Asymmetric capacity costs and joint venture buy-outs

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Abstract

In this paper, we build a simple theory of joint venture buy-outs based on asymmetric access to capital, synergy, and an increased market size. If the market size is small then the outcome involves joint venture formation. If, however, the market size becomes sufficiently large then a buy-out always occurs.

JEL classification: F23; L13

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1. Introduction

One of the fascinating new developments in the field of international business has been joint venture formation. Especially in the last two decades the number of new joint ventures has increased dramatically. This has been documented by, among others, Hergert and Morris (1988) and Pekar and Allio (1994).[2]

At the same time, however, there has been an increase in joint venture instability. Kogut (1988) finds that about half of the 92 joint ventures that he studied had broken up by the

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[1] We are indebted to the co-editor, David M. Grether, and an anonymous referee of this journal for very helpful comments that added substantial value to our paper.

[2] There have been several studies that examine the question of joint venture formation at a theoretical level. These include, among others, Al-Saadon and Das (1996), D'Aspremont and Jacquemin (1988), Bardhan (1982), Chan and Hoy (1991), Chao and Yu (1996), Choi (1993), Combs (1993), Das (1998), Katz (1986), Marjit (1990, 1991), Purakayasthya (1993), Roy Chowdhury (1995), Singh and Bardhan (1991), Svejnar and Smith (1984).

sixth year. This issue has also been studied by Beamish (1985) and Gomes-Casseres (1987). Even in India there have been many cases of such instability.

However, compared to joint venture formation the issue of instability has received much less theoretical attention. In this paper, we seek to develop a simple theory of joint venture buy-outs that is motivated by the Indian experience. Both Bhandari (1996/1997) and Ghosh (1996) study the instability in Indian joint ventures during the mid-1990s. As examples we can mention the joint ventures between Daewoo and DCM, GE and Apar, Bausch and Lomb and Montori, GEC Alsthom and Triveni Engineering, and Suzuki and TVS. It appears that a major area of dispute was that of capacity expansion. While the multinational corporation (MNC from now on) partners were keen on capacity expansion, the domestic partners, who, for various reasons were fund constrained, were unwilling to do so. As a result, the MNC partners insisted on either partial or complete buy-outs as a precondition for capacity expansion. Often the threat of opening a fully owned subsidiary was also used.

In this paper, we seek to build a simple model where asymmetric access to capital leads to joint venture breakdown. An obvious example of such asymmetric access arises in case of international investments. A typical multinational will have better access to the international capital market compared to a local firm from a developing country. Thus, our paper is also a contribution to the analysis of cross-border acquisitions, a significant phenomenon in recent years.

We consider a situation where two firms, one MNC (denoted firm 1) and a domestic firm (denoted firm 2), are deciding whether to form a joint venture or not. The MNC has access to cheap capital, whereas the domestic firm has no access to capital and thus cannot open a subsidiary at all.

Moreover, joint venture formation leads to synergistic gains.[3] In joint ventures involving a foreign multinational and a domestic firm from a less developed country (LDC from now on), it has often been observed that the MNC provides the superior technology, management knowhow, etc. while the domestic firm provides a knowledge of local conditions, access to distribution channels, etc (see, for example, Miller et al., 1996).[4] Thus, if a joint venture forms, it can produce much more efficiently compared to either one of the parent firms.

We next briefly describe our findings. We demonstrate that whether a buy-out takes place or not depends on the level of demand. To begin with suppose that the demand level is low so that subsidiary formation is not feasible, even for firm 1. Given the synergistic effect, however, joint venture formation leads to strictly positive profits. Thus, for low levels of demand the outcome always involves joint venture formation.

We then consider a situation where this joint venture is already in place and there is an increase in the demand level. Now firm 1 (i.e. the MNC) re-evaluates its options regarding subsidiary formation and buy-out. If the increase is large enough then, for firm 1, opening a subsidiary becomes more profitable compared to remaining with the joint venture. The key to this result lies in the asymmetric access to capital of the two firms. For a large

[3] We are indebted to an anonymous referee who suggested that we explicitly introduce synergistic effects into our model.

[4] In the Indian context, in the alliance between Hewlett and Packard (HP) and HCL in computers, HP hoped for a quick access to the Indian market, while HCL hoped to utilize HP's competence in business processes, production and quality maintenance (see Business India, 1992).

enough demand, firm 1 will obtain almost the whole of the market profits via the subsidiary while the joint venture obtains only a small proportion of the profits. Thus, the threat of subsidiary formation is credible whenever the demand is sufficiently large. Now firm 1 can use the threat of subsidiary formation to drive down the payoff of firm 2 in case of a buy-out to its reservation level. Thus, a buy-out is profitable provided the aggregate payoff from a buy-out exceeds that from subsidiary formation. Given that a buy-out avoids the inefficiencies associated with subsidiary formation, this is always true. Hence, for a large enough demand a buy-out always occurs.

We finally relate our paper to the existing literature on joint venture instability.

In a series of papers, Roy Chowdhury and Roy Chowdhury (1999, 2000, 2001) study a learning based theory of joint venture instability. In these papers, joint venture formation involves some synergy between the two parent firms. With time, however, there is organizational learning so that the firms learn about each others' strengths. Thus, over time the value of the synergistic effect declines, leading to breakdown. The present paper, however, differs from Roy Chowdhury and Roy Chowdhury (1999, 2000, 2001) in several respects. First, our model is driven by asymmetric access to capital, rather than organizational learning. Second, the comparative statics result is the exact opposite. While in our model an increase in demand leads to instability, in Roy Chowdhury and Roy Chowdhury (1999, 2000, 2001) such an increase leads to greater stability. Other papers that examine organizational learning include Kabiraj (1999), Kabiraj and Lee (2000), Lin and Saggi (2000).

Our approach and the learning based approach are, however, complementary rather than competitive. Organizational learning is clearly an important element behind joint venture instability. However, consider a situation where the extent of organizational learning is not large enough to cause a break-down. We show that even in such a situation there is a possibility of joint venture breakdown based on asymmetric access to capital and an increase in the demand level. Thus, we can think of our model as providing a theory of joint venture instability in situations where learning effects are weak or has already been exhausted.

Among the other papers Mukherji and Sengupta (2001), Sinha (2001) study the impact of a sequential liberalization process on joint venture breakdown. While Sinha studies a model with informational asymmetries, Mukherji and Sengupta examine the effects of different degrees of competition, as well as different modes of control on joint venture instability. However, neither Mukherji and Sengupta nor Sinha study the impact of demand changes.

2. The model

Two firms, an MNC (firm 1) and a domestic firm (firm 2), endogenously decide on whether to form a joint venture, or open fully owned subsidiaries.

The market demand is (initially) given by

$$q = a - p, \tag{1}$$

where $a > 0$.[5]

[5] In Appendix A, we show that our argument applies even if we allow for more generalized demand functions. We are indebted to an anonymous referee for suggesting this extension.

In case of joint venture formation, the cost function of the joint venture is given by

$$C(q) = \begin{cases} cq, & \text{if } q \le \tilde{k}, \\ \infty, & \text{otherwise}, \end{cases} \tag{2}$$

where $\tilde{k}$ denotes the capacity level of the joint venture.

We assume that there is asymmetric access to capacity so that the per unit cost of capacity formation is r for firm 1 and infinitely high for firm 2.[6] Thus, firm 1 is the only firm that is capable of opening either a subsidiary or a joint venture. In case firm 1 decides to open a subsidiary its cost function is given by

$$C_s(q) = \begin{cases} c'q, & \text{if } q \le k_s, \\ \infty, & \text{otherwise}, \end{cases} \tag{3}$$

where k_s denotes the capacity level of the subsidiary firm. The synergistic effect is captured by assuming that $c' > c$, so that production costs are lower under the joint venture.

Under a joint venture the capacity costs are borne by firm 1. Out of the joint venture profits (gross of capacity costs), a fraction $(1 - \alpha)$ goes to firm 1 and a fraction α goes to firm 2. For simplicity we assume that the sharing rule α is exogenously fixed by the government.[7]

We assume that

Assumption 1.

$$c + \frac{r}{1-\alpha} < a < c' + r.$$

Note that since $a > c + r/(1-\alpha) > c + r$, joint venture formation leads to strictly positive aggregate profits. However, since $c' + r > a$, subsidiary formation is not profitable for firm 1, at least to begin with. Thus, firm 1's only option, at least initially, is to open a joint venture.

In this paper, it is our goal to build a model where a buy-out does not occur with the initial (low) level of demand, but does occur when the demand level increases. Assumption 1 ensures that for low levels of demand there is no subsidiary or buy-out.

The sequence of actions is as follows. We consider a two stage game.

In stage 1, the MNC decides on how much capital to invest in the joint venture.

In stage 2, production takes place. In this stage, the joint venture management decides on the level of output that will maximize the gross joint venture profits. For all $q \le \tilde{k}$, this equals $(a - q)q - cq$.[8] Finally, the gross joint venture profits are divided among the two firms according to the sharing rule α.

[6] While this assumption is extreme, the qualitative results will not change as long as the cost of capacity expansion is sufficiently different for the two firms.

[7] However, we can alternatively assume that α is determined through some bargaining procedure, e.g. the Nash bargaining solution. This does not affect the analysis qualitatively.

[8] We can alternatively assume that the joint venture firm maximizes the aggregate joint venture profits *net* of capacity costs. This, however, does not change the argument qualitatively.

Suppose that the total installed capacity level in the joint venture is $\tilde{k}$. Then the output level chosen by the joint venture management

$$q = \begin{cases} \dfrac{a-c}{2}, & \text{if } \tilde{k} \geq \dfrac{a-c}{2}, \\ \tilde{k}, & \text{otherwise.} \end{cases} \tag{4}$$

Clearly, firm 1's profit levels are

$$(1-\alpha)\frac{(a-c)^2}{4} - r\tilde{k}, \qquad \text{if } \tilde{k} \geq \frac{a-c}{2}, \tag{5}$$

$$(1-\alpha)(a-c-\tilde{k})\tilde{k} - r\tilde{k}, \qquad \text{otherwise.} \tag{6}$$

Letting $\tilde{K}$ denote the optimal capacity level, we have that $\tilde{K} = (a-c)(1-\alpha) - r/2(1-\alpha)$. Since firm 1 obtains only a fraction of the joint venture profits but has to bear the whole of the capacity costs, $\tilde{K}$ is less than $(a-c-r)/2$, the capacity level that maximizes aggregate profits.[9]

Let $J_i(a)$ denote the equilibrium level of profit of firm i. Then

$$J_1(a) = (1-\alpha)\left[\frac{(a-c)^2}{4} - \frac{r^2}{4(1-\alpha)^2}\right] - r\left(\frac{(a-c)(1-\alpha)-r}{2(1-\alpha)}\right), \tag{7}$$

$$J_2(a) = \alpha\left[\frac{(a-c)^2}{4} - \frac{r^2}{4(1-\alpha)^2}\right]. \tag{8}$$

Summarizing the above discussion we obtain our first proposition. This shows that for low levels of demand a joint venture obtains.[10] Moreover, the greater is α (the share of the domestic firm in joint venture profits), the lower is the capacity installed in the joint venture.

Proposition 1. *Under Assumption 1 the outcome involves joint venture formation with a capacity (and output) level of* $(a-c)(1-\alpha) - r/2(1-\alpha)$.

3. Demand increase

In this section, we consider a situation where there is an existing joint venture with a capacity level of $\tilde{K}$. We then analyze the game that follows an upward shift in the demand

[9] Let us briefly solve for the sharing rule in case it is not exogenously given but follows a symmetric Nash bargaining solution. Given that the disagreement payoffs of both the firms are zero, α must be such that the net aggregate payoff is equally shared among the two firms. Hence, α must satisfy the following equation:

$$(1-\alpha)\left[\frac{(a-c)^2}{4} - \frac{r^2}{4(1-\alpha)^2}\right] - r\left(\frac{(a-c)(1-\alpha)-r}{2(1-\alpha)}\right) = \frac{(a-c)^2}{8} - \frac{r^2}{8(1-\alpha)^2} - \frac{r[(a-c)(1-\alpha)-r]}{4(1-\alpha)}.$$

[10] We are indebted to an anonymous referee for the idea that the initial formation of joint ventures can also be explained within the present framework.

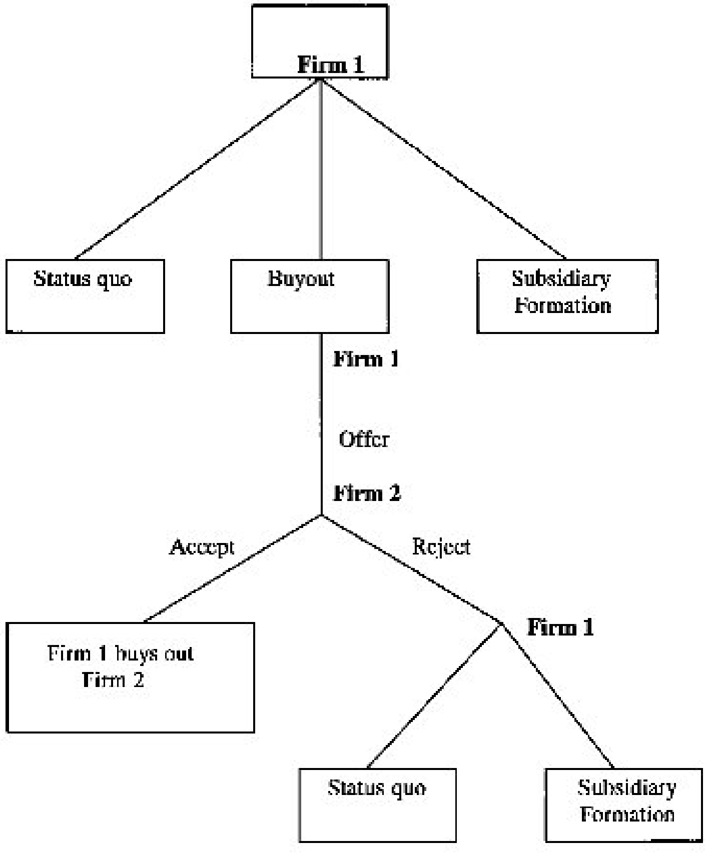

Fig. 1. The game tree.

function to $A - p$, where $A > a$. We show that if the demand level (i.e. A) is very large, then there is always a buy-out.

We are interested in the case where A becomes very large, so that in what follows we always assume that $A > c' + r$.

The game tree is as follows (see Fig. 1). We consider a one period, multi-stage game. In stage 1, firm 1 decides to opt for any one of the following three options,

(i) status quo (i.e. stay with the joint venture),
(ii) opening a subsidiary, or
(iii) buy-out.

(i) **Status Quo.** The MNC first decides whether to invest in the joint venture. Then production takes place.
(ii) **Subsidiary Formation.** The MNC first decides on how much additional capacity to put into the joint venture firm and/or into opening a subsidiary. In the next stage, the original joint venture firm and the new subsidiary compete over quantities *a la*

Cournot, with the management of the subsidiary firm maximizing the profit of the subsidiary.[11]

Let the capacity level of the subsidiary be k_s. If $k_s = 0$, then we say that firm 1 decides not to open a subsidiary.

(iii) **Buy-out.** Firm 1 makes a take it or leave it offer to firm 2. The offer specifies the price that firm 1 is willing to pay to firm 2 in return for obtaining sole ownership of the company. If firm 2 accepts, then firm 1 pays the offered price to firm 2, and firm 1 becomes the sole owner of the erstwhile joint venture firm. If firm 2 rejects the offer, then firm 1 has two options, either to open a subsidiary, or to opt for the status quo.

We then examine these three options by turn.

Status Quo. We first consider the outcome under a joint venture. Clearly, for large A, the joint venture is going to be capacity constrained. The question is whether firm 1 would find it optimal to invest in the joint venture.

We consider a two stage game. In stage 1, firm 1 invests in some additional capacity, so that the capacity level of the joint venture goes up to k ($\geq \tilde{K}$). In stage 2, the joint venture management decides how much to produce.

Stage 2. Suppose that the total installed capacity in the joint venture is k. Then the output level chosen by the joint venture management

$$q = \begin{cases} \dfrac{A-c}{2}, & \text{if } k \geq \dfrac{A-c}{2}, \\ k, & \text{if } \tilde{K} \leq k < \dfrac{A-c}{2}. \end{cases} \tag{9}$$

Clearly, firm 1's profit levels are

$$(1-\alpha)\frac{(A-c)^2}{4} - r(k-\tilde{K}), \qquad \text{if } k \geq \frac{A-c}{2}, \tag{10}$$

$$(1-\alpha)(A-c-k)k - r(k-\tilde{K}), \qquad \text{if } \tilde{K} \leq k < \frac{A-c}{2}. \tag{11}$$

Thus, in equilibrium the capacity choice of firm 1 involves $K = (A-c)(1-\alpha) - r/2(1-\alpha)$. Let $J_i(A)$ denote the equilibrium level of profit of firm i. Then

$$J_1(A) = (1-\alpha)\left[\frac{(A-c)^2}{4} - \frac{r^2}{4(1-\alpha)^2}\right] - r\left(\frac{(A-c)(1-\alpha)-r}{2(1-\alpha)} - \tilde{K}\right), \tag{12}$$

$$J_2(A) = \alpha\left[\frac{(A-c)^2}{4} - \frac{r^2}{4(1-\alpha)^2}\right]. \tag{13}$$

The following observation is useful.

Observation 1.

(i) $\dfrac{\partial J_1(A)}{\partial A} = \dfrac{(A-c)(1-\alpha)}{2} - \dfrac{r}{2}$, and

[11] We could instead assume that the subsidiary is directly controlled by firm 1 and maximizes the profit of firm 1. This does not affect the results qualitatively.

(ii) $\dfrac{\partial^2 J_1(A)}{\partial A^2} = \dfrac{1-\alpha}{2}$.

Subsidiary Formation. We then analyze the option of forming a subsidiary. Again we consider a two stage game. In stage 1, firm 1 decides how much capital to invest in the subsidiary and the joint venture. In stage 2, the subsidiary and the joint venture firm compete over quantities.

We begin by defining what we call strategy S. Under this strategy firm 1 only invests in the subsidiary and does not invest in the joint venture at all.[12]

We begin by solving for the optimal level of k_s under strategy S when firm 1 selects k_s so as to maximize its own profits. Note that whenever $k_s \leq (A - c' - \tilde{K})/2$ the profit function of firm 1 is

$$k_s(A - c' - k_s - \tilde{K}) + (1-\alpha)\tilde{K}(A - c - k_s - \tilde{K}) - rk_s. \tag{14}$$

This is because under Cournot competition the equilibrium output level of the subsidiary is k_s and that of the joint venture is $\tilde{K}$. For large A there is an interior solution where

$$A - c' - 2k_s - \tilde{K} - (1-\alpha)\tilde{K} - r = 0. \tag{15}$$

Thus, letting K_s denote the equilibrium value of k_s we have that $K_s = A - c' - r - \tilde{K}(2-\alpha)/2$.

Let $S_i(A)$ denote the profit levels of the i-th firm when firm 1 is following strategy S and $k_s = K_s$. Thus

$$S_1(A) = \frac{1}{4}(A - c' - r - \tilde{K}(2-\alpha))(A - c' - r - \alpha\tilde{K}) + \frac{(1-\alpha)\tilde{K}}{2}(A - 2c + c' + r - \alpha\tilde{K}), \tag{16}$$

$$S_2(A) = \frac{\alpha\tilde{K}}{2}(A - 2c + c' + r - \alpha\tilde{K}). \tag{17}$$

The following observation is useful.

Observation 2.

(i) $\partial S_1(A)/\partial A = 1/2(A - c' - r - \tilde{K})$, and
(ii) $\partial^2 S_1(A)/\partial A^2 = 1/2$.

Suppose that firm 1 opens a subsidiary following strategy S. Proposition 2 below demonstrates that for large A, the profit of firm 1 is larger than that under the status quo option.

Proposition 2.

$$\lim_{A\to\infty} \frac{S_1(A)}{J_1(A)} > 1.$$

[12] Of course, it is possible that under the given parameter conditions strategy S is not optimal for firm 1.

Proof. Applying l'Hospital's rule twice and then using Observations 1(ii) and 2(ii) we have that

$$\lim_{A\to\infty}\frac{S_1(A)}{J_1(A)}=\lim_{A\to\infty}\frac{\partial^2 S_1(A)/\partial A^2}{\partial^2 J_1(A)/\partial A^2}=\frac{1}{1-\alpha}>1. \qquad \square$$

The intuition is as follows. For firm 1, the advantage of being in the joint venture lies in the synergistic effect, while the attraction of subsidiary formation lies in the fact that firm 1 obtains the whole of the subsidiary profits. As demand becomes very large, however, the synergistic advantages become relatively less important. At the same time subsidiary formation becomes more attractive. For A large, the disadvantages of being in a joint venture outweigh the advantages. Hence, the result.

Buy-out. We begin by showing that for firm 1 buy-out dominates subsidiary formation.

Proposition 3. *For firm 1, the profits from a buy-out are greater than that under subsidiary formation.*

Proof. There are two cases to consider.

Case 1. In case of subsidiary formation suppose that strategy S is optimal for firm 1. In that case firm 2's reservation payoff is $S_2(A)$. Hence, firm 1's payoff from a buy-out is $(A-c-r)^2/4+r\tilde{K}-S_2(A)$, whereas firm 1's payoff from subsidiary formation is $S_1(A)$. Clearly, for firm 1 a buy-out dominates subsidiary formation if and only if

$$\frac{(A-c-r)^2}{4}+r\tilde{K}-S_2(A)>S_1(A) \text{ i.e., } \frac{(A-c-r)^2}{4}+r\tilde{K}>S_1(A)+S_2(A). \tag{18}$$

Observe that the L.H.S. of Eq. (18) represents the aggregate profit of the two firms under a buy-out, whereas the R.H.S. represents the aggregate profit of the two firms under subsidiary formation by firm 1 (when firm 1 follows strategy S). The L.H.S. exceeds the R.H.S. because a buy-out avoids the inefficiencies associated with subsidiary formation (arising out of rent dissipation and cost inefficiencies).

Case 2. Next suppose that in case of subsidiary formation it is not optimal for firm 1 to follow strategy S. Suppose instead that firm 1 is following the optimal strategy regarding capacity investment. Let the profit levels of the two firms under this optimal capacity strategy be denoted by $\bar{S}_1(A)$ and $\bar{S}_2(A)$. Thus, a buy-out dominates subsidiary formation if and only if

$$\frac{(A-c-r)^2}{4}+r\tilde{K}-\bar{S}_2(A)>\bar{S}_1(A) \quad \text{or} \quad \frac{(A-c-r)^2}{4}+r\tilde{K}>\bar{S}_1(A)+\bar{S}_2(A). \tag{19}$$

Again the above equation holds since the L.H.S. of Eq. (19) represents the aggregate profit of the two firms under a buy-out, whereas the R.H.S. represents the aggregate profit of the two firms under subsidiary formation by firm 1 (when firm 1 follows the optimal capacity strategy). □

Note that for this proposition we do not need A to be large.[13]

Intuitively speaking Proposition 3 follows since under a buy-out firm 1 can avoid the inefficiencies associated with subsidiary formation, namely rent dissipation and cost inefficiencies.

Finally, we show that for large A, buy-out dominates status quo as well.

Proposition 4. *If A is large in the sense that* $S_1(A) > J_1(A)$, *then, for firm 1, the profits from a buy-out are greater than those under the status quo option.*

Proof. Again there are two cases to consider.

Case 1. In case of subsidiary formation, suppose strategy S is optimal for firm 1. Note that buy-out dominates status quo if and only if

$$\frac{(A-c-r)^2}{4} + r\tilde{K} - S_2(A) > J_1(A). \tag{20}$$

Note that

$$\frac{(A-c-r)^2}{4} + r\tilde{K} - S_2(A) > S_1(A) > J_1(A), \tag{21}$$

where the first inequality follows from Case 1 of Proposition 3 and last inequality follows from the hypothesis of this proposition.

Case 2. Suppose strategy S is not optimal. Again let the profit levels of the two firms under the optimal capacity levels be $\bar{S}_1(A)$ and $\bar{S}_2(A)$. Thus, a buy-out dominates subsidiary formation if and only if

$$\frac{(A-c-r)^2}{4} + r\tilde{K} - \bar{S}_2(A) > J_1(A). \tag{22}$$

Note that

$$\frac{(A-c-r)^2}{4} + r\tilde{K} > \bar{S}_1(A) + \bar{S}_2(A), \geq S_1(A) + \bar{S}_2(A), > J_1(A) + \bar{S}_2(A), \tag{23}$$

where the first inequality follows from Case 2 of Proposition 3, the second inequality follows from a simple revealed preference argument for firm 1 and the final inequality follows from the hypothesis of this proposition. □

The intuition is as follows. If the increase in demand is large enough, then for firm 1, opening a subsidiary becomes more profitable than the status quo option (see Proposition 2), so that the threat of subsidiary formation is credible. Now firm 1 can use the threat of subsidiary

[13] Of course, unless $A > c' + r$, subsidiary formation is not even feasible.

formation to drive down the payoff of firm 2 in case of a buy-out. Given that firm 2 can be driven down to its reservation level, a buy-out is profitable for firm 1 provided that the aggregate payoff from a buy-out exceeds that under subsidiary formation. Since a buy-out avoids the inefficiencies associated with subsidiary formation, this is always true.

Thus, Propositions 2–4 together show that if A is large enough then there is always a buy-out.

4. Conclusion

This paper was motivated by some empirical facts regarding joint venture breakdown. We build a simple model based on asymmetric access to capital and synergy that is capable of explaining the stylized facts. Another important factor turns out to be the level of demand. If demand is low then we find that the outcome involves joint venture formation. An increase in the demand level, however, could lead to joint venture breakdown, a result that is new in the literature.

This model also allows us to make some predictions regarding the effect of tariff policies. Suppose that owing to liberalization the government reduces tariff levels in the industry concerned, leading to a reduction in the demand level facing the existing firms. Our theory suggests that the result should be an increase in joint venture stability, a testable implication of our theory.

Appendix A

In this appendix, we show that our arguments apply for more general demand functions.

Suppose that the initial demand function is of the form $a - f(q)$, and later the demand function shifts up to $A - f(q)$, where $A > a$, $f(q)$ is twice differentiable, $f'(q) > 0$, $f''(q) \geq 0$ and $f(0) = 0$. Thus, the demand function is negatively sloped and (weakly) concave. The assumption that $f(0) = 0$ is just a normalization which allows us to work with Assumption 1 in this case as well. Note that this formulation allows for linear demand functions.

A.1. Initial demand

We first consider the case where the demand function is of the form $a - f(q)$. We assume that Assumption 1 holds in this case as well, so that none of the firms can profitably open a subsidiary. Let $q^m(a)$ solve the equation $a - f(q) - af'(q) = c$. If the capacity level installed in the joint venture is $\tilde{k}$, then the output level selected by the joint venture management

$$q = \begin{cases} q^m(a), & \text{if } \tilde{k} \geq q^m, \\ \tilde{k}, & \text{otherwise.} \end{cases} \tag{A.1}$$

Clearly, firm 1's profit is

$$(1 - \alpha)(a - c - f(\tilde{k}))\tilde{k} - r\tilde{k}, \quad \forall\ \tilde{k} \leq q^m(a). \tag{A.2}$$

Let $\tilde{K}$ denote the optimal capacity (and the output) level for firm 1. Then $\tilde{K}$ solves the following first order condition:

$$(1-\alpha)(a-c-f(\tilde{k})-\tilde{k}f'(\tilde{k}))-r=0. \qquad (A.3)$$

Thus, under the initial demand parameters there is always joint venture formation and the optimal capacity level solves Eq. (A.3).

A.2. Demand increase

We then consider the case where the demand function is $A-f(q)$.

Status Quo. Let the total installed capacity level in the joint venture be k. Note that in this case the profit level of firm 1 is given by

$$(1-\alpha)k(A-c-f(k))-r(k-\tilde{K}), \quad \text{if } \tilde{K}\le k<q^m(A). \qquad (A.4)$$

Let $K(A)$ solve the following first order condition

$$A-f(k)-kf'(k)=\frac{r}{1-\alpha}+c. \qquad (A.5)$$

Letting $J_1(A)$ denote the equilibrium profit level of firm 1

$$J_1(A)=(1-\alpha)K(A)(A-c-f(K(A)))-r(K(A)-\tilde{K}). \qquad (A.6)$$

The following Observation mimics observation 1 earlier.

Observation 3.

(i) $\partial J_1(A)/\partial A=(1-\alpha)K(A)$, and
(ii) $\partial^2 J_1(A)/\partial A^2=1-\alpha/2f'(K)+Kf''(K)$.

Subsidiary Formation. Suppose firm 1 decides to follow strategy S. Letting k_s denote the capacity level of the subsidiary, $\forall k_s\le q^m(A-\tilde{K})$ the profit level of firm 1 is given by

$$[A-c'-f(k_s+\tilde{K})]k_s+(1-\alpha)\tilde{K}[A-c-f(k_s+\tilde{K})]-rk_s. \qquad (A.7)$$

If K_s denotes the optimal level of k_s, then K_s solves the following first order condition

$$A-f(k_s+\tilde{K})-(k_s+\tilde{K})f'(k_s+\tilde{K})=c'+r-\alpha\tilde{K}f'(k_s+\tilde{K}). \qquad (A.8)$$

Let $S_1(A)$ denote the profit level of firm 1 when it opens a subsidiary and invests in the subsidiary alone at the level K_s. The following observation mimics Observation 2 earlier.

Observation 4.

(i) $\partial S_1(A)/\partial A=K_s(A)+(1-\alpha)\tilde{K}$, and
(ii) $\partial^2 S_1(A)/\partial A^2=1/2f'(K_s+\tilde{K})+(K_s+\tilde{K})f''(K_s+\tilde{K})-\alpha\tilde{K}f''(K_s+\tilde{K})$.

We then introduce a technical assumption that we require for our analysis. Note that Assumption 2 below is satisfied for linear demand functions.

Assumption 2. $2f'(q)+qf''(q)$ is decreasing in q.

We require one final observation.

Observation 5.

$$K_s + \tilde{K} > K.$$

The argument is simple. Given Assumption 1, from Eqs. (A.5) and (A.8) it follows that

$$a - f(K) - Kf'(K) > a - f(K_s + \tilde{K}) - (K_s + \tilde{K})f'(K_s + \tilde{K}).$$

Since $f'(q) > 0$ and $f''(q) \geq 0$, we have that $K_s + \tilde{K} > K$.

Proposition 5 below is the analogue of Proposition 2 earlier. Suppose that firm 1 opens a subsidiary and follows strategy S while doing so. Then we demonstrate that for large A, the profit of firm 1 is larger than that under the status quo option.

Proposition 5.

$$\lim_{A\to\infty} \frac{S_1(A)}{J_1(A)} > 1.$$

Proof. Applying l'Hospital's rule twice and then applying Observations 3(ii) and 4(ii) we have that

$$\lim_{A\to\infty} \frac{S_1(A)}{J_1(A)} = \lim_{A\to\infty} \frac{1}{1-\alpha} \frac{2f'(K) + Kf''(K)}{2f'(K_s + \tilde{K}) + (K_s + \tilde{K})f''(K_s + \tilde{K}) - \alpha\tilde{K}f''(K_s + \tilde{K})}. \quad \text{(A.9)}$$

Note that given Assumption 2 and Observation 5, the second term in the R.H.S. of Eq. (A.9) is also greater than 1. □

Given Proposition 5, the analogue of Propositions 3 and 4 follow as well. This follows since the proofs of Propositions 3 and 4 do not depend on the linearity assumption. Thus, in this case also, for large A, buy-out dominates both status quo and subsidiary formation.

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