JV if and only if $I \leq (1+\delta_2)[\pi(\underline{c}) - \pi(\overline{c})]$, otherwise it is status quo.

(b) Suppose that $\delta_1 \leq \delta_1^*$. Then the equilibrium involves status quo if $I < I_3$. If $I \geq I_3$, then there is adoption of the new technology by the joint venture if $I \leq (1+\delta_2)[\pi(\underline{c}) - \pi(\overline{c})]$, otherwise the outcome involves status quo.

Again we find that JV breakdown is more likely if δ_1 is large. How does the outcome depend on which firm has control? Comparing the results in Propositions 1 and 3 we find that JV breakdown is not affected by this factor. The intuition is the same as that for the result that a change in bargaining power does not affect the incentive for JV breakdown.

We then examine if a change in control affects the adoption of the new technology by the JV. Suppose that $\delta_1 \leq \delta_1^*$ and that the bargaining power lies with the MNC. Comparing Propositions 1 and 3 we find that for $I \geq I_3$, the outcome always involves JVN if there is MNC control as well, whereas if there is local firm control then the outcome may involve status quo. Thus JVN is more likely if control lies with the MNC, rather than the local firm.

We then assume that adopting the new technology in the JV is the efficient outcome in the sense that

$$(1+\delta)\pi(\underline{c}) - I > (1+\delta)\pi(\overline{c}),$$

where $\delta = \min\{\delta_1, \delta_2\}$. Note that this implies that $(1+\delta_2)[\pi(\underline{c}) - \pi(\overline{c})] > I$. Now suppose that $\delta_1 \leq \delta_1^*$. Then, from Proposition 2, the outcome would involve JVN if there is MNC control, but the local firm has the bargaining power. However, recall that there would be status quo if $I < I_3$ and the MNC has both control, as well as bargaining power. Thus local firm having the bargaining power is more conducive to efficiency, at least under some parameter configurations. Similarly, for $I_2 < I < I_3$, the outcome is efficient (i.e. involves JVN) if there is local firm control, but the MNC has the bargaining power, whereas the outcome would be inefficient (i.e. involve status quo) if the MNC has both control and bargaining power. Thus the local firm having control is more conducive to efficiency, compared to the case where the MNC has both control and bargaining power.[16]

5 The Effect of a Demand Shift

In this section we study the effect of a change in demand on the pattern of technology adoption and market structure.

Let $\pi(c, A)$ be the reduced form monopoly profit (under equilibrium) where c is a cost parameter and A is a demand shift parameter.[17] We assume that the reduced form profit function is multiplicatively separable.

Assumption 3. $\pi(c, A) = g(A)h(c)$, where $g'(A) > 0$ and $h'(c) < 0$.

Note that Assumption 3 holds for a large class of demand and cost functions, including the examples given in Section 2.[18]

[16] One can easily work out the case when both control and bargaining power lie with the local firm. Here also we have all the possible equilibria depending on the parameter values, viz., status quo, JVN and MNC subsidiary. The possibility of JV breakdown occurs when the MNC is less impatient and the cost associated with the new technology is not large.

[17] Such a demand shift parameter arises naturally for the demand functions $A - p$ and $Ap^{-\alpha}$, where $\alpha > 1$.

[18] It is sufficient to note that in Example (i) the profit function can be expressed as $\pi(c, A) = (\frac{A^2}{4})(\frac{1}{1+c})$, whereas

The following observations will be used in Proposition 4 later.

Observation 1. *δ_1^* is independent of A.*

Proof. Given Assumption 3, note that

$$\delta_1^* = \frac{\pi(\underline{c})}{\pi(\underline{d})} - 1 = \frac{h(\underline{c})}{h(\underline{d})} - 1,$$

which is independent of A. □

Observation 2. *For $\delta_1 > \delta_1^*$, I_2 is increasing in A.*

Proof. Suppose $\delta_1 > \delta_1^*$. This implies that $(1+\delta_1)\pi(\underline{d}) > \pi(\underline{c}) > \pi(\overline{c})$, i.e. $(1+\delta_1)\pi(\underline{d}) - \pi(\overline{c}) > 0$. Hence from Assumption 3 it follows that $(1+\delta_1)h(\underline{d}) - h(\overline{c}) > 0$. Next note that $I_2 = (1+\delta_1)\pi(\underline{d}) - \pi(\overline{c}) = g(A)[(1+\delta_1)h(\underline{d}) - h(\overline{c})]$. Given Assumption 3, we have that I_2 is increasing in A. □

We then demonstrate that under some parameter configurations an increase in demand might result in JV breakdown, a regime shift from JVN to MNC subsidiary to be more precise.

Proposition 4. *Suppose $\delta_1 > \delta_1^*$. An increase in demand (i.e. A) might result in joint venture breakdown.*

Proof. Suppose that $I = I_2(A) + \epsilon$, where $\epsilon > 0$ but very small. As Propositions 1, 2 and 3 show, the equilibrium outcome involves status quo (i.e., JV with the old technology). Now suppose that A increases to A'. From Observation 1, the condition $\delta_1 > \delta_1^*$ continues to be satisfied. From Observation 2, however, $I_2(A)$ increases. In fact let A' be such that $I = I_2(A) + \epsilon < I_2(A')$. From Propositions 1, 2 and 3 the equilibrium outcome will involve JV breakdown. □

In the literature that seeks to explain JV breakdown by means of synergy and organizational learning, we find that an increase in the level of demand makes JVs more stable (see Roy Chowdhury and Roy Chowdhury, 1999, 2001a, 2001b). The result in Proposition 4 runs counter to this in that we find that an increase in demand may increase JV instability. The intuition is as follows. With an increase in demand there is an increase in the MNC's payoff from subsidiary formation, as well as the profit of the JV. Note, however, that in case of subsidiary formation it obtains a profit in both the periods, whereas in case it remains with the JV it obtains a payoff for the first period only. Thus in case the discount factor is large enough, then with an increase in A, the subsidiary payoff increases at a faster rate, making breakdown relatively more attractive.

in Example (ii), the profit function can be written as $\pi(c, A) = (\frac{A}{\alpha^\alpha})(\frac{\alpha-1}{c})^{\alpha-1}$.

6 Conclusion

In this paper we provide a theory of JV breakdown that is triggered by the availability of a new technology. We show that depending on the parameter values the outcome can involve any one of the following, viz., adoption of new technology in the JV, status quo and opening up a subsidiary by the MNC. In the first two cases the JV structure is retained, but in the third case the JV breaks up. We demonstrate that the possibility of JV breakdown arises only when the foreign firm is relatively patient (i.e. has a large discount factor) and investment cost is small. Moreover, a change in the control structure or the bargaining power does not affect the incentive for JV breakdown. However, they do affect the pattern of technology adoption in case the JV survives. Finally, we show that an increase in the demand level could lead to the breakdown of the JV.

7 Appendix

Proof of Proposition 2.

To begin with consider the case where $I < I_3$. Then the MNC's reservation payoff is $(1+\delta_1)\pi(\underline{d}) - I$ and subsidiary opening by the MNC is a credible threat at the first period. Given the assumption on the bargaining power of the local firm, the MNC knows that it will not receive any of the profits in the second period. Hence the MNC will opt for JVN provided it can be fully compensated from the first period JV profits. This is possible if and only if

$$\delta_1 \leq \delta_1^*. \tag{4}$$

On the other hand, the status quo can be implemented if the MNC can be fully compensated from the first period status quo profits of the JV , that is, if

$$\pi(\overline{c}) \geq (1+\delta_1)\pi(\underline{d}) - I \Leftrightarrow I \geq I_2. \tag{5}$$

Thus, in this case (i.e., when $I < I_3$) depending on the parametric situation we have the following possibilities.

(i) If $\delta_1 > \delta_1^*$ and $I_1 < I < I_2$, then it is not possible to fully compensate the MNC in case of JVN or status quo. Thus the outcome is subsidiary formation.

(ii) If $\delta_1 > \delta_1^*$ and $I_2 \leq I < I_3$, then compensation is possible only in case of status quo. Hence the outcome is status quo. In this case the MNC has a payoff of $(1+\delta_1)\pi(\underline{d}) - I$ and the local firm has a payoff of $(1+\delta_2)\pi(\overline{c}) - (1+\delta_1)\pi(\underline{d}) + I$.

(iii) If $\delta_1 \leq \delta_1^*$ and $I < I_2$, then compensation is possible only under JVN. Hence the outcome is JVN. In this case the MNC has a payoff of $(1+\delta_1)\pi(\underline{d}) - I$ and the local firm has a payoff of $(1+\delta_2)[\pi(\underline{c}) - I] - (1+\delta_1)\pi(\underline{d}) + I$.

(iv) Whereas if $\delta_1 \leq \delta_1^*$ and $I_2 \leq I < I_3$, then the MNC can be fully compensated under both status quo and JVN. Since the MNC is indifferent between the two outcomes, we assume that the MNC chooses that outcome that maximizes the local firm's payoff. Hence the outcome is JVN only if

$$\begin{aligned}[(1+\delta_2)\pi(\underline{c}) - I] - [(1+\delta_1)\pi(\underline{d}) - I] &\geq (1+\delta_2)\pi(\overline{c}) - [(1+\delta_1)\pi(\underline{d}) - I], \\ \text{i.e. } (1+\delta_2)I_1 &\geq I,\end{aligned}$$

otherwise, the outcome is status quo.

We then consider the case where $I \geq I_3$. Then opening the subsidiary is never profitable for the MNC; so its reservation payoff is zero. In case the JV adopts the technology, the local firm will earn a discounted payoff of $(1+\delta_2)\pi(\underline{c}) - I$. Note that because of its bargaining power, it extracts all the surplus in the first period, viz., $\pi(\underline{c}) - I$, and because of the learning assumption it derives $\pi(\underline{c})$ in the second period. Similarly, in case the MNC opts for status quo, the local firm can extract the whole of the surplus and will have a payoff of $(1+\delta_2)\pi(\overline{c})$. Since the MNC is indifferent between the two outcomes, it will choose that outcome that maximizes the local firm's payoff. Hence in equilibrium the new technology will be adopted by the JV if and only if

$$\begin{aligned}(1+\delta_2)\pi(\underline{c}) - I &\geq (1+\delta_2)\pi(\overline{c}), \\ \text{i.e. } (1+\delta_2)I_1 &\geq I;\end{aligned}$$

otherwise, the outcome will be status quo. This leads to Proposition 2.□

Proof of Proposition 3.

Here we have local firm control, but the bargaining power lies with the MNC. First consider the case where $I < I_3$. Then the MNC's reservation payoff is $(1+\delta_1)\pi(\underline{d}) - I$ and that of the local firm is 0. Now if the local firm decides to adopt the new technology in the JV, the maximum payoff that the MNC could extract is $[\pi(\underline{c}) - I]$, and the MNC will offer $\{\pi(\underline{c}) - I, 0\}$ in the first period if and only if $\pi(\underline{c}) - I > (1+\delta_1)\pi(\underline{d}) - I$, i.e. $\delta_1 \leq d_1^*$. Under this situation the local firm's payoff will be $\delta_2\pi(\underline{c})$, given the assumption about learning. But if $\delta_1 > \delta_1^*$, by its decision of adopting the new technology the local firm would derive a payoff 0, because the MNC would opt for subsidiary formation and the JV would break up. But if the local firm's decision is not to adopt the new technology, then the MNC will obtain a payoff $\pi(\overline{c})$ from the existing JV (in which case the local firm will get a payoff $\delta_2\pi(\overline{c})$), whereas the MNC will get a payoff $(1+\delta_1)\pi(\underline{d}) - I$ by opening its subsidiary. Then if $\pi(\overline{c}) \geq (1+\delta_1)\pi(\underline{d}) - I$, i.e. if $I \geq I_2$, the MNC derives larger payoff from status quo. Thus when $I < I_3$, we have the following possibilities.

(i) If $\delta_1 \leq \delta_1^*$, the outcome is JVN. In this case the MNC has a payoff of $\pi(\underline{c}) - I$ and the local firm has a payoff of $\delta_2\pi(\underline{c})$.

(ii) If $\delta_1 > \delta_1^*$ and $I_1 < I < I_2$, it is not possible by the MNC to be fully compensated in case of either JVN or status quo, so the outcome is MNC subsidiary. The corresponding payoffs of the MNC and the local firm are respectively $(1+\delta_1)\pi(\underline{d}) - I$ and 0.

(iii) If $\delta_1 > \delta_1^*$ and $I_2 \leq I < I_3$, while the first period profit under JVN is less than the MNC's reservation payoff, the first period status quo profit is not less. Therefore, the outcome is status quo. The MNC will appropriate all the first period profit, $\pi(\overline{c})$, and the local firm will get only the second period profit, that is $\delta_2\pi(\overline{c})$.

Now consider the case when $I \geq I_3$. Here $V_s = 0$, that is the MNC's reservation payoff is 0 and that of the local firm is $(1+\delta_2)\pi(\overline{c})$ (from its subsidiary). Now if the local firm's decision is not to adopt the new technology, the MNC will offer $\{0, \pi(\overline{c})\}$ in each period. If it is accepted, their payoffs are $\{0, (1+\delta_2)\pi(\overline{c})\}$. If the local firm's decision is to adopt the new technology, the MNC can extract $\pi(\underline{c}) - I$ (i.e., all first period JV profits) if $\delta_2\pi(\underline{c}) \geq (1+\delta_2)\pi(\overline{c})\}$. But when $\delta_2\pi(\underline{c}) < (1+\delta_2)\pi(\overline{c})\}$, the maximum that the MNC can extract from the JVN is $[\pi(\underline{c}) - I] - [(1+\delta_2)\pi(\overline{c}) - \delta_2\pi(\underline{c})]$ provided that this is non-negative, that is $I \leq (1+\delta_2)[\pi(\underline{c}) - \pi(\overline{c})]$. So when $I > (1+\delta_2)[\pi(\underline{c}) - \pi(\overline{c})]$, the equilibrium outcome is status quo because $(1+\delta_2)\pi(\underline{c}) - I > (1+\delta_2)\pi(\overline{c})$. □

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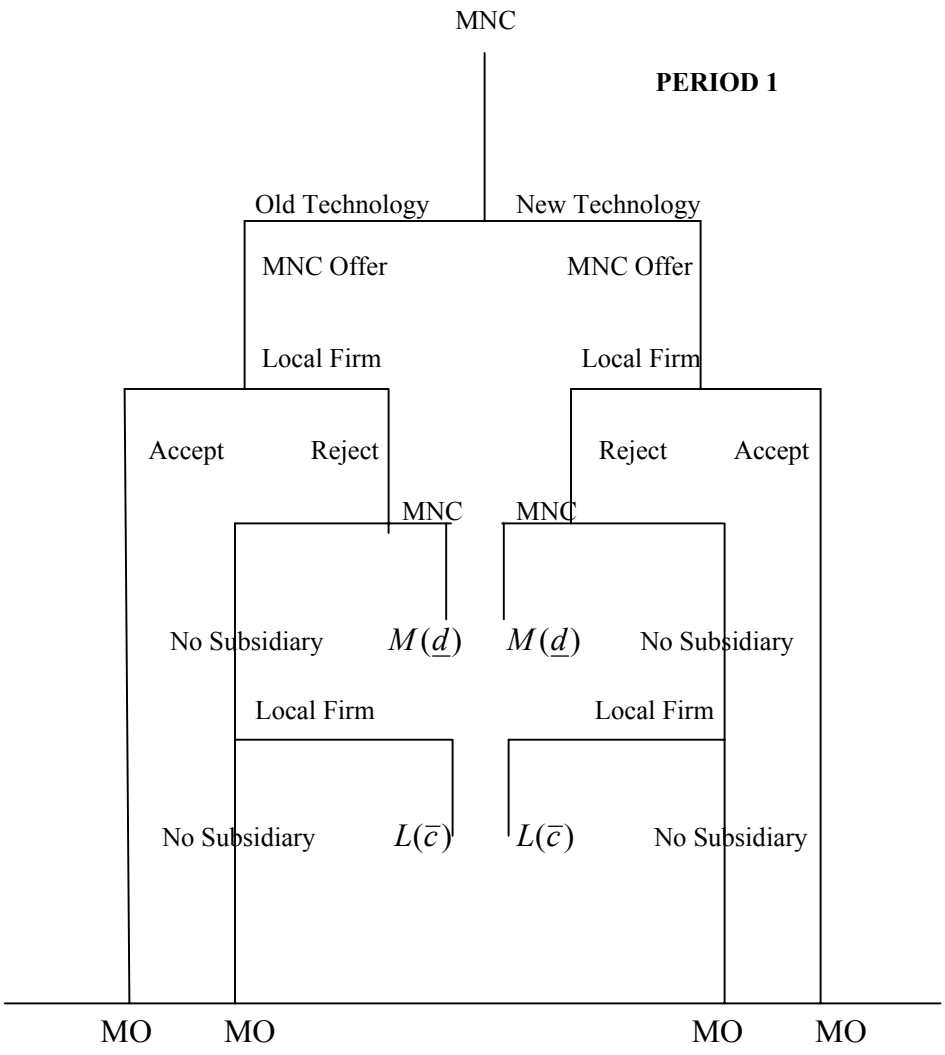
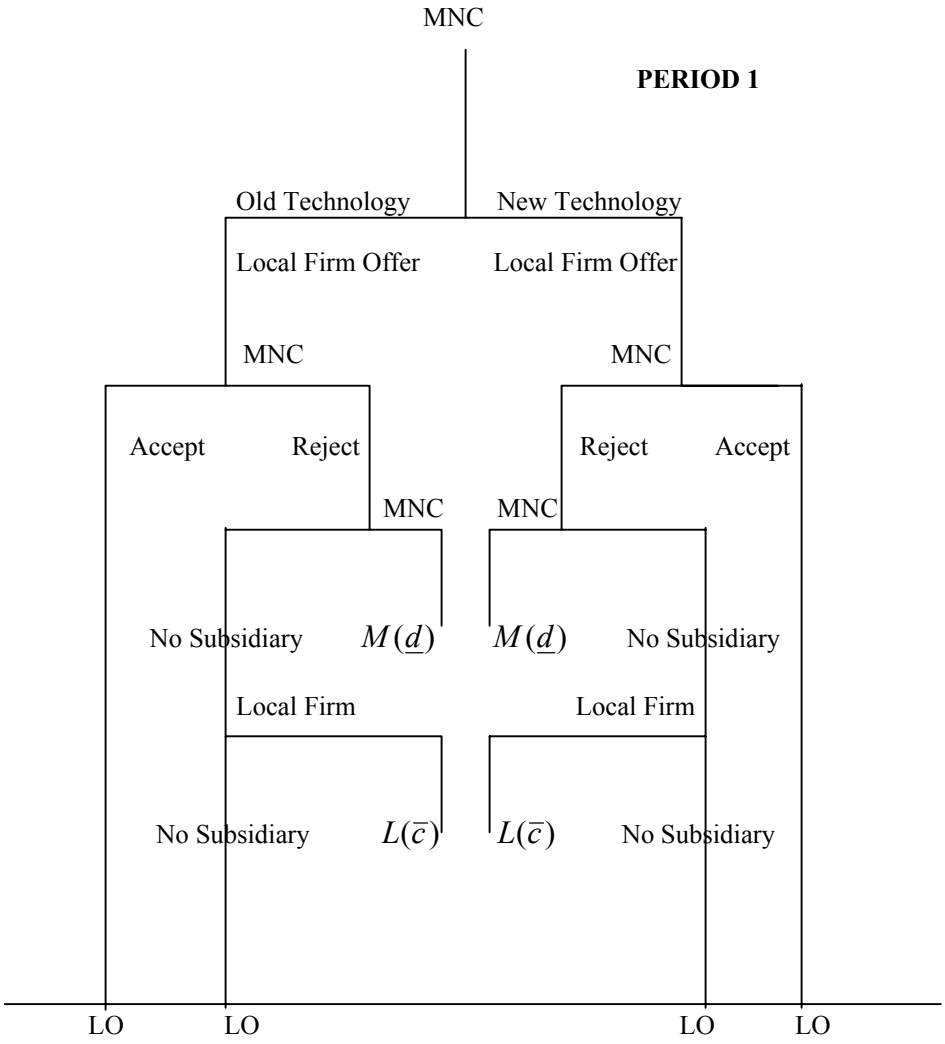


Node MO : The MNC makes an offer to the local firm, which decides whether to accept or reject. If the local firm rejects, then there is subsidiary formation by the local firm.

Node $L(\overline{c})$: There is subsidiary formation by the local firm, which operates as a monopolist in both the periods with its corresponding cost function.

Node $M(\underline{d})$: There is subsidiary formation by the MNC, which operates as a monopolist in both the periods with its corresponding cost function.

FIGURE 1: MNC has both Control and Bargaining Power

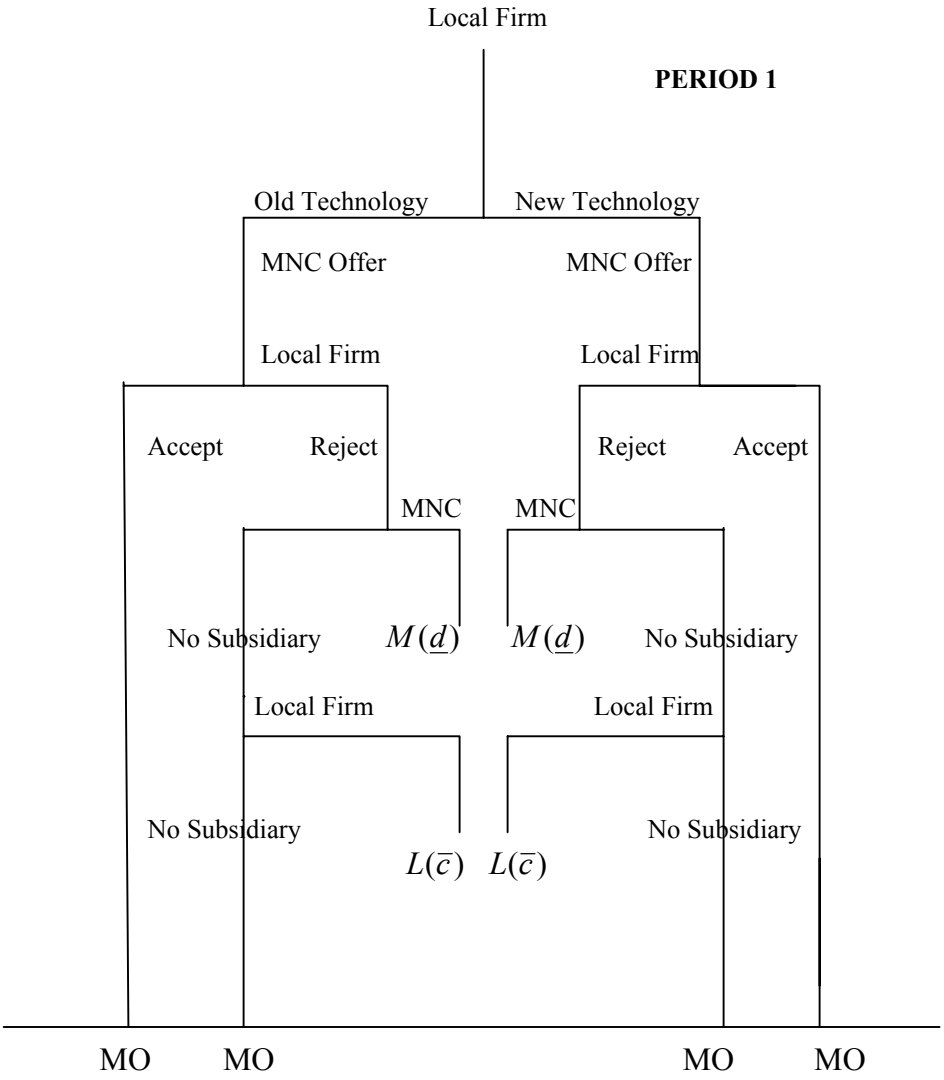


Node LO : The local firm makes an offer to the MNC, which decides whether to accept or reject. If the MNC rejects, then there is subsidiary formation by the local firm.

Node $L(\overline{c})$: There is subsidiary formation by the local firm, which operates as a monopolist in both the periods.

Node $M(\underline{d})$: There is subsidiary formation by the MNC, which operates as a monopolist in both the periods.

FIGURE 2: MNC Control, Local Firm has Bargaining Power



Node MO: The MNC makes an offer to the local firm, which decides whether to accept or reject. If the local firm rejects, then there is subsidiary formation by the local firm.

Node $L(\bar{c})$: There is subsidiary formation by the local firm, which operates as a monopolist in both the periods.

Node $M(\underline{d})$: There is subsidiary formation by the MNC, which operates as a monopolist in both the periods.

FIGURE 3: Local Firm Control, MNC has Bargaining Power