Input production joint venture*

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Abstract

In many industries it is quite common to observe firms delegating the production of essential inputs to independent ventures jointly established with competing rivals. The diffusion of this arrangement and the favourable stance of competition authorities call for the assessment of the social and private desirability of Input Production Joint Ventures (IPJV), which represent a form of input production cooperation, not investigated so far. IPJV can be seen as an intermediate organizational setting lying between the two extremes of vertical integration and vertical separation. Our investigation is based on an oligopoly model with horizontally differentiated goods. We characterize the conditions under which IPJV is privately optimal finding that firms' incentives may be welfare detrimental. We also provide a rationale for the empirical relevance of IPJV both in terms of its ability to survive and in terms of disengagement incentives.

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1 Introduction

In many industries we observe firms which delegate the production of an essential input to an independent venture carried out in cooperation with one (or more) firm(s) competing in the downstream market for the final good. Many examples may be found in most sectors.

In the automotive, for instance, Ford and PSA produce and design diesel engines in a specific joint venture; Ford and Fiat produce in a jointly owned plant the KA and the 500 on the basis of many common inputs.

In the electronic industry Sony jointly produces with rival Sharp newest liquid crystal displays.

In the media production, newspapers get rough news from press agencies they jointly own, like Associated Press in U.S.A. and ANSA in Italy.

In the chemicals it is quite common for giant companies to jointly own plants where ethylene and other basic components for plastics are manufactured, such as in the recent agreement between Dow and Kuwait Petroleum Corporation (Hewitt, 2008). Many other industries display cases of joint ventures in upstream sections of production. A great portion of them are known and visible even to the accidental observer.

Most of these joint ventures devoted to the manufacturing of an essential input are autonomous companies owned and governed on an equal foot by delegates of firms operating and competing among each other in the Downstream (D) section of the vertical chain of production.

We may term this arrangement as *Input Production Joint Venture* (IPJV). It may be regarded as an intermediate organizational setting lying between two extremes: Vertical Integration (VI), where the essential input is entirely manufactured in-house and Vertical Separation (VS), where the intermediate good is bought from external and independent firms operating in the Upstream (U) section of the vertical chain of production. Industrial Organization (IO) has so far considered VS, VI[1] and partial VS,[2] while the case of IPJV is studied only in the management literature.[3]

The closest case so far analyzed in IO is the Research Joint Venture (RJV) with a large and consolidated literature.[4] A RJV is a pre-production choice, based on the maximization of firms' joint profits. A IPJV requires an independent input producer owned on an equal stake by D firms. The profit of the venture accrues *ultimately* to the D firms which own the IPJV which is a particular case of Equity Joint Venture, as defined by Hewitt (2008)[5]. From

[1] For a recent survey of most theoretical and empirical issues on vertical integration, see Lafontaine and Slade (2007).

[2] The analysis of partial outsourcing can be found in Alvarez and Stenbacka (2007), Shy and Stenbacka (2005), Moretto and Rossini (2008).

[3] See for example Hewitt (2008) and the rich management literature surveyed on the subject.

[4] The seminal paper on R&D cooperation is d'Aspremont and Jacquemin (1988) which was then extended by, e.g, Kamien *et al.* (1992), and generalized by Amir *et al.* (2003) and Lambertini and Rossini (2009).

[5] "An equity joint venture .....is a joint venture or alliance which has the following characteristics, namely where (i) each party has an ownership interest in a jointly owned business, (ii)

the market structure viewpoint this arrangement is a kind of partial collusion. However, it does not seem to have given rise to much antitrust complain and suit so far.

Here, we would like to start to fill the gap in IO and analyze IPJV. Our aim is to examine feasibility, private and/or social desirability of IPJV considering also static uncertainty. A major problem we shall investigate is the stability of this arrangement or, in other words, the incentives that firms have to disengage or to join the plot of firms doing IPJV.

As said above the closest case to IPJV is provided by Research Joint Ventures (RJV). As literature emphasizes RJV is able to raise industry profits and, in most cases, also social welfare.[6] This result has produced a favorable stance by the US Department of Justice and many other antitrust authorities. "RJVs often provide procompetitive benefits, such as sharing the substantial economic risks involved in R&D, increasing economies of scale in R&D beyond what individual firms could realize....The antitrust enforcement agencies also view most RJVs as procompetitive and typically analyze them under the rule of reason because of their potential to enable participants to develop more quickly or efficiently new or improved goods, services, or production processes. Under the *Competitors Collaboration Guidelines*, the agencies will not ordinarily challenge a RJV when there are three or more other independently controlled firms with comparable research capabilities and incentives".[7] The case we are going to analyze of IPJV could be classified, according to the received taxonomy, as a subset of Production Joint Venture. Towards these arrangements the stance of market authorities has been mostly benign due to their supposed procompetitive effect and to the benefit consumers get: "Courts typically have analyzed true production joint ventures under the rule of reason and generally have upheld them".[8] The favorable stance of antitrust authorities should be also justified on the basis of the instability of IPJV. As reported in the management literature, almost one half of joint ventures end in a divorce (Hewitt, 2008, p.12).

In the ensuing pages we develop an oligopoly model with horizontally differentiated goods and analyze IPJV comparing it with VI. We replicate some canonical results on social superiority of VI, with linear pricing. However, we show that IPJV (partial or complete, according to whether only some or all firms in the market participate in the joint venture) is privately preferred to VI for high enough levels of competition in the D product market. These novel results obtain in the most unfavorable scenarios for IPJV, i.e., with zero fixed costs. *A fortiori*, they hold in the case of positive fixed costs, since IPJV prevents

the jointly owned business has a distinct management structure in which each party directly participates and (iii) the parties share the profits (or losses) of the jointly owned business". (Hewitt, 2008, p. 96).

[6] The pionereeing contribution comes from Kamien, Muller and Zang (1992) who found that joint process research and development is welfare maximizing when firms compete à la Cournot in the product market and in most cases of Bertand competition. The existence of spillovers due to RJV are crucial to the result. For the most recent contributions on the topic, which do not subvert the initial wisdom, see...

[7] Jacobson (2007) p. 447.

[8] Ibidem, p. 450.

wasteful replication of fixed costs. The private profitability of IPJV goes up as we move to more competitive market structures, i.e., as the number of firms increases, as products become closer substitutes or as we go from Cournot to Bertrand competition. The advantage of IPJV, when competition gets tougher, is due to the fact that D firms are able to reap profits in U (they jointly own) so as to compensate for the reduced returns in D. In this sense D firms are not afraid of competition in D. On the contrary, they may love it since they are sheltered by their profit "reserve" in U. As for the disengagement issue, we find that, when firms doing IPJV compete with vertically integrated rivals and product market substitutability is low, there may be an incentive to leave the IPJV. However, in some cases, incumbent vertically integrated firms may compensate IPJV members to stay in and make IPJV stable.

The outline of the paper is as follows. In Section (2) we compare VI with IPJV in a duopoly model, and we investigate the role of the degree of product differentiation, fixed cost and the nature of competition in the D product market in determining the private and social desirability of IPJV. In Section (3), we extend our analysis to oligopoly and we consider partial IPJV, i.e., the case in which only some of the firms in the market participate in the IPJV while competing with other VI firms. In Section (4) we address the disengagement question widely analyzed in the managerial literature on Joint Ventures (Hewitt, 2008).Private incentives to disengage from the IPJV may in some circumstances dominate and make a IPJV unsustainable. Finally, in Section (5) we analyze the relative preference of the different vertical arrangements under static uncertainty. Conclusions are given in Section (6).

2 A simple duopoly model

We begin with a simple model where there are two firms competing in the downstream (D) market. Each firm i produces a differentiated product, q_i sold at price p_i. The demand system is given by linear inverse demand schedules $p_i = a - q_i - bq_j$ in the region of quantities where prices are positive. The parameter $a > 0$ represents the market size; $b \in [0, 1]$ measures the degree of substitutability between the two final products (if $b = 1$, products are perfect substitutes; if $b = 0$, products are specialized, i.e., perfectly differentiated). To manufacture a final good, each firm needs an essential input which is produced either by the firm itself (VI) or by an independent U enterprise owned in equal stakes by the two D firms (Input Production Joint Venture - IPJV). More precisely, for the input production the D firms set up an Equity Joint Venture (Hewitt, 2008) whose profits accrue ultimately to the D firms.

As it is customary in the literature on vertical relationships we assume that one unit of input is embodied in each unit of output (perfect vertical complementarity). Input production requires a fixed cost equal to $f \geq 0$. Assume that the marginal production cost of the input is constant and equal to $z < a$; without loss of generality we set $z = 0$. Given the inverse demand system for the final goods Cournot competition leads to different equilibria according to the vertical arrangements and the resulting U market structure. We examine two distinct cases in turn.

The *first* is based on *VI:* there are two (symmetric) firms each comprising a U and a D activity. Their profits are:

$$\begin{aligned}\pi_1 &= q_1 p_1 - f \\ \pi_2 &= q_2 p_2 - f\end{aligned}$$

Quantity competition yields the customary symmetric equilibrium with the following price and industry profits (C stands for Cournot):[9]

$$\begin{aligned} p_{VI}^C &= \frac{a}{(b+2)} \\ \Pi_{VI}^C &= 2\left(\frac{a}{2+b}\right)^2 - 2f > 0 \\ \iff f/a^2 &< \frac{1}{(2+b)^2} \equiv s^{VI}(b). \end{aligned} \tag{1}$$

The *second* case is based on *IPJV*. The D firms jointly own on an equal stake the independent U producer of the essential input, while competing among themselves in the D section. Namely, both D firms get the input at the linear price g set at the input stage by the (monopolistic) U producer in order to maximize its profit, $\pi_U = g(q_1 + q_2)$. The vertical interaction between U and D is modelled as a two stage-game solved backwards, as it is customary in literature adopting linear pricing.[10] The input price is set at the monopoly level, $g_M = a/2$ and the IPJV symmetric equilibrium magnitudes are (labeled with J):

$$\begin{aligned} q_J^C &= \frac{a}{2(b+2)}, \\ \pi_J^C &= \frac{a^2}{4(b+2)^2}, \\ \pi_U^C &= \frac{a^2}{2(b+2)} - f, \\ p_J^C &= \frac{a(3+b)}{2(b+2)}. \end{aligned}$$

[9] Equilibrium variables are:

$$\begin{aligned} q_1^* = q_2^* &= \frac{a}{2+b} \\ \pi_1^* = \pi_2^* &= \left(\frac{a}{2+b}\right)^2 - f \\ p_1^* = p_2^* = p_{VI}^* &= \frac{a}{(b+2)}. \end{aligned}$$

[10] Recent examples may be found in Sappington (2005) and Arya *et al.* (2008).

Industry profits are:

$$\begin{aligned}\Pi_J^C &= \frac{(b+3)\,a^2}{2\,(b+2)^2} - f > 0 \\ \iff & f/a^2 < \frac{(b+3)}{2\,(b+2)^2} \equiv s^J\,(b)\,. \end{aligned} \tag{2}$$

Comparing the equilibrium values of the two vertical arrangements we may write the following proposition.

Proposition 1 Private and social relative efficiency of IPJV vs. VI.

a) Assume that input production does not require any fixed cost, i.e. $f = 0$. *In a duopoly market, a producer of a final good is indifferent between vertically integrating (VI) and participating to a IPJV as long as the final goods are homogeneous. In contrast, when the final goods are horizontally differentiated, downstream firms benefit if they switch to vertical integration. As for consumers, they always prefer vertical integration, which turns out to be Pareto superior.*

b) Assume that the fixed cost in U *is* $f > 0$ *and let* $s = f/a^2$ *be a relative measure of fixed cost vis à vis market size. It appears that IPJV is privately preferred for large levels of* s *(high relative fixed cost) and for increasing levels of* b *(decreasing differentiation). Consumers' preferences do not change with respect to point a). Social welfare turns out to be always superior with VI.*

Proof. a) Suppose first that $f = 0$. Profits' comparison is:

$$\Pi_J^C - \Pi_{VI}^C = (b-1)\,\frac{a^2}{2\,(b+2)^2} \leq 0.$$

As for the consumer surplus, it is higher under VI where the equilibrium price is lower, i.e., $p_J^* - p_{VI}^* = \frac{a(b+1)}{2(b+2)} > 0$. Therefore, VI is privately and socially preferred.

b) Suppose now $f > 0$, the previous comparison becomes:

$$\begin{aligned}\Pi_J^C - \Pi_{VI}^C &= \frac{f\left(8b + 2b^2 + 8\right) - a^2\,(1-b)}{2\,(b+2)^2} \geq 0 \\ \iff & \frac{f}{a^2} \geq \frac{(1-b)}{2\,(b+2)^2} \equiv \overline{s}\,(b) \end{aligned} \tag{3}$$

where $s \equiv f/a^2$ is a relative measure of fixed cost with respect to market size. As for social welfare (SW) we have to compare the sums of consumer surplus and industry profits in the two cases (VI and IPJV). Straightforward calculations lead to the definition of the following threshold:

$$\widetilde{s}\,(b) = \frac{(5+b)}{4\,(b+2)^2} \tag{4}$$

below which the SW of VI is larger than the SW of IPJV. Therefore, in the feasible set of parameters, VI is always socially preferred.

For the sake of simplicity, we plot (1), (2), (3) and (4) in the plane (b, s) in Figure 1 below. The upper solid line defines $s^J(b)$ above which neither vertical arrangement is feasible. The intermediate solid line defines $s^{VI}(b)$ below which VI is feasible. The lower solid line defines $\overline{s}(b)$ above which IPJV is privately preferred to VI, while below this line VI is preferred. The dashed line represents the social welfare frontier, $\widetilde{s}(b)$ below which VI is socially preferred to IPJV.

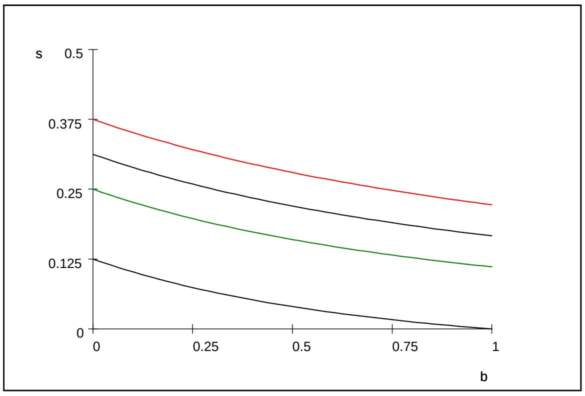

FIGURE 1 Threshold lines for private and social ranking of JIPV vs VI.

■

Discussion. Whenever the fixed cost of producing the essential input is sufficiently high, IPJV is privately more efficient. This becomes more likely as differentiation decreases. While the first effect is fairly obvious, the second is less clear-cut and points to the influence of differentiation on D competition. As $b \to 1$ industry profits "migrate" to U since the D section becomes more competitive driving down profits. The opposite occurs for VI which suffers from a tougher competition in D and does not benefit from any U profit buffer since it internally transfers the input at the marginal cost. In our duopoly scheme IPJV is never socially efficient since it introduces a sort of U collusion coupled to double marginalization. This negative effect has to be contrasted with the wasteful duplication of fixed costs associated to VI. The large areas of private superiority of IPJV, even in the duopoly case, accounts for the observed diffusion of Equity Joint Ventures along the vertical chain of production.

We conclude the duopoly case by investigating the profitability of the two vertical arrangements when firms compete à la Bertrand and we compare the results with Cournot.

Consider the same linear inverse demand system, $p_i = a - q_i - bq_j$. The demand schedule, for $b \neq 1$, is then given by $q_i = \alpha - \beta p_i + \delta p_j$, with

$$\alpha = \frac{a}{1+b}, \beta = \frac{1}{(1-b)(1+b)}, \delta = \frac{b}{(1-b)(1+b)}.$$

Under VI, price competition yields the following symmetric equilibrium (B stands for Bertrand):

$$
\begin{aligned}
p^B_{VI} &= \frac{(a-ab)}{(2-b)} \\
\pi^B_{VI} &= \frac{a^2(1-b)}{(b-2)^2(b+1)} - f \\
q^B_{VI} &= \frac{a}{(2-b)(b+1)}
\end{aligned}
$$

So that aggregate profits are $\Pi^B_{VI} = 2\frac{a^2(1-b)}{(b-2)^2(b+1)} - 2f$.[11] Under IPJV, the equilibrium magnitudes are:

$$
\begin{aligned}
p^B_J &= \frac{a(3-2b)}{2(2-b)} \\
\pi^B_J &= \frac{a^2(1-b)}{4(b-2)^2(b+1)} \\
\pi^B_U &= \frac{a^2}{2(2-b)(b+1)} - f \\
q^B_J &= \frac{a}{2(2-b)(b+1)}
\end{aligned}
$$

So that aggregate profits are $\Pi^B_J = \frac{(3-2b)a^2}{2(b-2)^2(b+1)} - f$.

Comparing the equilibrium values of the two vertical arrangements in the two distinct market structures, we obtain the following results.

Proposition 2 Bertrand duopoly and comparisons

a) With Bertrand competition in the D market, if $f = 0$ IPJV is privately preferred to VI as long as $b \in [\frac{1}{2}, 1)$.

b) IPJV under Bertrand competition yields larger D quantities, lower D prices, higher U profits and lower D profits than under Cournot competition, i.e., $q^B_J > q^C_J$, $p^B_J < p^C_J$, $\pi^B_U > \pi^C_U$ and $\pi^B_J < \pi^C_J$; industry profits and consumer surplus are higher under Bertrand.

Proof. a) Comparing the joint profits under the two scenarios we find that:

$$\Pi^B_J - \Pi^B = \frac{(2b-1)a^2}{2(b-2)^2(b+1)} + f.$$

Assume $f = 0$, $\Pi^B_J - \Pi^B > 0 \iff b > 1/2$.

[11] As one can expect (Sing and Vives, 1984), the same scenario under quantity competition leads to higher profits, i.e. $\Pi^C_{VI} > \Pi^B_{VI}$.

b) The IPJV scenario under price and quantity competition yields the following equilibrium comparisons:

$$q_J^B - q_J^C = \frac{b^2 a}{2(b+1)(b+2)(2-b)} > 0,$$

$$p_J^B - p_J^C = \frac{-b^2 a}{2(b+2)(2-b)} < 0,$$

$$\pi_U^B - \pi_U^C = \frac{b^2 a^2}{2(b+1)(b+2)(2-b)} > 0,$$

$$\pi_J^B - \pi_J^C = \frac{-b^3 a^2}{2(b+2)^2(b-2)^2(b+1)} < 0, \text{ and}$$

$$\Pi_J^B - \Pi_J^C = \frac{\left(4-2b-b^2\right)a^2 b^2}{2(b+2)^2(b-2)^2(b+1)} > 0.$$

■

Discussion. The profitability of IPJV vs VI increases when we go from a Cournot to a Bertrand market structure regardless of the fixed cost. In fact, this form of joint venture is strictly preferred over VI when goods are sufficiently substitutable even in the absence of fixed costs. The presence of positive fixed costs clearly reinforces the relative profitability of IPJV. As for the comparison of IPJV under the two natures of competition, with Bertand the D externality affects the distribution of profits along the vertical chain making the U section more profitable and the D section less profitable vis à vis Cournot. Nonetheless Bertrand competition is able to make for larger industry profits. This outcome is due to the larger quantity produced that allows for higher U profits which overcompensate for the squeeze in D. As a result, in line with Singh and Vives (1984), Bertrand competition is socially preferred to Cournot competition.[12]

3 Oligopoly

Here we extend and generalize the investigation conducted in the above section. We consider an oligopoly where $n \geq 3$ firms operate. The extension comes from the analysis of mixed cases which were not contemplated in the duopoly framework, and from the stance of the US Department of Justice quoted in the introduction (Jacobson, 2007; p. 447). To this aim we go through the case of a mixed market arrangement where vertically integrated (VI) firms compete with non integrated firms which buy the essential input from an independent producer serving all non integrated companies. As in the previous section, the independent U producer, responsible for IPJV, is owned by non integrated firms which are active in D.

Consider the linear inverse demand schedule $p_i = a - q_i - b\sum_{j\neq i} q_j$. Again, without loss of generality, we set the marginal cost of production of the essential input $z = 0$.

[12] This is in contrast with Arya, *et al.* (2008) who maintain that the selling of input by a VI firm to D competitors may reverse the standard social ranking of Cournot vs Bertrand.

Now, we are able to extend the analysis to three distinct scenarios that we study in turn. In the first, all firms are *VI*, in the second, *partial IPJV*, some firms are VI and others participate in the IPJV, while in the third all firms participate in the IPJV and we have *complete IPJV*.

First, under complete *VI* we have n (symmetric) firms each comprising the U and the D sections of the vertical production process. Equilibrium magnitudes are:

$$q_{iVI}^{*} = \frac{a}{2+b(n-1)}, \forall i = 1, ..., n$$
$$\pi_{iVI}^{*} = \left(\frac{a}{2+b(n-1)}\right)^{2} - f$$
$$p_{iVI}^{*} = p_{VI}^{*} = \frac{a}{2+b\left(n-1\right)},$$

so that aggregate profits are:

$$\Pi_{VI} = n\left(\frac{a}{2+b(n-1)}\right)^{2} - nf > 0.$$

Second, we figure out *partial IPJV* with $(n-k)$ D firms, competing with k VI firms, while jointly owning the independent input producer which sets price g. The D firms' profits are:

$$\pi_{iD} = p_i q_i - g q_i, i = 1, ..., n-k$$

while the VI firms' profits are:

$$\pi_{jVI} = p_j q_j - f, j = n-k+1, ..., n$$

with $k \geq 1$ and $n > k$. Cournot competition leads to the following input price equilibrium:

$$\begin{aligned} g \quad &= \quad \arg\max_{g}\left(g\sum_{i=1}^{n-k} q_i - f\right) \\ \iff \quad & g_P = \frac{a\left(2-b\right)}{4-2b\left(1-k\right)} \end{aligned} \tag{5}$$

Notice that the price set by the partial IPJV, g_P, does not depend on the total number of firms in the industry, n. It depends on the number of firms adopting VI, i.e., k, as well as on b, the degree of product differentiation in the D market. In particular, g_P is decreasing in k and in b (the tougher the competition in D, the lower the input price). These two effects may be deemed vertical externalities since they originate in D while their effect extends to U price setting.

Remaining equilibrium magnitudes are:

$$
\begin{aligned}
p_{jVI} &= \frac{a\left(b\left(k+n-2\right)+4\right)}{2\left(b\left(n-1\right)+2\right)\left(b\left(k-1\right)+2\right)}, j=n-k+1,...,n \\
\pi_{jVI} &= \frac{a^2\left(b\left(k+n-2\right)+4\right)^2}{4\left(b\left(k-1\right)+2\right)^2\left(b\left(n-1\right)+2\right)^2}-f, j=n-k+1,...,n \\
p_i &= \frac{a\left(6-b^2\left(n-1\right)-b\left(5-2n-k\right)\right)}{2\left(b\left(n-1\right)+2\right)\left(b\left(k-1\right)+2\right)}, i=1,...,n-k \\
\pi_{iD} &= \frac{a^2}{4\left(b\left(n-1\right)+2\right)^2}, i=1,...,n-k \\
\pi_U &= \frac{\left(2-b\right)\left(n-k\right)a^2}{4\left(b\left(k-1\right)+2\right)\left(b\left(n-1\right)+2\right)}-f \\
\pi_{cons}^{pJ} &= \frac{a^2\left(b\left(k+2n-5\right)+b^2\left(1-n\right)+6\right)}{4\left(b\left(k-1\right)+2\right)\left(b\left(n-1\right)+2\right)^2}-\frac{f}{n-k},
\end{aligned}
$$

where p_{jVI}, π_{jVI} and p_i, π_{iD} are the prices and profits of the VI firms and of the D firms, respectively; $\pi_{cons}^{pJ}=\pi_{iD}+\frac{1}{n-k}\pi_U$ are the consolidated profit of a firm participating in the (partial) IPJV. Industry profits are

$$
\Pi_{PJ}=\frac{a^2\left(k^2b^2(n-b+bn+2)-k\left(3b^2-12bn-b^3+6b^2n-3b^2n^2+b^3n^2-4\right)+n(b-2)^2(bn-b+3)\right)}{4(bn-b+2)^2(bk-b+2)^2}-f\left(k+1\right).
$$

Under *complete IPJV*, the n D firms set up an Equity Joint Venture for the joint input production (IPJV). The Equity Joint Venture is thus the unique input producer setting the monopoly input price $g_M=a/2$. The equilibrium values are:

$$
\begin{aligned}
q_{iJ}^* &= \frac{a}{2\left(bn-b+2\right)} \\
\pi_{iD}^* &= \frac{a^2}{4\left(bn-b+2\right)^2} \\
\pi_U^* &= \frac{na^2}{4\left(bn-b+2\right)}-f \\
p_{iJ}^* &= \frac{\left(bn-b+3\right)a}{2\left(bn-b+2\right)}.
\end{aligned}
$$

Aggregate profits are

$$
\Pi_J=\frac{\left(bn-b+3\right)a^2n}{4\left(bn-b+2\right)^2}-f.
$$

Let us compare the different market and vertical arrangements analyzed above. We classify them according to the degree of downstream market competition measured by b and n, since, as b and n increase, competition in D becomes tougher.[13] To perform the comparison we split the feasible set of the differentiation parameter b into distinct areas which depend on n.[14] In what follows we abstract from fixed cost assuming $f = 0$ and we confine to a partial IPJV where a single VI firm competes with $(n-1)$ D firms owning the IPJV, i.e., $k = 1$. These two assumptions simplify the analysis without compromising the results and basic intuitions. Later on, we will discuss extensions to $f > 0$ and $k > 1$.

By comparing aggregate profits in the three analyzed vertical arrangements, we get the following thresholds:

$$\Pi_{VI} - \Pi_J = \tfrac{(-b(n-1)+1)a^2 n}{4(bn-b+2)^2} > 0 \iff b < \frac{1}{n-1} \equiv b^{PJ}(n) \tag{6}$$

$$\Pi_{VI} - \Pi_{PJ} = \tfrac{\left(b^2 n - b^2 - 4bn + 4\right)(n-1)a^2}{16(bn-b+2)^2} > 0 \iff b < \tfrac{2\left(n-\sqrt{n^2-n+1}\right)}{n-1} \equiv b^{VI}(n) \tag{7}$$

$$\Pi_J - \Pi_{PJ} = \tfrac{(bn-b-2)a^2}{16(bn-b+2)} > 0 \iff b > \frac{2}{(n-1)} \equiv b^J(n). \tag{8}$$

From these comparisons we can derive the following:

Proposition 3 Private and social efficiency of complete IPJV, partial IPJV and VI.

a) For sufficiently high levels of product differentiation, i.e., $b \in \left(0, b^{VI}(n)\right)$, the private ranking is: VI $\succ$ partial IPJV $\succ$ complete IPJV;

b) For upper intermediate levels of product differentiation, i.e., $b \in \left(b^{VI}(n), b^{PJ}(n)\right)$, the private ranking is: partial IPJV $\succ$ VI $\succ$ complete IPJV;

c) For lower intermediate levels of product differentiation, i.e., $b \in \left(b^{PJ}(n), b^{J}(n)\right)$, the private ranking is: partial IPJV $\succ$ complete IPJV $\succ$ VI;

d) For low levels of product differentiation, i.e., $b \in (b^J(n), 1]$, the private ranking is: complete IPJV $\succ$ partial IPJV $\succ$ VI.

e) As for the social welfare (SW) we have the following ranking: $SW_{VI} > SW_{PJ} > SW$.

Proof. For the sake of simplicity, we plot (6), (7) and (8) in the plane (n, b) in Figure 2 below. The upper solid line defines $b^J(n)$, above which complete IPJV is the preferred vertical arrangement. Notice that this threshold is meaningful, i.e., lower than 1, only for $n \geq 4$. The intermediate solid line defines $b^{PJ}(n)$, above which partial IPJV is preferred to complete IPJV, which is better than VI. Between $b^{PJ}(n)$ and the lower solid line which defines $b^{VI}(n)$, partial IPJV is preferred to VI which is better than complete IPJV. Finally, between the horizontal axis and the lower solid line, VI is preferred to partial IPJV which is

[13] As b increases, products become closer substitutes and the market size (the total quantity) decreases. As for the number of firms, an increase in n, which also defines the number of varieties, determines an increase of the market size (because of consumers' love for variety); however as firms' profits decrease with n, we take n as another measure of competition.

[14] As standard in the oligopoly literature, we treat n as a real number. Clearly, we will take into account the integer problem when it is necessary.

better than complete IPJV.

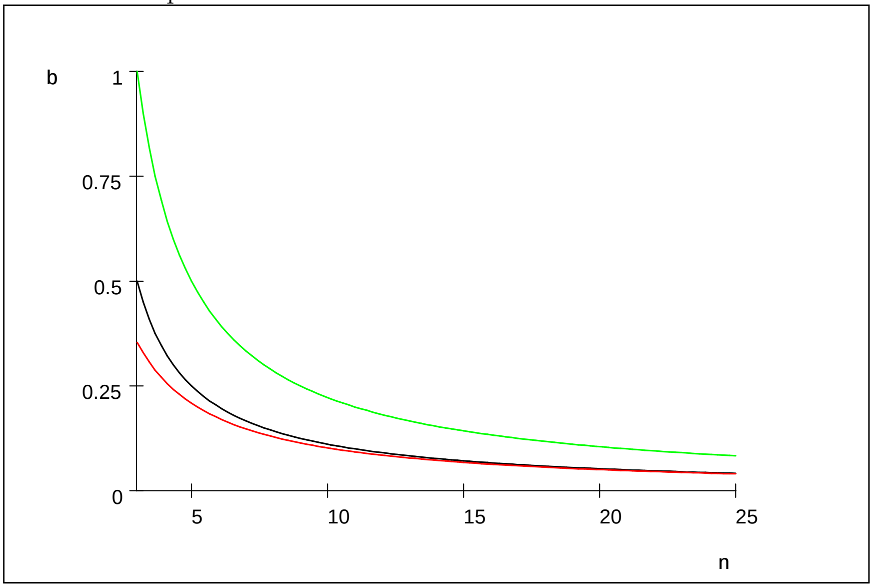

FIGURE 2: Comparisons between aggregate industry surpluses under VI, partial and completeJIPV

As for social welfare ranking, straightforward calculations lead to:

$$SW_{VI} = \frac{a^2(3 + b(n-1))n}{2(2 + b(n-1))^2}$$

$$SW_{PJ} = \frac{a^2(4(5 + 7n) + b(n-1)(16 - 3b + 3(4 + b)n))}{32(2 + b(n-1))^2}$$

$$SW_J = \frac{a^2(7 + 3b(n-1))n}{8(2 + b(n-1))^2}.$$

whose ranking, $SW_{VI} > SW_{PJ} > SW$ is independent of the values of n and b. ■

Discussion.

The above results emphasize the effect of competition measured by b on private (industry) preferences towards the vertical arrangements. As the degree of product differentiation decreases firms prefer to switch from VI to some form of IPJV (partial or complete). This result somewhat replicates and extends the duopoly outcome seen above.[15] However, in the present oligopoly framework we are able to analyze also the effect of n as well as the interaction between n and b. As D competition gets fiercer with the number of firms, only high levels of differentiation are able to preserve the private advantage of VI. On the

[15] In line with these findings, the extension to a Bertrand oligopoly which also implies a more competitive D market structure increases the JIPV profitability. The intuition is the same as for the duopoly case.

contrary, under IPJV the D firms are able to "shift" to U the profit cancelled due to tougher competition. With IPJV in U the D firms are able to compensate the lost profit in D with the monopoly profit obtained by the single independent U producer. If the market structure changes and a VI firm enters we have partial IPJV. As a result, the U market becomes more contestable since the VI firm makes its own input in-house and drives down the input demand faced by the incumbent U firm. This translates into a lower g. Therefore, the entry of a VI firm selling in D provides an automatic policing of the U market. This is an external effect and it occurs even if the VI company does not sell any input to the rival D firms, which keep on buying the input from the IPJV.

The limitation of the analysis to zero fixed costs is adopted for a neater investigation of D market structure effects (b, n) on the ranking of industry preferences for the three distinct vertical arrangements. If we consider positive fixed cost the qualitative results obtained in the oligopoly market do not change as far the effects of b and n are concerned. Nonetheless, a positive f is going to increase the likelihood of the adoption of IPJV, making this arrangement more privately (and socially) desirable, since average fixed costs for individual firms go down with respect to the VI case. This effect has been properly investigated in Proposition (1). Extensions are straightforward.

Consider now the case of $1 < k < n$. If $k \to n$, the partial IPJV tends to disappear as the market is made entirely by VI firms. Notice that the thresholds $b^{VI}(n)$ and $b^{J}(n)$, which define respectively the lower and the upper limit of the area where partial IPJV is the preferred setting, now depend also on k. Moreover, $\partial b^{J}/\partial k \leq 0$ as it can be easily verified. Further, as k increases, the aggregate profits of partial IPJV decrease, whereas those of VI do not change, making for an indirect proof that $\partial b^{VI}/\partial k > 0$. Therefore, in the limit, $k \to n$, the interval $\left(b^{VI}(n), b^{J}(n)\right)$ would not exist anymore. In other words, as the number of VI firms (k) in the partial IPJV configuration increases, the probability that partial IPJV is the most preferred setting vanishes.

Last but not the least, in most received literature RJV is deemed superior because of internalization of spillovers, i.e., externalities. Here, we do not introduce any external effect in the input production. Nonetheless, if external effects were there they would add to the private benefits of IPJV and have an impact similar to the saving of fixed costs that the IPJV implies. In all these cases we may seem areas of social preference emerge beyond and above private efficiency.

4 Disengagement

In Proposition (3) we have analyzed industry preferences towards the three vertical arrangements. However, one of the main faults of a Joint Venture is its ability to last and survive despite the presence of incentives to leave it and go alone or join other ventures. This problem is widely analyzed in the managerial literature on Joint Ventures (Hewitt, 2008) and is usually framed as a disengagement question.

The sort of disengagement we are going to consider is caused by the (individual) incentives firms have to move from one status (for instance VI or VS with IPJV) to another.

To evaluate these incentives we have to compare individual profits in the different statuses.

The analysis begins with the consideration of two extreme cases and subsequently goes to the intermediate.

4.1 Individual incentives

Consider *first the two extremes*, VI and complete IPJV. As they are symmetric situations, individual and aggregate preferences coincide. Therefore, we may write:

$$\pi^*_{iVI} - \pi^*_{iJ} > 0 \iff b < b^{PJ}(n) \tag{9}$$

where $b^{PJ}(n)$ is defined in (6) and decreasing in n. From (9) we see that there is an incentive for firms involved in IPJV to leave the joint venture and become VI, provided b is sufficiently low. This event becomes more likely the lower is the number of firms in the market (as b^{PJ} is decreasing in n). In other words, the incentive to leave the IPJV plot is higher when the market is made by few firms and/or the degree of differentiation is high (low b). In these circumstances the IPJV turns out to be quite fragile and liable to fall apart due to private incentive to disengage.[16]

The *intermediate situation* of partial IPJV has two types of actors, the VI firm and the D firms owning the independent IPJV. Simple computations show that the VI firm is worse off than the $(n-1)$ D firms if fixed costs are high enough. If we abstract from fixed costs, the VI firm enjoys a variable cost advantage (input price) with respect to the D firms. Therefore, it holds a higher market share allowing for higher profits.

If each firm in the IPJV adopts the VI arrangement, the advantage of the existing VI firm (the n^{th} firm in the market) fades away as the equation below shows:

$$\pi^*_{nVI} - \pi^*_{iVI} = \frac{(bn - b + 8)(n-1)a^2 b}{16(bn - b + 2)^2} > 0.$$

The above positive difference defines the loss of profit of the existing VI firm when remaining firms turn to VI.

As for the D firms, they gain from disengaging only in some areas of parameters b and n. To see this we compute the difference representing the incentive to disengage of the D firms belonging to the IPJV plot. This difference is given by the following:

$$\begin{aligned} \pi^*_{iVI} - \pi^{*pJ}_{icons} &= a^2 \frac{b^2(n-1) + b(4-2n) + 2}{8(bn - b + 2)^2} > 0 \\ &\iff b < \tfrac{(n-2) - \sqrt{(n^2 - 6n + 6)}}{(n-1)} \equiv b_1(n). \end{aligned} \tag{10}$$

[16] These conclusions hold for zero fixed costs. Strictly positive fixed costs erode the incentives to disengage from JIPV.

From the comparison of individual incentives we obtain the following.

Lemma 4 *i) For $n = 3, 4$ and for sufficiently low levels of substitutability, i.e., $b < b^{VI}(n)$, the D firms decide to leave the IPJV plot as they reap larger profits if they disengage and the VI firm has no incentive to stop them. For higher levels of product substitutability, i.e., $b > b^{VI}(n)$, the D firms have again the incentive to leave. However, disengagement may not occur since the existing unique VI firm can prevent disengagement by compensating the D rival firms. This is feasible since the loss of the VI would be higher than the gain the D firms would get if they turn to VI.*

ii) For $n = 5, 6...$ and for sufficiently low levels of substitutability, i.e., $0 < b < b^{VI}(n)$, the D firms disengage. For $b^{VI}(n) < b < b_1(n)$, the VI firm can stop disengagement since the aggregate profits of partial IPJV are larger than those of complete VI. Finally for $b_1(n) < b < 1$ there is no incentive to disengage.

Proof. We begin stating that

$$\pi^*_{iVI} - \pi^{*pJ}_{icons} > 0 \iff b^2(n-1) + b(4-2n) + 2 > 0.$$

This polynomial has two roots: $b_1 = \frac{(n-2)-\sqrt{(n^2-6n+6)}}{(n-1)}$, $b_2 = \frac{(n-2)+\sqrt{(n^2-6n+6)}}{(n-1)}$. They are real numbers only for $n > 4$. Therefore, i) for $n = 3, 4$ the difference $\pi^*_{iVI} - \pi^{*pJ}_{icons}$ is strictly positive for all feasible b. In other words, each D firm gains a positive surplus by disengaging from the partial IPJV. This occurs in both cases, i.e., when each firm leaves the IPJV plot on an individual basis and when all IPJV firms leave as a group.

ii) For $n \geq 5$, the two roots are real. In particular $b_1 \in (0, 1)$, while $b_2 \geq 1$, and is not acceptable. Therefore, $\pi^*_{iVI} - \pi^{*pJ}_{icons} > 0 \iff b < b_1$.

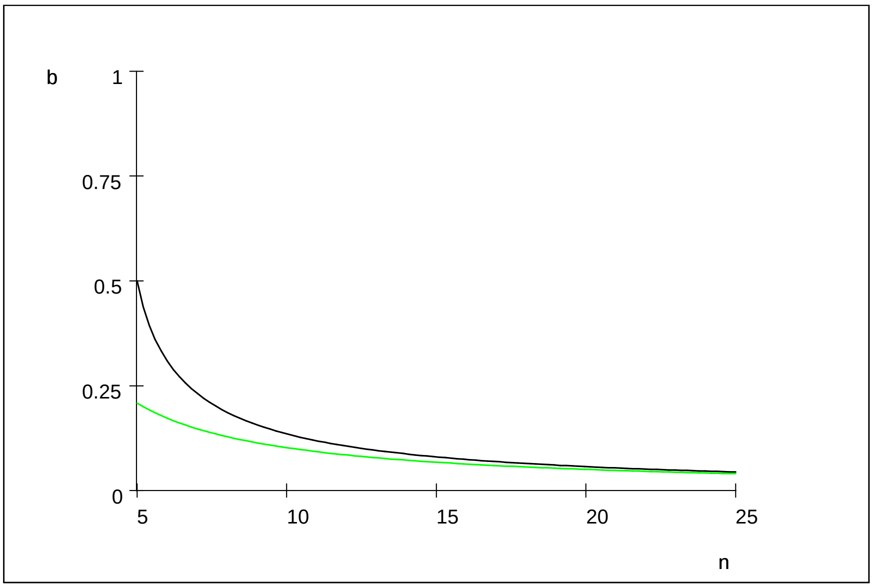

FIGURE 3: Ranges of b defining the private incentive to disengage

Figure 3 depicts the thesholds defined by (7) and (10) in the plane (n, b). The solid upper line represents the frontier defined by b_1. Above the line there is no incentive to disengage from IPJV, while below the incentive is nonnegative. The solid lower line defines the frontier $b^{VI}(n)$. Below it, disengagement is profitable and feasible. Above it and below the the frontier, defined by b_1, the VI firm could compensate the IPJV firms if they agree not to move, since the loss the VI would bear in the case of disengagement would be larger than the gain IPJV firms obtain. ■

4.2 Sorting the equilibria

From the above considerations and taking into account Lemma 4, we may derive the following.

Proposition 5 Sorting Nash equilibria (NE)

For low levels of product market substitutability, i.e., $b < b^{VI}(n)$, the adoption of VI by all firms is a NE. For high levels of product market substitutability, i.e., $b > b^{J}(n)$, the adoption of IPJV by all firms is a NE. For intermediate levels of product substitutability partial IPJV turns out to be a NE if a mechanism is set up whereby the VI firm(s) compensates the D firms in order to stop them from disengaging and leaving the IPJV.

Proof. Looking at the aggregate industry profits, we see that for $b < b^{VI}(n)$, (lower solid line in Figure 3), VI is strictly better than partial IPJV, so that the adoption of VI by all firms is a NE (there would not be any possibility for the single VI firm of the partial IPJV configuration to compensate the others not to disengage). Also for $n \geq 5$ and $b < b_1$ the D firms gain from the switch: however only for $b^{VI}(n) < b < b_1$ there is the compensation incentive (the difference between the profit of the VI firm in the presence of disengagement and the VI profit without disengagement is larger than the difference between the profits of Ds with disengagement and those without disengagement). For $n \geq 5$ and $b^J > b > b_1$ the D firms participating to the partial IPJV do not have any incentive to disengage as $\pi^*_{iVI} < \pi^{*pJ}_{icons}$: in this area the partial IPJV is a NE. Finally, for $b > b^J(n) > b_1$, aggregate profits are higher with complete IPJV, so that the D firms have the incentive and the possibility to persuade the single VI firm to join the venture. The single VI firm would not have the incentive to switch, unless compensated by D firms, since:

$$\pi_{nVI} - \pi_i^J = \frac{1}{16}a^2 > 0,$$

where π_i^J is the compensated profit of a firm in the complete IPJV,

$$\pi_i^J = \frac{a^2}{4(bn-b+2)^2} + \frac{1}{n}\frac{na^2}{4(bn-b+2)}$$

and for $k = 1$

$$\pi_{nVI} = \frac{(bn-b+4)^2 a^2}{16(bn-b+2)^2}.$$

These prove the existence of the Nash equilibria mentioned in Proposition 5. ■

Discussion. The wealth of Nash Equilibria proves the private efficiency of IPJV in many circumstances and its ability to survive. However, the fact that there are many areas of incentives to disengage and also some mechanism that may sustain them points to the frequent divorces observed in many joint ventures of all kinds, IPJV included.

5 Profit volatility of VI and IPJV

A further question we address concerns the relative preference of the different vertical arrangements under uncertainty. Actually, an important rationale behind many forms of joint ventures is risk sharing. We thus investigate the effect of uncertain market demands for the final goods on IPJV desirability. The answer may come from a simple extension to a triopoly framework with one VI firm competing with the other two D firms which jointly own, on an equal stake, an independent input producer (partial IPJV). We enrich the model by the considerations of both Cournot and Bertand competition.

Consider the following inverse demand functions:

$$\begin{aligned} p_1 &= a - q_1 - b(q_2 + q_3) + e \\ p_2 &= a - q_2 - b(q_1 + q_3) + e \\ p_3 &= a - q_3 - b(q_1 + q_2) + e \end{aligned} \tag{11}$$

where e is the additive shock parameter with $E(e) = 0$, and $E\left(e^2\right) = \sigma^2$.

We begin with Cournot competition. In this framework the D firms maximize expected profits selecting a quantity to which they will stick regardless of the realization of the stochastic shock. This quantity is anticipated by U, which chooses the profit maximizing input price g. This price is deterministic. Given the optimal g, D firms get realized profits and prices which depend on the stochastic shock. As usual, the VI firm just maximizes expected profit of the entire vertical chain of production. The set of equilibrium realized profits is:

$$\pi_{1D} = \pi_{2D} = \frac{a(a + 4(1+b)e)}{16(1+b)^2}$$

$$\pi_U = \frac{a^2(2-b)}{8(1+b)}$$

$$\pi_{cons} = \frac{a(a + 4(1+b)e)}{16(1+b)^2} + \frac{a^2(2-b)}{16(1+b)}$$

$$\pi_{VI} = \frac{a(b+2)(2a+ab+4e(1+b))}{16(1+b)^2}$$

As it can be seen, only π_U is certain, while π_{1D}, π_{2D}, π_{VI} are affected by uncertainty. If we take expectations we see that all expected profits are equal to certainty profits of the corresponding triopoly case. Therefore, the private rankings do not change with respect to what seen above in the certainty case. However, volatility is not irrelevant. If we compare the variance of π_{VI} with that of π_{cons}, we discover that the former is more volatile than the latter:

$$var(\pi_{VI}) = \frac{a^2(2+b)^2}{16(1+b)^2}\sigma^2 > var(\pi_{cons}) = \frac{a^2}{16(1+b)^2}\sigma^2.$$

This means that the profit volatility of the IPJV is lower than that of VI. This result is due to the fact that the U joint venture is not affected by uncertainty and therefore its profit provides a sort of cushion against risk also for D firms. On the contrary the VI firm does not enjoy this chunk of sure profit and therefore shows higher volatility. IPJV does not generate an actual risk sharing along the vertical chain, since the entire risk is faced by D firms while the U joint venture is somehow isolated from risk.

A different story can be told when firms compete à la Bertrand, while facing the same kind of demand uncertainty. In that case the equilibrium profits are:

$$\pi_{1D} = \pi_{2D} = \frac{a(1-b)(a+ab+4e)}{16(2b+1)}$$

$$\pi_U = \frac{a(1-b)(2+3b)(a+ab+4e)}{8(1+b(3+b-2b^2)}$$

$$\pi_{cons} = \frac{a(1-b)(3-(-4+b)b)(a+ab+4e)}{8(1+b(3+b-2b^2)}$$

$$\pi_{VI} = \frac{a(1-b)\left(2-b^2+3b\right)\left(a(b+1)\left(2-b^2+3b\right)+4e\left(1-b^2+b\right)\right)}{16(b^2-b-1)^2(2b+1)}$$

As far as the different level of volatility of the two arrangements are concerned, we can write the following variances:

$$var(\pi_{VI}) = \frac{a^2(-1+b)^2(-2+(-3+b)b)^2}{16(1+b(3+b-2b^2)^2}\sigma^2 < var(\pi_{cons}) = \frac{a^2(-1+b)^2(-3+(-4+b)b)^2}{16(1+b(3+b-2b^2)^2}\sigma^2,$$

from which it appears that the ranking of volatility under Bertrand competition is reversed. In addition to that, the sharing of risk along the vertical chain in the IPJV is now more balanced since both U and D profits are affected by σ^2 and, therefore, they both contribute to the entire volatility of IPJV.

Taking into account all these considerations, we may write the following result.

Proposition 6 Effect of demand uncertainty on IPJV

Additive demand uncertainty does not change the ranking of private and social preference of IPJV in both Cournot and Bertrand competition with respect to certainty. However, it does affect the relative volatility of the two vertical arrangements and risk sharing along the vertical chain: under Cournot competition IPJV is less volatile than VI and the entire market risk is born by D firms, while under Bertrand competition the IPJV is more volatile and there is risk sharing between U and D firms.

Discussion. The above result underlies the importance of IPJV for risk sharing along the vertical chain of production, regardless of the nature of competition assumed in D. The fact that IPJV changes the distribution of risk between U and D according to whether Bertrand or Cournot is adopted may make one of the two market strategies preferred because of the risk allocation that it produces.

6 Conclusions

In these pages we have analyzed the social and private desirability of Input Production Joint Ventures (IPJV), which can be seen as an intermediate organizational setting lying between the two extremes of vertical integration and vertical separation. As pointed out in the management literature, this form of joint venture is widely adopted in many industries. Nonetheless, the theoretical IO literature on this topic is surprisingly thin. Generally, production joint ventures do not arise competitive concerns from antitrust authorities on the basis of economies of scale and synergies. IPJV is definitely a form of partial collusion. When compared to vertical integration, in some cases, IPJV turns out to be privately desirable but inefficient from a social welfare point of view, even if it allows for savings in fixed cost.

Our results are twofold. We provide a first theoretical model for the analysis and show that IPJV may be privately preferred to vertical integration even in the absence of wasteful duplication of fixed costs: firms' incentives to form a IPJV increase with the degree of downstream market competition. We characterize the conditions under which IPJV is privately optimal and argue that firms' incentives may be welfare detrimental. Finally, we provide a rationale for the empirical relevance of IPJV both in terms of its ability to survive and in terms of disengagement incentives. To this purpose we investigate market structures where firms doing IPJV compete with vertically integrated rivals. We find that, if product market substitutability is low, there may be an incentive for firms doing IPJV to leave and turn to vertical integration. However, this incentive could be efficiently neutralized via a transfer mechanism whereby incumbent vertically integrated firms compensate IPJV members to stay in. Our emphasis on disengagement is due to the high rate of divorces among firms joining IPJV (Hewitt, 2008).

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