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Nonverifiability, noncontractibility and ownership determination models in foreign direct investment, with an application to foreign operations in Japan

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Abstract

Firms' intangible assets are important inputs for their foreign operations. Inputs of intangible assets and the resulting output are often not contractible in that neither precise use of such inputs nor potential products which can be produced by taking advantage of such inputs can be completely delineated in a contract. Where such incomplete contracts prevail, control of residual rights becomes essential for protecting firms' intangible assets. Ownership is often used to control residual rights in international operations.

In this paper we present a few interrelated models of ownership determination for firms' international operations. We show that a firm's ownership share in its foreign operation reflects the importance of the firm's intangible assets used in the operation and the resulting bargaining power relative to its local partners'. We test our theoretical implications using data on foreign firms' manufacturing operations located in Japan. Our empirical results are consistent with theoretical predictions. © 1998 Elsevier Science B.V.

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1. Introduction

One of the main decisions facing a firm considering foreign direct investment (FDI) is that of the ownership structure for its foreign operation: should it be a fully-owned subsidiary, or should it be a joint venture with a firm in the host country? In case of a joint venture, how much ownership should the foreign parent firm have in the joint venture? Alternative theories of FDI do not generally address the question of ownership structure for firms' FDI.[2]

Yet the ownership structure for a foreign subsidiary is particularly important for technology-based manufacturing firms whose competitive edge primarily comes from intangible assets such as engineering and scientific knowledge, production skills and know-how, and brand names. These intangible assets may also reflect product quality, marketing and other management techniques. It is generally difficult for a foreign firm to write a legal contract with a local joint venture partner firm which specifies precisely the way in which a particular intangible asset is to be used in the joint venture.

Such a problem of skill spillover will likely be reduced if the provider of intangible skills owns substantial equity in the operations utilizing such skills. This is because the ownership of an asset includes not only the entitlement to the return stream resulting from the use of the asset, but also the residual rights of control over all aspects of the use of the asset except those rights which are explicitly contracted away (Grossman and Hart, 1986). In this sense equity participation in a direct investment plays an essential role in technology-based firms' expansions into foreign markets where potential competitors also do business.[3]

Two types of direct investment, fully-owned and jointly owned subsidiaries, have different implications for the diffusion of a foreign parent firm's technology. While a fully-owned subsidiary can keep foreign parent firm's loss due to unauthorized use of its intangible assets to a minimum, the foreign parent firm (FP) might not be able to reap fully the return that its intangible assets could potentially earn. This may occur, for example, if FP or its 100% subsidiary, is not familiar with local production inputs and distribution and marketing practices. The

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[2] In this paper we only consider foreign operations involving ownership, since ownership is thought to be essential for reducing the loss of intellectual property rights as well as reducing certain agency cost. Analysis of contractual arrangements without ownership, which may provide firms with adequate protection under certain circumstances (for instance, for the hotel industry), is beyond the scope of the paper.

[3] Equity participation is an effective means to control residual rights, but it does not eliminate skill spillover fully. For example, skill spillover caused by a turnover of key technical personnel cannot be completely eliminated by equity participation. See also Nakamura et al., 1996 for the dynamic stability of joint ventures.

geographical distance between FP and its fully-owned foreign subsidiary also increases FP's cost of agency (monitoring)[4].

1.1. Literature review on foreign ownership

Hymer (1960) and Caves (1971) put forward the hypotheses that firms invest abroad to capitalize on the ownership of various firm-specific intangible assets, provided that firms are able to transfer these assets at very low cost. The internalization theory (e.g. Buckley and Casson (1976)) explains FDI as a result of firms' minimizing transaction costs by internalization of an externality leading to a newly created market where none existed before. According to these theories firms would have a strong economic incentive to avoid joint ventures (Franko, 1989).[5]

Williamson (1985) transaction cost theory predicts that opportunistic human nature and the necessity to encourage efficiency and specialized investments determine the boundaries of the firm. Nakamura and Yeung (1994) present a Williamson-type principal-agent model for the determination of FP's ownership share in a joint venture (JV) in which FP, the dominant provider of intangible skills to JV, chooses its ownership share in JV by balancing the marginal benefit (intrinsic profit) it receives from JV against the marginal cost of control (agency cost and technology spillover). In this and other transaction cost based models of FDI JP plays no role in the determination of its ownership share in JV. This is because transaction cost theory is concerned primarily with minimizing foreign investing firms' transaction costs and hence does not deal with the bargaining processes that may take place between FP and JP.[6]

In this paper we model technology-based firms' decisions on the forms of ownership for their foreign subsidiaries. We approach modelling joint ventures

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[4] See Brickley and Dark (1989) for empirical evidence that franchising is associated with the distance, a source of agency (monitoring) cost, between the owner of an intangible asset (e.g. brand name, reputation) and the site of business operation using the intangible asset.)

[5] Some modifications have been proposed to the internalization theory to allow for the possibility of joint ventures. Such modifications include consideration of mutual trust, commitment and risk hedging (Beamish and Banks, 1987) and government restrictions on complete merger (Buckley and Casson, 1985). The foreign ownership implications of various theories of FDI discussed here also apply to Dunning's eclectic theory (e.g. Dunning, 1988) since the eclectic theory subsumes both Hymer-Caves and internalization theories.

[6] The principal-agent framework of the sort used by Nakamura and Yeung (1994) seems appropriate, for example, for joint ventures in which the local partners (JP) are required by the host government to be drawn from a homogeneous and competitive supply of local firms. Another useful application of transaction cost theory is to analysis of FDI in LDC where strict government regulations on foreign ownership exist (Hennart, 1989). Gomes-Casseres (1989) p.23 points out that explaining ownership structures of FDI requires transaction cost theory combined with arguments about the strategic benefits of cooperation between (parent) firms.

from the perspective of the theory of contracts which addresses the question of the allocation of decision rights between contracting parties. Contractibility of foreign operations and control of residual rights play important roles in this framework. We show that FP's ownership share in its foreign subsidiary generally depends on the conditions under which its intangible assets (and JP's in case of a JV) are transferred to JV as well as on its bargaining power relative to JP's.

We apply our model predictions to analyze empirically the ownership structures of technology-based foreign firms' subsidiaries in Japan. Our empirical findings are generally consistent with model predictions.

The rest of the paper is organized as follows. In the next section, our models and theoretical analysis for the ownership structure of direct investments are presented. Empirical results are presented in 3.. The paper ends with concluding remarks.

2. Models for ownership of foreign operations

2.1. Why does ownership matter?

FP's operations in a host country generally require tangible and intangible production inputs from FP, local firms and local workers. Suppose all inputs are observable and their quantities used and the resulting output produced are verifiable. (This means, for example, that a dispute about an illegal use of FP's production input can be unequivocally resolved by a third party (like a court) which contradicts or confirms disputing party's observation.) Furthermore suppose that there are well-specified contracting mechanisms for the use of each input and the disposition of outputs. Under these ideal conditions there is no need for FP to own any part of its foreign operations since all aspects of the operations can be contracted out to local input providers.

In practice there are certain important reasons why some of these ideal conditions fail to hold. First, the quantities of some intangible assets inputs and the output produced are not verifiable. For example, use of a licensed technology or brand name may not be limited to originally specified purposes; and nonverifiable output arises when JV's accounting procedure cannot delineate every benefit resulting from the use of FP's transferred assets (technology spillover).

Secondly, many contractual relationships incur agency cost because of the lack of incentives on the part of input providers in the host country.

In both cases vertical integration, or direct ownership of foreign operations, may help mitigate FP's problems.[7]

It is important to note that so long as contracts can effectively protect the rights of parent (transferring) firms (i.e. complete contracting is possible), ownership

[7] Sappington (1991) discusses related contracting issues.

structure may not matter even if there is information asymmetry between FP and its contracting firms including JP in the host country.[8] On the other hand, contract incompleteness can lead to departures from the first-best solution even when there are no information asymmetries among the risk-neutral contracting parties (Hart and Holmström, 1987). Contract incompleteness can throw light on the importance of the allocation of decision rights or rights of control.

In the following subsections we consider three different types of production settings for FP's foreign operations. We are particularly interested in the way observability, verifiability, contractibility and incentive concerns of foreign operations are related to the ownership of such operations.

2.2. Foreign operations involving the cost of technology spillover: ownership as a mechanism to reduce the loss in property rights

Suppose FP has an opportunity for a foreign operation with an expected income Y, where Y is assumed to be constant. This operation requires intangible assets as inputs from both FP and its JV partner JP. Both FP and JP are assumed to be risk neutral in the following. We assume that transfer of the intangible assets is itself verifiable but the output resulting from the use of the transferred assets is not verifiable.

Under such circumstances it is often difficult to write a contract which prohibits potential competitors (including JV partners) from taking advantage of the transferred assets. Suppose that, without any ownership in the operation, FP and JP incur the maximum costs of technology spillover, C_F and C_J, respectively. We also assume that FP (JP) receives portions of its joint venture partner's technology spillover. These costs of spillover are assumed to decrease as the owners of the intangible assets increase their ownership shares in the operation.

We also assume for simplicity that side payments are not allowed between FP and JP. (The introduction of such side payments, however, would not change our results to follow.) This assumption is justified on the practical ground that side payments in the context of international operations correspond to the contractible aspects of the use of intangible assets such as technology and name brand. It is customary to contract away contractible aspects of transactions involving technical licencing or brand use in the form of lump-sum payments or royalty payments on

[8] Some limited illegal use of tangible assets under contract is also known. Contractual violations often reported include use of machines for purposes not allowed in the contract and use of machines with the intensity not allowed under contract. Dow (1993) also argues that noncontractibility of output and investment in physical assets is the primary reason why labor-managed firms are not viable. Since labor-managed firms own their capital equipment and the associated rights to noncontractible output, labor-managed firms cannot attract any investors for investing in their capital assets. Without such investments from outside, labor-managed firms could not exist. Labor-managed firms could be viable, however, if their output (or investments) is contractible.

product sales. We are interested, however, in noncontractible aspects of use of intangible assets for which meaningful side payments cannot be determined.

Denote by β FP's ownership share in the operation, where $0 \leqslant \beta \leqslant 1$. Then JP's share is $1-\beta$. The net expected benefits from the operation for FP and JP are given by:

$$FP: U_{F} = \beta Y + \beta g_{F} C_{J} - (1-\beta) C_{F} = \beta (Y + g_{F} C_{J} + C_{F}) - C_{F} \tag{1a}$$

$$\begin{aligned} JP: U_{J} &= (1-\beta) Y + (1-\beta) g_{J} C_{F} - \beta C_{J} \\ &= (Y + g_{J} C_{F}) - \beta (Y + g_{J} C_{F} + C_{J}). \end{aligned} \tag{1b}$$

$\beta_{F} C_{J}$ and $(1-\beta) g_{J} C_{F}$, respectively, denote the portions of their respective partner's technology spillover that FP and JP receive, where $0 \leqslant g_{F}$, $g_{J} \leqslant 1$. When $g_{F}=1$ ($g_{J}=1$), then JP's (FP's) spillover all goes to FP (JP). In order that FP and JP choose to have a JV, we must have

$$U_{F} \geqslant 0 \text{ or } \beta \geqslant \underline{\beta} \tag{2a}$$

$$U_{J} \geqslant 0 \text{ or } \beta \leqslant \bar{\beta}, \tag{2b}$$

where

$$\underline{\beta} = \frac{C_{F}}{Y + g_{F} C_{J} + C_{F}} \tag{3a}$$

$$\bar{\beta} = \frac{Y + g_{J} C_{F}}{Y + g_{J} C_{F} + C_{J}}. \tag{3b}$$

$\underline{\beta}$ is the minimum acceptable ownership share for FP, while $1-\bar{\beta}$ is the minimum acceptable ownership share for JP. The feasible region for beta, $(\underline{\beta}, \bar{\beta})$, is empty if $(Y+g_{F}C_{J})(Y+g_{J}C_{F})<C_{F}C_{J}$ holds, that is, expected income including the benefits from the JV partner's technology spillover is small relative to the costs of spillover. In this case FP would have no foreign operation. In the following we assume $(Y+g_{F}C_{J})(Y+g_{J}C_{F})>C_{F}C_{J}$. Note also that: $\underline{\beta}=0$ if and only if $C_{F}=0$, and $\bar{\beta}=1$ if and only if $C_{J}=0$.

Full cooperation between FP and JP leads to the first-best solution β^{FB} in a joint expected income maximization as follows.

$$\underset{\beta}{Max} \{Y - (1-\beta)(1-g_{J}) C_{F} - \beta (1-g_{F}) C_{J}\} \text{ subject to (2)}. \tag{4a}$$

Note that if $g_{F}=g_{J}=1$, then ownership share $\bar{\beta}$ plays no role since $U_{F}+U_{J}=Y$. The first-best optimal ownership share for FP is:

$$\beta^{FB} = \bar{\beta} \text{ if } (1-g_{J}) C_{F} > (1-g_{F}) C_{J} \tag{4b}$$

$$\beta^{FB} = \underline{\beta} \text{ if } (1-g_{J}) C_{F} < (1-g_{F}) C_{J} \tag{4c}$$

This means that, under ideal conditions, the ownership share for a parent firm with a larger spillover cost should be maximized. Note, in particular, that

$$\beta^{\mathrm{FB}} = 1 \ \text{if} \ C_{\mathrm{J}} = 0\,, \ C_{\mathrm{F}} > 0 \tag{4d}$$

$$\beta^{FB} = 0 \ \text{if} \ C_{\mathrm{J}} > 0\,, \ C_{\mathrm{F}} = 0\,. \tag{4e}$$

The results (4d–e) are consistent with our intuition that if a joint operation requires transfer of only one parent firm's intangible assets, that parent firm should own the operation fully.

The general first-best solution is not likely to be implemented in practice since the assumption of full cooperation underlying the linear program (4a) is unlikely to hold given that neither the use of intangible assets nor the production output which makes use of the intangible assets as inputs are verifiable or contractible. Under such conditions both FP and JP will attempt to maximize their ownership shares in the operation to protect their own interests.

A behavioral model which is suitable to describe the negotiation process between FP and JP in determining their ownership shares in the operation is the Nash bargaining solution (Nash, 1950). We denote the relative bargaining power of FP and JP, respectively, by α and $(1-\alpha)$, where $0 \leqslant \alpha \leqslant 1$. Following the literature (e.g. Farge and Wells, 1982) we assume that the parent firms' bargaining power is an exogenously given parameter in this paper. Then the Nash bargaining solution, β^{NB}, is given by

$$\underset{\beta}{Max}\ U_{\mathrm{F}}^{\alpha}\, U_{\mathrm{J}}^{1-\alpha} \tag{5}$$

where U_{F} and U_{J} are given by (1a) and (1b).[9] β^{NB} is given by

$$\beta^{\mathrm{NB}} = \alpha\bar{\beta} + (1-\alpha)\underline{\beta} = \bar{\beta} + \alpha(\bar{\beta} - \underline{\beta}) \tag{6}$$

where $\bar{\beta}$ and $\underline{\beta}$ are given by (3b) and (3a), respectively. (See Appendix A). Note that, for $0 \leqslant \alpha \leqslant 1$, we have $\underline{\beta} \leqslant \beta^{NB} \leqslant \bar{\beta}$.

In extreme cases where either FP or JP has all the bargaining power, we have

$$\beta^{\mathrm{NB}} = \bar{\beta} \ \text{if} \ \alpha \equiv 1 \tag{7a}$$

$$\beta^{\mathrm{NB}} = \underline{\beta} \ \text{if} \ \alpha \equiv 0\,. \tag{7b}$$

Comparing (7a–b) with (4b–c), we see that the first-best solution and the Nash

[9] The threat points for FP and JP in the Nash bargaining game are both equal to zero. The standard assumption that there is no information asymmetry between the bargaining parties (FP and JP) regarding the relevant variables defining their information sets (Y, C_{F} and C_{J} in our case) is assumed to hold here. It seems reasonable that this assumption holds in practice, since no credible bargaining is likely to take place between FP and JP without their fully mutual knowledge about Y, C_{F} and C_{J}.

bargaining solution coincide in the extreme cases where $(1-g_J)C_F>(1-g_F)C_J$ implies FP possesses the entire bargaining power $\alpha=1$, or symmetrically, $(1-g_J)C_F<(1-g_F)C_J$ implies that JP possesses the entire bargaining power $(1-\alpha)=1$. In general, however, β^{NB} does not coincide with β^{FB}.

In Appendix A we calculate the loss of efficiency that is incurred when the Nash rather than the first-best solution is adopted. Such efficiency loss is maximized when the entire bargaining power rests with the parent firm whose cost of spillover is smaller than the other parent firm's.

An important empirical issue is how α affects β^{NB}. From (6) we have $d\beta^{NB}/d\alpha=\bar{\beta}-\underline{\beta}>0$. Thus β^{NB} increases linearly as FP's bargaining power increases. This means that with a higher bargaining power FP will be able to receive a larger share of JV's profits $(\beta Y+\beta g_F C_J)$. (See (1a).)

2.3. Foreign operations involving noncontractible output: ownership as an incentive mechanism for reducing agency cost

Suppose FP's foreign operation requires inputs of intangible assets, K_F and K_J, respectively, from FP and its potential joint venture partner JP in the host country. The intangible assets required by JV's production satisfy the following conditions: (1) any amount of each of these intangible assets can be transferred from a parent firm to JV; the parent firm decides how much of its assets to be transferred, and the amount transferred is only known to the parent firm (information asymmetry), (2) the costs of transferring K_F and K_J amounts of intangible assets from FP and FJ to JV are, respectively, $C_F(K_F)$ and $C_J(K_J)$,[10] and (3) JV's expected income given transfer of K_F and K_J is denoted by $Y(K_F, K_J)$; this expected income is not contractible in the sense that not all future income resulting from the use of transferred intangible assets can be specified in a contract. The last assumption implies that, because of moral hazard, neither FP nor JP may be willing to provide optimum amounts of their intangible assets to JV. This is an agency cost problem.

Our scenario differs from the standard agency problem in which output is assumed to be contractible (observable) even if the agents' input (effort) levels may not be (Jensen and Meckling, 1976). In this traditional framework it is possible to write contracts which would induce the agents to provide effort levels which are consistent with a second-best optimal solution to the principal-agent problem. Such contracts typically involve sharing of output between the principal and the agents (e.g. stock performance-based executive compensation schemes).

When output is not contractible, as is the case for our present model, the potential moral hazard problem of an undersupply of required intangible assets could be mitigated by providing both FP and JP with some ownership in JV. Being owners of JV, FP and JP both become entitled to residual rights in any part of JV's

[10] These costs represent only the marginal costs of transferred assets and do not include, for example, the costs due to skill spillover and other externalities.

output $Y(K_F, K_J)$ resulting from using their intangible assets. Thus, even if Y is not contractible,ownership shares in JV provide the parent firms with incentives to supply certain intangible assets to JV,[11] reducing the agency cost.

The first-best solution is obtained by assuming that both K_F and K_J are observable. It is characterized by optimal transfer of intangible assets given by

$$\underset{K_F,\,K_J}{Max}\; Y(K_F, K_J) - C_F(K_F) - C_J(K_J). \tag{8}$$

Assuming that Y is concave in K_F and K_J and C_F and C_J are convex in K_F and K_J, respectively, optimal transfer (K_F^{FB} and K_J^{FB}) satisfies the following first-order conditions:

$$\partial Y/\partial \mathrm{K}_F = C_{F'} \tag{9a}$$

$$\partial Y/\partial \mathrm{K}_J = C_{J'}\ . \tag{9b}$$

In Appendix A we derive expressions for the first best solution, K_J^{FB} and K_F^{FB}, when Y is of Cobb-Douglas form and C_F and C_J are quadratic functions of the following types:

$$Y(K_F, K_J) = AK_F^m k_J^n\ ,\ \ 0 \leqslant m, n \leqslant 1 \tag{10a}$$

$$C_F(K_F) = (1/2)K_F^2\ ,\ \ C_J(K_J) = (1/2)K_J^2\ . \tag{10b}$$

Parameters m and n describe the relative importance of K_F and K_J in generating income Y.[12] In particular we have[13]

$$K_F^{FB}/K_J^{FB} = \sqrt{m/n}\ . \tag{10c}$$

(10c) means that the intangible asset which has more relative impact on JV's income is transferred in larger quantities to JV.

The first-best solution derived above is not attainable in practice, since neither FP nor JP has any incentive to disclose the quantities of their intangible assets

[11] Ownership is the standard way of protecting residual rights of control in most international joint ventures, but it is not the only way for protecting residual rights. (A simple non-international example is found in Hart (1987).) Ownership does not play the dominant control role in Japanese domestic interfirm relationships either. It is also important to note that division of ownership of JV between JV partners could be viewed as a contract. In this view there would be no issue of noncontractibility in practice since residual rights of all joint ventures are assigned by contract to the JV partners. In this paper we follow the standard notion in the contract literature that 'contract' does not involve agreement on the residual rights of control over 'noncontractibles.' We are indebted to a referee for pointing out this apparent contradiction in terminology.

[12] Note also that Y is concave in K_F and K_J.

[13] Since K_F^{FB} and K_J^{FB} characterize fully the first-best solution, it is not necessary to consider ownership structure.

transferred. In order to obtain the second-best cooperative solution, we consider the following game in which we introduce ownership as an incentive mechanism to induce the supply of intangible assets. First, FP and JP cooperate to choose ownership share, β, for FP. Given β, FP and JP play a non-cooperative game in choosing their respective supply of intangible assets, K_F and K_J. We denote by $K_F^{S\beta}$ and $K_J^{S\beta}$ the second best solution which is derived in Appendix B when Y is given by (10a). Under the second best assumption both K_F and K_J are undersupplied compared to the first best solution. That is, the second-best leads to efficiency loss. It is also shown in Appendix B that the second-best input levels are influenced not only by the relative importance ratio (m/n) but also by second best ownership parameter β^{SB} ((B9) in Appendix B). The introduction of ownership distorts the relative mix of the two intangible inputs.

The second-best solution would be the best that is attainable in practice provided that FP and JP cooperate in determining their ownership shares in JV. Such a cooperation is unlikely to prevail, however, since both FP and JP would insist on securing as much ownership share in JV as possible. Under such circumstances the behavioral hypothesis which is more plausible for describing the behavior of FP and JP is the Nash bargaining solution β^{NB}.

Assuming as before that $\alpha(0<\alpha<1)$ denotes FP's bargaining power relative to JP's, $(1-\alpha)$, β^{NB} is derived by maximizing $\{\beta Y - C_F\}^{\alpha}\{(1-\beta)Y - C_J\}^{1-\alpha}$ with respect to β. When Y, C_F and C_J are given by (10a) and (10b), then Nash bargaining inputs coincide with the second best ($K_F^{S\beta}$ and $K_J^{S\beta}$) and[14]

$$\beta^{NB} = (1/2)\{m + (2 - m - n)\alpha\}\,. \tag{11}$$

It follows that, even if JP had no bargaining power ($\alpha = 1$), JP will have a positive ownership share, $1-\beta^{NB} = (n/2)$ for $n>0$. This occurs because ownership is being used here to induce JP to provide intangibles (K_J) required for JV's production process. Similarly, even if FP has no bargaining power ($\alpha = 0$), $\beta^{NB} = m/2$ is still positive for $m>0$.[15] (See Table 1.) Thus given bargaining based share for FP (β^{NB}), the second best solution without agency cost would be attained.

Finally, we note that $d\beta^{NB}/d\alpha = (2-m-n)/2>0$. β^{NB} increases linearly with α. Thus with a higher bargaining power FP can receive a larger share of JV‘‘s profits (βY). This result is consistent with our earlier results for the model discussed in the previous subsection.

[14] It is assumed as before (see (6)) that there is no information asymmetry between FP and JP regarding Y, C_F and C_J given by functional forms (10a) and (10b) which define the relevant information sets for FP and JP. Note that K_F and K_J are not part of these information sets for the Nash bargaining game.

[15] If m = O, β^{NB} = O follows. JP will have a fully owned subsidiary in this case. This is, of course, not an interesting situation to consider, since this subsidiary does not require any input from FP. See also Hart and Moore (1990) for an incentive situation similar to our present case.

Table 1
Second best and Nash equilibrium ownership solutions: β^{SB} and β^{NB}

Contributions of intangible assets[a]					
m	0.25	0.75	1.50	0.25	0.75
n	0.40	0.40	0.40	0.75	0.75
Second best ownership[b]: β^{SB}					
β^{SB}	0.4305	0.6077	0.7760	0.3279	0.5000
Nash equilibrium ownership[c]: β^{NB}					
FP's bargaining power: α					
0.00	0.1250	0.3750	0.7500	0.1250	0.3750
0.25	0.2938	0.4813	0.7625	0.2500	0.4375
0.50	0.4625	0.5875	0.7750	0.3750	0.5000
0.75	0.6313	0.6938	0.7875	0.5000	0.5625
1.00	0.8000	0.8000	0.8000	0.6250	0.6250

[a] m and n are respectively, the contributions to JV's expected income of the intangible assets FP and JP provide. (See 10a) in the text.)
[b] β^{SB} is given by (B14c) in Appendix B .
[c] β^{NB} is given by (11) in the text.▶

2.4. Foreign operations involving technology spillover and non- contractible output: FP faces loss in property rights, JP incurs agency cost

We have considered two models which presume symmetrically positioned FP and JP in terms of technology spillover and agency costs. In some circumstances, however, it is more appropriate to assume that FP with its superior technology attempts to set up its joint venture abroad with a production input to be provided by a JP abroad. In this case FP may suffer from a technology spillover while JP may incur agency cost. An appropriate model for such a situation, which is presented in this sub-section, combines certain features of the two models discussed so far.

Consider an FP's foreign operation JV to which FP provides some constant, indivisible and intangible input K_F. Without any input from FP, JV would not exist. FP suffers from the cost of technology spillover $(1-\beta)C_F$ where β is FP's ownership share in JV. JV also requires an input of intangible assets from JP. The amount of JP's input, K_J, is not observable, and JP's cost of providing K_J is $C_J(K_J)=(1/2)K_J^2$. Noncontractible expected income from JV's operation is given by

$$Y = AK_J^n \text{ if } K_F > 0 \tag{12a}$$

$$Y = 0 \text{ if } K_F = 0 . \tag{12b}$$

where K_F is a nonnegative constant, $A>0$ and $0<n\leqslant 1$. Assuming that K is observable, maximizing with respect to β and K[16]

$$\text{Max } AK_J^n - (1-\beta)C_F - (1/2)K_J^2 \tag{13a}$$

gives the first best solution

$$\beta^{FB} = 1 \tag{13b}$$

$$K_J^{FB} = \text{some positive constant} \tag{13c}$$

$$K_J^{FB} = A^{1/2-n} n^{1/2-n}\,. \tag{13d}$$

The first-best solution implies FP fully owns JV and purchases K_J^{FB} amounts of intangible input from JP. Given that Y is not contractible, however, JP will never agree to implement this first-best solution.

In the second-best world both FP and JP cooperate to determine their respective ownership shares first and then JP chooses its optimal level of input K_J given β. The second-best solution is given by setting $m=0$ in (B8):

$$K_J^{SB} = \{An(1-\beta)\}^{1/2-n}\,. \tag{14}$$

It follows that $K_J^{SB}<K_J^{FB}$ for any $\beta(0<\beta\leqslant 1)$. K_J will always be undersupplied if FP obtains ownership share in JV. For the reasons given before, the second-best solution is not likely to be implemented in practice. The following Nash solution may, as before, resolve the conflict of interest between FP and JP: maximize with respect to beta and K_J

$$\{\beta Y - (1-\beta)C_F\}^{\alpha}\{(1-\beta)Y - C_J(K_J)\}^{1-\alpha} \tag{15a}$$

$$\text{s.t.} \quad \{K_J \text{ maximizes } (1-\beta)Y - C_J\} \tag{15b}$$

K_J^{SB} in (14) also solves (15b). Substituting (14) into (15a), we derive the first-order condition for β^{NB} to satisfy given values of A, n, C_F and α (see Appendix C). Thus use of share β^{NB} derived from Nash bargaining will ensure the second-best solution for FP and JP.

Finally, as before, β^{NB} increases with α:

$$d\beta^{NB}/d\alpha > 0\,. \tag{16}$$

A higher bargaining power allows the parent to secure a larger fracton of JV's profits.

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[16] While model (12) combines certain features of the previous two models, the latter are not special cases of the former, since these three models all assume different types of bilateral interactions between FP and JP.

3. Foreign ownership shares: empirical results for foreign firms' operations in japanese manufacturing industries

In all three cases discussed above contractibility of output is not satisfied, and potential parent firms are likely to demand positive ownership shares in JV. The first-best solution is feasible only if the foreign operation requires only one of the parent firms' (usually FP's) intangible assets. Under such circumstances, FP will set up a fully-owned subsidiary ($\beta^{FB}=1$) and contract out necessary production inputs locally.

If the first-best solution for setting up a fully-owned subsidiary is not feasible, FP and its potential JP will either adopt a second-best strategy or proceed to a Nash bargaining solution. We have argued that the latter is more likely to be implemented in practice.

3.1. Empirical model

Our results suggest that FP's ownership shares in its joint operations (JV) are positively correlated with FP's bargaining power relative to JP's.[17] Fully-owned subsidiaries (SUB) arise in the limiting case where FP's bargaining power relative to JP's is very large. In the rest of this section we propose and estimate an empirical model for testing the theoretical relationship between ownership and FP's relative bargaining power.

Suppose FP's propensity to own a share of JV is explained by a set of factors denoted by P. For modelling convenience suppose that, in the first stage, FP decides on whether or not it wants to set up a fully-owned subsidiary (SUB) for its foreign operation. If FP decides to have a joint venture, JV, with a local partner, then the second stage decision problem for FP is to determine its share of ownership in JV. In both stages P is the primary explanatory variable of interest for FP's decisions.

Then our empirical model for the first stage is:

$$q=1 \text{ if } G_1(P, B_1) - \varepsilon_1 > 0 \text{ SUB is chosen} \tag{17a}$$

$$q=0 \text{ if } G_1(P, B_1) - \varepsilon_1 \leqslant 0 \text{ JV is chosen} \tag{17b}$$

where B_1 consists of factors which are not included in P, ε_1 is a normal error term with mean zero and variance σ_1^2 and G_1 is a linear function of P and B_1.

If FP chooses JV (i.e. $q=0$), then FP's ownership share in JV, α, is determined by

[17] Another empirical implication of our models, for example, is concerned with the relationships between FP's ownership share and spillover costs C_F and C_J. (See Footnote 21 below.) We thank a referee for pointing this out to us.

$$\alpha = G_2(P, B_2, \varepsilon_2) \quad (18)$$

where B_2 consists of variables not included in P, ε_2 is normally distributed with mean 0 and variance σ_2^2, and G_2 is linear in P, B_2 and ε_2. It is also assumed that ε_1 and ε_2 are correlated with covariance σ_{12}. We expect P to have a positive effect on both G_1 and G_2, i.e., $\partial G_i / \partial P > 0$ ($i = 1, 2$).

We estimate (17) and (18) using data on 231 technology-based foreign firms' manufacturing operations located in Japan in 1989.

3.2. Foreign direct investment in Japan

Foreign firms increased their direct investments in Japan from about $930 million in 1984 to more than $3.2 billion in 1988. Most of these investments come from the U.S. and Europe. Foreign firms' operations in Japan are large relative to domestic Japanese firms. About one third of foreign affiliated firms are capitalized at more than 100 million yen while 99% of all domestic Japanese firms are capitalized at less than 100 million yen (Toyo Keizai, 1989). This is also reflected, for example, in the fact that U.S. firms' operations in Japan are considerably larger, on average, than U.S. firms' foreign operations in other countries (U.S. Dept. of Commerce, 1980, U.S. Dept. of Commerce, 1985). They are also more profitable than domestic firms (Nakamura, 1991, 1993).

The ownership patterns for foreign firms' subsidiaries were under strict government supervision until 1950. By the 1950 Law Concerning Foreign Investment, however, foreign firms were permitted to own at most 49% of Japanese firms. This law was changed in 1973 to permit foreign firms to obtain, subject to certain exceptions, full ownership. In 1977, 7% of U.S. firms' subsidiaries reported they were required to limit their U.S. parent firms' equity. In 1982 the fraction decreased to 3%. This compares with 1982 fractions of, for example, 1% for France and for West Germany, 2% for Italy and 3% for Australia (Contractor, 1990). Thus it appears that the shares of foreign ownership in Japan could be, and were, adjusted relatively frequently in recent years in response to company and government policies reflecting the interests of foreign and Japanese parent firms and Japanese domestic considerations. For example, at least 314 (190) foreign firms' subsidiaries have been established in Japan in 1988 (in 1989) while the ownership patterns for at least 151 (100) subsidiaries have changed during the same period (Toyo Keizai, 1989, Toyo Keizai, 1990).[18]

[18] These changes in ownership patterns include changes (increases or decreases) in foreign parent firms' ownership shares in joint ventures, buyouts of joint ventures by either foreign or Japanese parent firms and changes resulting from the reorganizations (mergers and acquisitions) of parent and subsidiary firms.

3.3. Empirical specification and estimation results

Our sample consists of 231 foreign affiliated manufacturing firms in electric equipment, general machinery, precision and pharmaceutical industries. Foreign parent firms which fully or partially own these operations adjust their ownership shares in these operations regularly to reflect their optimal decisions. Also the skills spillover to Japanese competitors in these industries is known to be of significant concern for foreign parent firms. Thus our data seem quite suitable for testing our model implications. (See Table 2 for descriptive statistics of the sample.)

P in (17) and (18) consists of variables which reflect FP's bargaining power relative to JP's as well as noncontractibility of FP's intangible assets. As proxies

Table 2
Descriptive statistics

	All	Fully-owned ($\beta = 1$)	Jointly-owned ($\beta < 1$)
FP's ownership share (β)	0.74(0.25)[a]	1.0(0)	0.56(0.17)
%IMP	0.49(0.37)	0.69(0.33)	0.35(0.33)
%EXP	0.11(0.19)	0.09(0.14)	0.12(0.15)
#W-JV[b]	619(2,156)	649(1,812)	599(1,211)
#W-FP[c]	47,306(76,677)	42,050(51,383)	50,951(97,200)
Capital-JV[d]	4,446(34,261)	3,023(12,112)	5,432(11,121)
R&D-FP[e]	0.06(0.05)	0.08(0.05)	0.05(0.04)
R&D-JP[e]	–	–	0.02(0.03)
Ind R&D-FRN[f]	0.07(0.03)	0.08(0.03)	0.06(0.03)
Ind R&D-JPN[f]	0.05(0.02)	0.06(0.02)	0.05(0.02)
P/E Ratio-FP[g]	15.4(4.3)	15.7(4.0)	15.2(4.6)
P/E Ratio-JP[g]	–	–	36.3(35.8)
Europe[e]	0.39	0.40	0.38
Electric Equipment[i]	0.28	0.23	0.33
Precision[i]	0.12	0.12	0.12
Pharmaceutical[i]	0.18	0.22.	0.15
General Machinery[i]	0.42	0.43	0.40
No. of observations		94	137

Source: Calculated from Toyo Keizai (1993). Data are for 1991.
[a]Numbers in parentheses are standard deviations.
[b]Numbers of workers employed by FP's operation in Japan.
[c]Numbers of workers employed by FP.
[d]Capitalization (book value) for FP's operation in million yen.
[e]Firm R&D/sales ratios for the parent firms of U.S.–Japan joint ventures.
[f]Industry R&D/sales ratios for the U.S. and Japanese industries to which the parent firms of U.S.–Japan joint ventures belong.
[g]The price–earnings ratios for the parent firms of U.S.–Japan joint ventures.
[h]FP is a European firm.
[i]Industry dummy variables.

for the factors affecting *P* we consider the following variables: the proportion of imports from FP in JV's procurement (%IMP) and the proportion of exports in JV's sales (%EXP), the R&D-to-sales ratios for FP and JP (R&D-FP and R&D-JP), the price-to-earnings ratios for FP and JP (P/E-FP and P/E-JP) and the size of FP's operation in Japan measured by the number of workers (#W-JV). (See Nakamura, 1991, Nakamura, 1991a for the relationships of these variables to JVs' performance.)

JV's imports from FP's global production network reflect FP's superb technology and other intangible assets including its ability to manage global operations. Hence they provide FP with a considerable amount of bargaining power. Most of JP's imports are in the form of intermediate goods from FP. Since FP's technology is less likely to be lost to potential competitors if JV imports FP's technology in the form of intermediate goods rather than in the form of technology licensing agreement, %IMP also measures the degree of FP's bargaining power which allows FP to transfer its technology in the form of intermediate goods rather than relying on licensing agreements.

One of FP's most important intangible assets is its investment in R&D (R&D-FP), which strengthens its bargaining power. It is also likely that large R&D-FP is associated with higher levels if noncontractibility in JV's output and the inputs from FP as well as higher degree of potential spillover of FP's technology. Our prediction is that the higher R&D-FP, the more ownership FP demands in JV. JP's R&D status (R&D-JP) in Japan, on the other hand, negatively impacts FP's bargaining power in JV. (We will replace firm R&D ratios with the corresponding industry average R&D ratios for the U.S. and Japan, R&D-US and R&D-JPN, in FP's first stage choice between SUB and JV, since FP's potential JV partners and their firm-specific R&D ratios are unknown.)[19]

The price-earnings ratios, P/E-FP and P/E-JP, are expected to capture the intangible (financial, managerial and other) assets FP and JP each own. In bilateral negotiations between FP and JP, therefore, a large value for P/E-FP (P/E-JP) is likely to increase (decrease) FP's bargaining power. In order to capture the long-term effects of intangible assets we include as our P/E variables the price-earnings ratios averaged over 10 years prior to the sample period in the JV ownership share Eq. (18).

[19] An important econometric issue in empirical studies of FDI is the treatment of data for the parent firms of SUBs and JVs. Using data for US-Japan JVs in the chemical industry in Japan, Nakamura (1991) shows that certain performance measures of JVs are sensitive to whether or not specific parent firm variables are included in econometric specifications. Also certain JV variables work as proxies for missing parent firm variables. This issue is quite relevant in the present context since FP's choice between a SUB and a JV may be influenced by the characteristics of available potential local JV partners. Our strategy here is to use industry means as proxies for parent R&D-sales ratio variables in probit choice between a SUB and a JV (Table 2) and then use firm-specific parent firm variables for analysis of JVs (Table 3). In Table 3 we also control for selection bias. Further research on these econometric issues is warranted.

FP's other important intangible assets include its brand name, the reputation of its product outside Japan and its ability to organize its operations in Japan as part of its international network of production. Many successful FP operations in Japan export significant amounts of their output (usually under FP brand) to overseas markets, including FP's operations elsewhere outside Japan. Such exports also reflect FP's ability to take advantage of Japan's comparative advantage in manufacturing. JV's export-to-sales ratio generally reflects the strengths of FP's brand name, product reputation and ability for global production strategy, and hence FP's bargaining power.

We also include JV's size (number of workers JV employs, ≠W- JV). The large size of FP's operation may weaken FP's bargaining power because of the difficulty (e.g. agency cost) associated with having to manage a large local workforce alone without a Japanese partner.

We estimate the probability that FP chooses a fully-owned subsidiary, SUB (dependent variable $q_i = 1$), over a joint venture, JV ($q_i = 0$), using a probit model (see (17))

Table 3
Probit estimates for the probability that foreign firms choose fully-owned subsidiaries

	(1)	(2)
%IMP	2.102***[a]	2.314***
	(8.34)[b]	(4.68)
%EXP	0.571	−0.342
	(1.32)	(0.367)
%R&D-US	–	0.219***
		(2.85)
%R&D-JPN	–	0.459***
		(3.52)
≠W-JV[d]	0.000	0.000
	(0.991)	(0.514)
Elec.eq.dummy	–	–
Prec.dummy	0.022	0.891
	(0.081)	(1.11)
Pharma.dummy	0.175	0.896
	(0.681)	(0.090)
Gen. machi. dummy	0.671***	1.12
	(3.31)	(0.175)
Constant	−1.704***	0.543
	(7.71)	(0.640)
Log likelihood	−126.42	−47.76
No. of obs.	231[c]	92[d]

[a]See the text for the variable definitions. *, **, ***: statistically significant at 10%, 5% and 1%, respectively.
[b]Numbers in parentheses are asymptotic absolute *t*-ratios.
[c]Includes all observations.
[d]Includes U.S. firms' operations in Japan for which all relevant data are available.

Table 4
Determinants of foreign firms' ownership shares in joint ventures

	(1)	(2)	(3)
%IMP	.772***[a]	1.08*	.973*
	(3.28)[b]	(1.64)	(1.68)
%EXP	.274**	.485***	.458***
	(3.61)	(3.56)	(3.84)
R&D-FP	-	.245	-.413
		(.326)	(.570)
R&D-JP	-	-.072**	-.079***
		(2.40)	(3.24)
P/E-FP	-	-	-.001
			(.277)
P/E-JP	-	-	-.002***
			(3.28)
≠W-JV[d]	-.00001***	-.00001	-.00001*
	(2.81)	(1.61)	(1.90)
Elec. Eq. dummy	-	-	-
Prec. dummy	-.042	-.046	.041
	(.851)	(.382)	(.421)
Pharma. dummy	.047	.036	.065
	(1.09)	(.451)	(.951)
Gen. Machi. dummy	.111*	.161	.147
	(1.84)	(1.22)	(1.22)
Selection bias[c]	-.558**	-.784	-.649
	(2.60)	(1.27)	(1.19)
Constant	.509***	.463***	.545***
	(17.42)	(6.76)	(6.80)
R^2	.228	.457	.548
No. of obs.	137[d]	49[e]	49[e]

[a]See the text for the variable definitions. *,**,***: statistically significant at 10%, 5% and 1%, respectively.
[b]Numbers in parentheses are heteroskedasticity corrected absolute *t*-ratios (Amemiya, 1985; White, 1980).
[c]The possible bias due to selection into the subsample of JVs is corrected for by Heckman's selection bias term (Heckman, 1976, 1979).
[d]All JVs.
[e]US-Japan JVs for which all relevant data are available.

$$\mathrm{Prob}(q=1)=\mathrm{Prob}(G_1(P,B_1)>\varepsilon_1)=F(G_1) \tag{19a}$$

where ε_1 is a normal random variable with mean zero and variance σ_1^2 and F is the distribution function for a standard normal variable. The function G_1 is given by

$$G_1=(1/\sigma_1)\,(\text{a function of regressors}) \tag{19b}$$

In (19) the explanatory variables of particular interest are %IMP(+), %EXP(+), %R&D-US(+), %R&D-JPN(−) and ≠W-JV(−), where the expected signs are given in parentheses. Estimation results for our probit model (19) are presented in Table 3. %IMP. %R&D-US and %R&D-JPN are highly significant with expected signs. Other variables including industry dummies are not statistically significant.[20]

If FP chooses to have a JV, FP's ownership share in JV, β, is determined by the bilateral negotiation between FP and JP according to Eq. (18) in which P now contains firm-specific R&D-to-sales and P/E ratios.

Since (18) is to be estimated using data on JVs, our estimation will be conditional on the event that FP chooses JV. We use Heckman (1976), Heckman (1979) sample selection bias specification (see also Amemiya (1985) (Ch.10.7) to correct for such bias).

Estimation results for (18) are presented in Table 4. Both %IMP and %EXP have expected positive signs and are significant at a 1% level. JP's bargaining power reflected in R&D-JP and P/E-JP is also significant. JV's size (#W-JV) is also significant and negative, as expected. This is consistent with the presence of FP's agency cost for monitoring its large operation in Japan. Such agency cost is reduced by allowing a local partner, JP, to participate in JV's management (Nakamura and Yeung, 1994). The industry dummies are not generally significant. (The only exception is in the first column (1) where no R&D nor P/E variables are included.)

It is also important to note in Table 4 that once bargaining variables are accounted for, selection bias term and industry dummies become insignificant. This increases our confidence that our regressors capture the essential factors underlying FP's and JP's ownership decisions in their JV.[21]

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[20] Table 2 shows that the FPs of SUBs are able to have their subsidiaries import more from them than the FPs of JVs. R&D-sales and P/E ratios are also higher for the FPs of SUBs than for the FPs of JVs. These observations are consistent with our probit results.

[21] Our formulation suggests that relative bargaining power may be an important factor for the determination of ownership of foreign operations. We experimented with various ways in which R&D and P/E ratios of parent firms enter our econometric specifications. We find that when they entered separately, the R&D and P/E ratios are significant for JP, as is shown in Table 4. On the other hand, the ratio between R&D-FP and R&D-JP or the ratio between P/E-FP and P/E-JP, which may be more appropriate measures of relative bargaining power under certain circumstances, are not significant in our specifications. Alternatively, the ratio between the R&D ratios of relevant U.S. and Japanese industries (R&D-US and R&D-JPN) becomes significant with a correct sign in probit (2) in Table 3 when it replaces respective industry R&D ratios. There are a number of possible explanations for this somewhat asymmetric behavior. First, FP's bargaining power plays a more significant role in FP's decision regarding whether or not to set up s fully-owned subsidiary than in the determination of joint venture ownership. Secondly, some aspects of FP's (and JP's) bargaining power are reflected in some other explanatory variables. Thirdly, these ratios capture factors other than bargaining or market power. For example, R&D ratios may capture spillover costs, C_F and C_J, respectively. Since equations (4b–c), for example, imply that FP's ownership is an increasing (decreasing) function of C_F (C_J), our results may also be consistent with the spillover cost explanation if R&D ratios are correlated with spillover costs. In order to answer these econometric issues adequately we need a larger data sample than the present one. We have started our plans for a new research project along these lines. We are indebted to a refereee for drawing our attention to these points.

4. Concluding remarks

When FP decides to set up an overseas operation, there are alternative ownership structures for such an operation. We have shown that optimal ownership structure depends crucially on the nature of inputs and output of the foreign operation. In particular, ownership structure is of little concern if every aspect of FP's foreign operation can be contracted out with predictable outcome, that is, a complete contract is available. This case is unlikely in practice since FP's superb intangible assets (e.g. brand name, technology), among other factors, that provide FP with globally competitive products, are usually not fully contractible. Output made using such intangible assets is also likely to have noncontractible aspects. This situation is further complicated if additional local inputs of intangible assets (e.g. distribution skill) are required for FP's foreign operation. In such a case both FP and its potential local partner firm will try to secure residual rights of control over FP's foreign operation. Direct ownership is the most effective method of controlling residual rights in international operations.

In this paper we have presented three interrelated models that differ in the ways by which FP and its local partner provide intangible assets to FP's operation. Full ownership of a foreign operation becomes the first best solution when FP's intangible assets are indispensable inputs into the foreign operation. We have shown that FP's full ownership is not necessarily feasible when FP's operation also requires inputs of intangible assets from a local partner. In this case FP may choose to accept a joint venture with a local firm as a second best solution. The importance of FP's intangible assets relative to its local partner's as inputs to a joint venture determines the degree of FP's partial ownership in the joint venture. We have also discussed efficiency implications of second best solutions.

In cases where both FP and its local partner cannot agree on each other's ownership shares in a joint venture which are either first best or second best, their joint venture ownership shares may be determined based on their relative bargaining power. We have considered the Nash bargaining solution for describing such a bargaining process. We have shown that FP's ownership in JV in the Nash bargaining solution increases with FP's bargaining power. This implies, among other things, that FP's Nash bargaining ownership share is likely to increase with the importance of FP's intangible assets relative to its local partner's, since the more important FP's (a local partner's) intangible assets are, the more bargaining power FP (a local partner's) possesses. This property is consistent with predicted relationships between ownership shares and intangible assets found for first and second best solutions discussed earlier.

Our theoretical analysis provides some empirically testable implications. One of them is the positive correlation between FP's ownership and relative bargaining power reflected in its intangible assets. We have empirically tested this using foreign firms' manufacturing operations located in Japan. Our preliminary empirical results are consistent with the theoretical predictions. Fruitful future empirical research includes exploring the effects of additional firm- and industry-specific explanatory variables which measure more directly the verifiability and contractibility of JV's inputs and output.

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Appendix A

Derivation of (6)

Differentiating (5) with respect to β, we obtain

$$\alpha U_F^{\alpha-1}\frac{\partial U_F}{\partial\beta}U_J^{1-\alpha} + (1-\alpha)U_F^{\alpha}U_J^{-\alpha}\frac{\partial U_J}{\partial\beta} = 0$$

Substituting (1a) and (1b) into this expression, solving the resulting equation for β and rearranging terms, we get (6).

Loss of efficiency of the Nash Bargaining solution (6)

The loss of efficiency incurred by adopting the Nash bargaining solution rather than the first-best solution is given by the difference in expected income from the operation $Y-(1-\beta)(1-g_J)C_F-\beta(1-g_F)C_J$ evaluated at $\beta=\beta^{FB}$ and $\beta=\beta^{NB}$. It is calculated using (4b–c) and (6) as follows:

$$[\bar{\beta}-\alpha\bar{\beta}-(1-\alpha)\underline{\beta}][(1-g_J)C_F-(1-g_F)C_{J]}$$

$$=(1-\alpha)(\bar{\beta}-\underline{\beta})[(1-g_J)C_F-(1-g_F)C_J] \text{ if } (1-g_J)C_F>(1-g_F)C_J$$

and

$$[\bar{\beta}-\alpha\bar{\beta}-(1-\alpha)\underline{\beta}][(1-g_J)C_F-(1-g_F)C_J]$$

$$=\alpha(\bar{\beta}-\underline{\beta})[(1-g_J)C_F-(1-g_F)C_J] \text{ if } (1-g_J)C_F<(1-g_F)C_J\,.$$

An upper bound for the efficiency loss is given by $(\bar{\beta}-\underline{\beta})|(1-g_J)C_F-(1-g_F)C_J|$. This upper bound is achieved when the entire bargaining power rests with the parent firm whose net cost of spillover is smaller than the other parent firm's.

Derivation of (10c)

Noting that Y is concave in K_F and K_J, optimization calculus provides the first-best solution:

$$K_F^{FB}=(A^2m^{2-n}n^n)^{(1/2)(2-m-n)} \tag{A1}$$

$$K_J^{FB}=(A^2m^m n^{2-m})^{(1/2)(2-m-n)}\,. \tag{A2}$$

(10c) follows from (A1–2). The first-best output for JV is given by

$$Y^{FB}=Y(K_F^{FB},K_J^{FB})=(A^2m^m n^n)^{1/(2-m-n)}$$

Appendix B

Derivation of the second best when Y is given by (10a)

This second best solution is derived by solving

$$\underset{\beta,\,K_F,\,K_J}{Max}\ Y(K_F,K_J)-C_F(K_F)-C_J(K_J)$$

$$\text{s.t.}\quad \beta Y-C_F\geqslant 0 \tag{B1}$$

$$(1-\beta)Y-C_J\geqslant 0 \tag{B2}$$

$$\beta\,\frac{\partial Y}{\partial \mathrm{K}_J}=C_F' \tag{B3}$$

$$(1-\beta)\,\frac{\partial \mathrm{Y}}{\partial \mathrm{K}_J}=C_J'\,. \tag{B4}$$

The rationality constraints (B1) and (B2) are for inducing FP and JP to accept the contract. The constraints (B3) and (B4) are incentive constraints for motivating both FP and JP to provide JV with optimum levels of inputs for a given level of FP's ownership share beta. These constraints describe a Nash game in which FP and JP both take into account the other player's response in making their decisions on the amounts of intangible assets to supply to JV. Using (10a–b), (B3) and (B4) become

$$\beta AmK_{\mathrm{F}}^{\mathrm{m}-1}K_{\mathrm{J}}^{\mathrm{n}}=K_{\mathrm{F}} \tag{B5}$$

$$(1-\beta)AnK_{\mathrm{F}}^{\mathrm{m}}K_{\mathrm{J}}^{\mathrm{n}-1}=K_{\mathrm{J}}\,. \tag{B6}$$

The second-best solution for K_{F} and K_{J} conditional on given β $(0<\beta<1)$ is derived by solving (B5) and (B6) and is given by

$$K_{\mathrm{F}}^{\mathrm{S\beta}}=\{\beta^{2-\mathrm{n}}(1-\beta)^{\mathrm{n}}A^{2}m^{2-\mathrm{n}}n^{\mathrm{n}}\}^{(1/2)(2-\mathrm{m}-\mathrm{n})} \tag{B7}$$

$$K_{\mathrm{J}}^{\mathrm{S\beta}}=\{\beta^{\mathrm{m}}(1-\beta)^{2-\mathrm{m}}A^{2}m^{\mathrm{m}}n^{2-\mathrm{m}}\}^{(1/2)(2-\mathrm{m}-\mathrm{n})}\,. \tag{B8}$$

It follows from (B7) and (B8) that

$$K_{\mathrm{F}}^{\mathrm{S\beta}}/K_{\mathrm{J}}^{\mathrm{SB}}=\sqrt{\{\beta/(1-\beta)\}\{m/n\}}\,. \tag{B9}$$

Comparing (B7) and (B8) with (A1) and (A2), we also get

$$K_{\mathrm{F}}^{\mathrm{S\beta}}<K_{\mathrm{F}}^{\mathrm{FB}},\,K_{\mathrm{J}}^{\mathrm{SB}}<K_{\mathrm{J}}^{\mathrm{FB}},\ \text{for all } \beta(0<\beta<1)\,. \tag{B10}$$

(B10) means that, under the second-best assumption, there is an efficiency loss because both K_{F} and K_{J} are undersupplied relative to the first best levels of supply. Comparing (B9) with (10c) we see that second-best input levels are influenced not only by the relative importance ratio (m/n) but also by ownership parameter β. The introduction of ownership distorts the relative mix of the two intangible inputs.In order to obtain the second-best ownership share, β^{SB}, we substitute (B7) and (B8) into (10a), (B1) and (B2). We have:

$$Y^{\mathrm{SB}}=Y(K_{\mathrm{F}}^{\mathrm{SB}},K_{\mathrm{J}}^{\mathrm{SB}})=\{\beta^{\mathrm{m}}(1-\beta)^{\mathrm{n}}A^{2}m^{\mathrm{m}}n^{\mathrm{n}}\}^{1/(2-\mathrm{m}-\mathrm{n})} \tag{B11}$$

$$C_{\mathrm{F}}(K_{\mathrm{F}}^{\mathrm{SB}})=(1/2)\{\beta^{2-\mathrm{n}}(1-\beta)^{\mathrm{n}}A^{2}m^{2-\mathrm{n}}n^{\mathrm{n}}\}^{1/(2-\mathrm{m}-\mathrm{n})} \tag{B12a}$$

$$C_{\mathrm{J}}(K_{\mathrm{J}}^{\mathrm{SB}})=(1/2)\{\beta^{\mathrm{m}}(1-\beta)^{2-\mathrm{m}}A^{2}m^{\mathrm{m}}n^{2-\mathrm{m}}\}^{1/(2-\mathrm{m}-\mathrm{n})}\,. \tag{B12b}$$

From (C2) below, we have

$$\beta Y^{\mathrm{SB}}=(2/m)C_{\mathrm{F}}(K_{\mathrm{F}}^{\mathrm{SB}}), \tag{B13a}$$

$$(1-\beta)Y^{\mathrm{SB}}=(2/n)C_{\mathrm{J}}(K_{\mathrm{J}}^{\mathrm{SB}}). \tag{B13b}$$

Under the assumption that $m+n<2$, $m>0$ and $n>0$, (B13a–b) implies that the rationality constraints (B1) and (B2) evaluated at $K_{\mathrm{F}}=K_{\mathrm{F}}^{\mathrm{SB}}$ and $K_{\mathrm{J}}=K_{\mathrm{J}}^{\mathrm{SB}}$ are always satisfied.Then β^{SB} is the solution to the optimization problem

$$\operatorname*{Max}_{\beta}\ Y^{\mathrm{SB}}-C_{\mathrm{F}}(K_{\mathrm{F}}^{\mathrm{SB}})-C_{\mathrm{J}}(K_{\mathrm{J}}^{\mathrm{SB}})$$

or

$$\operatorname*{Max}_{\beta}\ \beta^{m/(2-m-n)}(1-\beta)^{m/(2-m-n)}\{1-(1/2)\beta m-(1/2)(1-\beta)n\}\,. \tag{B14a}$$

β^{SB} is the solution to the first-order condition

$$2(m-n)\beta^2-2m(2-n)\beta-m(2-m)=0 \tag{B14b}$$

and is given by

$$\beta^{SB}=\frac{m(2-n)-\sqrt{mn(2-m)(2-n)}}{2(m-n)},\ m\neq n \tag{B14c}$$

$$\beta^{SB}=1/2,\ m=n,$$

where the other positive root of beta to the quadratic equation (B14b) is greater than one and has been dropped from our further consideration. When $m=n$, (B14a) becomes: maximize $\{1-(1/2m)\}\{\beta(1-\beta)\}^{m/(2-2m)}$ with respect to β.

Appendix C

Derivation of (11) β^{NB} when Y is given by (10a)

Conditions (B3) and (B4) imply that K_F and K_J in the Nash equilibrium solution are given by (B7) and (B8). The first-order condition for the Nash solution is given by

$$\begin{aligned}&\alpha[\beta Y-C_F]^{\alpha-1}[(1-\beta)Y-C_J]^{1-\alpha}\frac{\partial}{\partial\beta}[\beta Y-C_F]\\&(1-\alpha)[\beta Y-C_F]^{\alpha}[(1-\beta)Y-C_J]^{-\alpha}\frac{\partial}{\partial\beta}[(1-\beta)Y-\\&\alpha[(1-\beta)Y-C_J]\frac{\partial}{\partial\beta}[\beta Y-C_F]\\&(1-\alpha)[\beta Y-C_F]\frac{\partial}{\partial\beta}[(1-\beta)Y-C_J]=0\end{aligned} \tag{C1}$$

We have from (B7), (B8), (B11) and (B12) that

$$
\begin{aligned}
(1-\beta)Y^{\mathrm{SB}} &= (\beta^{\mathrm{m}}(1-\beta)^{2-m}A^2m^{\mathrm{m}}n^{\mathrm{n}})^{\frac{1}{2-\mathrm{m}-\mathrm{n}}} \\
&= \frac{2}{n}C_{\mathrm{J}}(K_{\mathrm{J}}^{\mathrm{SB}}) \\
\beta Y^{\mathrm{SB}} &= (\beta^{2-\mathrm{n}}(1-\beta)^{\mathrm{n}}A^2m^{\mathrm{m}}n^{\mathrm{n}})^{\frac{1}{2-\mathrm{m}-\mathrm{n}}} \\
&= \frac{2}{m}C_{\mathrm{F}}(K_{\mathrm{F}}^{\mathrm{SB}})
\end{aligned}
\tag{C2}
$$

From (10a) we have $\partial Y/\partial \mathrm{K}_{\mathrm{F}}=\mathrm{m}Y/K_{\mathrm{F}}$ and $\partial Y/\partial \mathrm{K}_{\mathrm{J}}=\mathrm{n}Y/K_{\mathrm{J}}$. (Superscript SB will be dropped from K_{F}, K_{J} and Y in the following.) It follows that

$$
\begin{aligned}
\frac{\partial}{\partial \beta}[\beta Y - C_{\mathrm{F}}] &= Y+\beta\left[\frac{\partial Y}{\partial \mathrm{K}_{\mathrm{F}}}K_{\mathrm{F}}' + \frac{\partial Y}{\partial \mathrm{K}_{\mathrm{J}}}K_{\mathrm{J}}'\right] - C_{\mathrm{F}}'K_{\mathrm{F}}' \\
&= Y + \beta\frac{\partial Y}{\partial \mathrm{K}_{\mathrm{J}}}K_{\mathrm{J}}' = \left[1+\beta n\frac{K_{\mathrm{J}}'}{K_{\mathrm{J}}}\right]Y
\end{aligned}
\tag{C3a}
$$

$$
\begin{aligned}
(1-\beta)Y - C_{\mathrm{J}}] &= -Y + (1-\beta)\left[\frac{\partial Y}{\partial \mathrm{K}_{\mathrm{F}}}K_{\mathrm{F}}' + \frac{\partial Y}{\partial \mathrm{K}_{\mathrm{J}}}K_{\mathrm{J}}'\right] - C_{\mathrm{J}}' \\
&= -Y + (1-\beta)\frac{\partial Y}{\partial \mathrm{K}_{\mathrm{F}}}K_{\mathrm{F}}' = \left[(1-\beta)m\frac{K_{\mathrm{F}}'}{K_{\mathrm{F}}}\right]
\end{aligned}
\tag{C3b}
$$

where (B3) and (B4) have been used, respectively, to obtain the second equalities in (C3a) and (C3b). We also have from (B7) and (B8):

$$
\begin{aligned}
\frac{K_{\mathrm{F}}'}{K_{\mathrm{F}}} &= \frac{2-n-2\beta}{2(2-m-n)\beta(1-\beta)} \\
\frac{K_{\mathrm{J}}'}{K_{\mathrm{J}}} &= \frac{m-2\beta}{2(2-m-n)\beta(1-\beta)}
\end{aligned}
\tag{C4}
$$

It follows that

$$
1+\beta n\frac{K_{\mathrm{J}}'}{K_{\mathrm{J}}} = \frac{4-4\beta-2m-2n+2m\beta+mn}{2(2-m-n)(1-\beta)}
$$

$$
(1-\beta)m\frac{K_{\mathrm{F}}'}{K_{\mathrm{F}}} - 1 = \frac{2m-4\beta+2n\beta-mn}{2(2-m-n)\beta}
$$

Substituting (C3) and (C5) into (C1), we get

$$\alpha(2-n)(4-4\beta-2m-2n+2m\beta+mn)$$

$$+\ (1-\alpha)(2-m)(2m-4\beta+2n\beta-mn)\ =\ 0$$

$$\Leftrightarrow\ \alpha(2-n)(2-m)(2-n-2\beta)$$

$$+\ (1-\alpha)(2-m)(2-n)(m-2\beta)\ =\ 0$$

$$\Leftrightarrow\ \alpha(2-n-2\beta)\ +\ (1-\alpha)(m-2\beta)\ =\ 0$$

$$\Leftrightarrow\quad \beta\ =\ \frac{1}{2}[m\ +\ (2-m-n)\alpha]$$

Q.E.D.

Derivation of the first-order condition for β^{NB}

The first-order condition for (15a) is similar to (C1) and given by

$$\alpha[(1-\beta)Y\ -\ C_{\mathrm{J}}]\frac{\partial}{\partial\beta}[\beta Y\ -\ (1-\beta)C_{\mathrm{F}}]$$
$$+\ (1-\alpha)[\beta Y\ -\ (1-\beta)C_{\mathrm{F}}]\frac{\partial}{\partial\beta}[(1-\beta)Y\ -\ C_{\mathrm{J}}]\ =\ 0 \tag{C7}$$

We have $\partial Y/\partial\mathrm{beta}=\{-n/(2-n)\}\ \{Y/(1-\beta)\}$ and $C_{\mathrm{J}}=n(1-\beta)(Y/2)$. It follows that

$$(1-\beta)Y\ -\ C_{\mathrm{J}}=\frac{2-n}{2}(1-\beta)Y \tag{C8}$$

and

$$\frac{\partial}{\partial\beta}[\beta Y\ -\ (1-\beta)C_{\mathrm{F}}]=Y+\beta\frac{\partial Y}{\partial\beta}\ +\ C_{\mathrm{F}}$$
$$=\ Y\ -\ \frac{n}{2-n}\,\frac{\beta}{1-\beta}Y\ +\ C_{\mathrm{F}} \tag{C9a}$$
$$=\ \frac{2-n-2\beta}{(2-n)(1-\beta)}Y\ +\ C_{\mathrm{F}}$$

$$\frac{\partial}{\partial\beta}[(1-\beta)Y-C_{\mathrm{J}}]=\ -\ Y \tag{C9b}$$

Substituting (C8), (C9a) and (C9b) into (C7), we obtain the first-order condition

$$(2\alpha - 2\beta - n\alpha)Y + (2 - n\alpha)(1 - \beta)C_F = 0\ .$$

Q.E.D.

Derivation of (16)

The implicit derivative of β with respect to α in (C9b), β', is given by

$$\begin{aligned}(2 - n - 2\beta')Y - \frac{n(2\alpha - n\alpha - 2\beta)}{(1-\beta)(2-n)}Y\beta' \\ - (2 - n\alpha)C_F\beta' - n(1-\beta)C_F = 0\end{aligned} \tag{C10}$$

Collecting terms involving β' in the left-hand side and other remaining terms in the right-hand side, we obtain an equation $M\beta' = N$, where

$$\begin{aligned}M &= \left[2 + \frac{n(2\alpha - n\alpha - 2\beta)}{(1-\beta)(2-n)}\right]Y + (2 - n\alpha)C_F \\ N &= (2-n)Y - n(1-\beta)C_F\end{aligned} \tag{C11}$$

From (C9b) we have $(1-\beta)C_F = \{(2\alpha - 2\beta - n\alpha)/(2 - n\alpha)\}Y$. Using this N is simplified as follows:

$$N = \frac{2(2 - n - n\beta)}{2 - n\alpha}Y$$

Similarly using $(2 - n\alpha)C_F = \{(2\alpha - 2\beta - n\alpha)/(1-\beta)\}Y$ which follows from (C9b), we can simplify M as follows:

$$M = \frac{2[(n-1)(2-n)\alpha + (2 - n - n\beta)]}{(1-\beta)(2-n)}Y$$

Since $0 < n \leqslant 1$, $0 < \alpha < 1$, $0 < \beta \leqslant 1$ and $Y > 0$, we have

$$N > 0 \text{ and } M > 0 \tag{C12}$$

It follows that $d\beta/d\alpha = \beta' = N/M > 0$.

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