THE UNIVERSITY of York

Discussion Papers in Economics

No. 12/09

INCREASING RETURNS, KNOWLEDGE TRANSFERS AND THE OPTIMAL DURATION OF EQUITY JOINT VENTURES

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Abstract

Rather than being a random unpredictable event, the break-up of an equity joint venture after a finite time can be modelled as the predictable consequence of underlying economic parameters under conditions of complete certainty. The paper examines the impact of a range of important economic parameters on the optimal duration of an equity joint venture, including the degree of economies of scale and knowledge transfer, and discusses the associated interface with relevant empirical evidence and analysis. It also highlights the policy implications of the analysis for the socially optimal corporate tax rate on the joint venture that aligns the privately optimal duration of the joint venture with its social optimum.

Keywords: Joint ventures, equity shareholdings, optimal duration, knowledge transfer, corporate tax rates.

JEL Classification: L24, L52, M29, O 39, H21

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1. Introduction

While joint ventures offer a potentially attractive form of corporate and industrial organisation, their high rate of break-up within ten years from their initial formation has been noted by Hewitt [2008], Kogat [1989], Beamish [1988], and others. In this paper, we model this process not as an uncertain random event, but rather as the predictable outcome of underlying economic variables, with break-up within a finite time resulting even under conditions of complete certainty. Given the prevalence of joint venture break-ups, it is in the interests of both partners in an equity joint venture to be fully aware of their own optimal durations of the joint venture in their initial negotiations for the formation of the equity joint venture. Where the underlying economic parameters imply differences in their individual optimal durations of the joint venture, there is nevertheless scope for mutually beneficial agreements on a binding date for the break-up of the joint venture, and for side payments to enable this binding agreement to be reached, either as cash payments or in terms of their relative shareholdings in the jointly-owned separate company that will manage the equity joint venture. From the viewpoint of economic policy, it is also of interest to determine how far the privately determined duration of the equity joint venture will diverge from a socially optimal duration, and the associated scope for corporate taxes and subsidies on the joint venture to remedy this divergence. We will examine these questions in more detail in the following sections and extend the earlier analysis in Mayston and Wang [2011] to include considerations of knowledge transfer and non-constant returns to scale.

2. Capabilities, Learning and Knowledge Transfer

The defining characteristic of an equity joint venture in this paper will be that each partner has a right to a share in the profits of the joint venture, which is operated through a separate company that is distinct from the partners themselves. In particular, the paper will investigate the consequences of two firms, A and B, considering the formation of an equity joint venture company J through which to pursue all of their interests in country Z, and in which they will individually own shares. The two firms are aware, however, that there are conflicting pressures and potential instabilities involved in joint ventures and wish to determine the optimal duration of their equity joint venture. In view of the empirical evidence of high rates of break-up, both have reason to consider it irrational simply to expect that the joint venture will necessarily last indefinitely. Rather than regarding its termination as a sign of failure, they wish to rationally optimise the length of time over which they can achieve positive benefits from its existence. After the agreed termination of the joint venture at time $t = T$, firms A and B will pursue their own individual interests in country Z. To determine the optimal length of duration of the joint venture, firms A and B therefore need to evaluate how they would fare on a stand-alone basic compared to their participation in the equity joint venture. In the following analysis, the notation $i = A, B$ will denote firms A and B pursuing their own interests as stand-alone businesses in country Z, while the notation $i = J$ will denote A and B acting as partners together in the operation of the equity joint venture.

In order to relate the optimal duration of the equity joint venture to underlying economic variables, we will assume a demand curve facing each firm i = A, B, J at each time t = 0,...., ∞ of the form:

$$q_{it} = \theta_{it} p_{it}^{-\varepsilon_i} \tag{2.1}$$

where p_{it} is the price which firm i charges for its differentiated output at time t, $\theta_{it} > 0$, and $\varepsilon_i > 1$ is the price elasticity of demand which firm i faces. Its total cost function is given by:

$$C_{it} = c_{it}.q_{it}^{1/\alpha_i} \tag{2.2}$$

where $c_{it} > 0$ is a constant at time t, and $\alpha_i > 0$ is the degree of economies of scale that firm i can achieve. Firm i's total after-tax profit at time t is therefore equal to:

$$\pi_{it} = (1-\tau_i)(p_{it}q_{it} - C_{it}) = (1-\tau_i)(\theta_{it} p_{it}^{1-\varepsilon_i} - c_{it}\theta_{it}^{1/\alpha_i} p_{it}^{-\varepsilon_i/\alpha_i}) \tag{2.3}$$

where $1 > \tau_i \geq 0$ is the corporate profit tax rate facing firm i, with the first order condition for profit maximisation:

$$(\partial \pi_{it} / \partial p_{it}) = (1-\tau_i)\theta_{it}[(1-\varepsilon_i) p_{it}^{-\varepsilon_i} + c_{it}(\varepsilon_i / \alpha_i)\theta_{it}^{(1/\alpha_i)-1} p_{it}^{-(\varepsilon_i/\alpha_i)-1}] = 0 \tag{2.4}$$

and hence the profit maximising price for firm i at time t of:

$$p_{it}^* = [\varepsilon_i c_{it} \theta_{it}^{(1/\alpha_i)-1} / \alpha_i(\varepsilon_i - 1)]^{1/(1+((1/\alpha_i)-1)\varepsilon_i)} > 0 \quad for\ \varepsilon_i > 1 \tag{2.5}$$

From (2.1), (2.2) and (2.5), the associated Lerner index of the market power of firm i = A, B, J is given by:

$$M_{Lit} \equiv (p_{it}^* - \partial C_{it} / \partial q_{it}) / p_{it}^* = 1/\varepsilon_i \tag{2.6}$$

with the market power for firm i greater the smaller is the price elasticity of demand that it faces.

From (2.4) and (2.5), the second order condition for profit maximisation requires:

$$(\partial^2 \pi_{it} / \partial p_{it}^2) = c_{it}(\varepsilon_i / \alpha_i)\theta_{it}^{((1/\alpha_i)-1)} p_{it}^{(-(\varepsilon_i/\alpha_i)-2)}[\varepsilon_i(1-(1/\alpha_i))-1] < 0 \tag{2.7}$$

which will be satisfied if:

$$\varepsilon_i > 1\ and\ \alpha_i \leq 1,\ or\ if\ \ 1 < \varepsilon_i < 1/(1-(1/\alpha_i))\ and\ \alpha_i > 1 \tag{2.8}$$

for i = A, B, J. From (2.1) – (2.5), the maximum net revenue of firm i at time t is:

$$\pi_{it}^* = (1-\tau_i)\theta_{it}^{\gamma_i}\chi_i c_{it}^{(1-\varepsilon_i)/\beta_i}\ where\ \beta_i \equiv 1+((1/\alpha_i)-1)\varepsilon_i, \gamma_i \equiv 1/(\alpha_i\beta_i), \chi_i \equiv \beta_i(\varepsilon_i/\alpha_i)^{-\varepsilon_i\gamma_i}(\varepsilon_i - 1)^{\vartheta_i} \tag{2.9}$$

with $\vartheta_i \equiv ((\varepsilon_i - 1)/\beta_i) > 0, \beta_i > 0, \gamma_i > 0, \chi_i > 0\ and\ hence\ \pi_{it}^* > 0\ under\ conditions\ (2.7)\ and\ (2.8)$ (2.10)

For the sake of concreteness, we will assume that each firm possesses a Cobb-Douglas production function of the form:

$$q_{it} = \prod_{k \in P} a_{ikt}^{\varsigma_{ik}} \prod_{h \in \Omega} x_{iht}^{\alpha_{ih}} \ where \sum_{h \in \Omega} \alpha_{ih} = \alpha_i \tag{2.11}$$

where x_{iht} is the level of input h into the production process of firm i at time t, a_{ikt} represents the ability of firm i at time t in the capability direction k to help transform its inputs into increased output, and $\varsigma_{ik} \geq 0$ is a parameter reflecting the importance of this capability for boosting firm i's productivity. The capability directions may include here the levels of both its technological knowledge and its management skills. Firm i is assumed to be a price-taker in its input markets, facing a price of κ_{iht} per unit of input h at time t. The minimisation of the total cost of its inputs to produce any given level q_{it} of its output at time t implies in (2.2) and (2.5):

$$c_{it} = \alpha_i \prod_{h \in \Omega} (\kappa_{iht} / \alpha_{ih})^{\alpha_{ih}/\alpha_i} / \prod_{k \in P} a_{ikt}^{\varsigma_{ik}/\alpha_i} \tag{2.12}$$

In the case of the joint venture, i.e. i = J, we will assume that it involves a combining of the capabilities and inputs of the two partners, such that partner A contributes to the joint venture its capabilities k within the set P_A and provides inputs h within the set Ω_A. Partner B on the other hand contributes to the joint venture its capabilities within the complementary set $P_B = P - P_A$ and provides inputs within the complementary set $\Omega_B = \Omega - \Omega_A$. We then have:

$$c_{Jt} = \alpha_J \prod_{h \in \Omega_A} (\kappa_{Aht} / \alpha_{Jh})^{\alpha_{Jh}/\alpha_J} \prod_{h \in \Omega_B} (\kappa_{Bht} / \alpha_{Jh})^{\alpha_{Jh}/\alpha_J} / \prod_{k \in P_A} a_{Akt}^{\varsigma_{Jk}/\alpha_J} \prod_{k \in P_B} a_{Bkt}^{\varsigma_{Jk}/\alpha_J} \tag{2.13}$$

As well as contributing complementary capabilities and inputs to the production process, the two partners may also contribute complementary marketing skills and local product market knowledge that can influence the demand for the joint venture's output. We will assume specifically that:

$$\theta_{Jt} = \theta_{Jt}^o \prod_{j \in \Theta_A} m_{Ajt}^{\iota_{Jj}} \prod_{j \in \Theta_B} m_{Bjt}^{\iota_{Jj}}, \ with \ \theta_{it} = \theta_{it}^o \prod_{j \in \Theta} m_{ijt}^{\iota_{ij}} \ for \ i = A, B \ and \ \theta_{J0}^o \geq \theta_{A0}^o + \theta_{B0}^o \tag{2.14}$$

m_{ijt} represents here the ability of firm i in the market-relevant direction j at time t, $\iota_{ij} \geq 0$ is a parameter reflecting the importance of ability in the market-relevant direction j for boosting demand for the output of firm i, and $\theta_{it}^o > 0$ is a parameter reflecting the importance of other external factors, such as consumer income, that affect the demand for firm i's output at time t. (2.14) involves the joint venture J combining the market-relevant skills and knowledge of partner A in the directions $j \in \Theta_A$ with the market-relevant skills and knowledge of partner B in the directions $j \in \Theta_B \equiv \Theta - \Theta_A$, where Θ is the set of all such market-relevant directions. It also involves firms A and B when acting as stand-alone firms relying upon their own abilities in all these directions.

The formation of the joint venture at time $t = 0$ is assumed to make use of the superior capabilities of each of the two partners in each direction that are available to it at its formation, so that:

$$a_{Ak0} > a_{Bk0} \ \ for\ k \in \mathrm{P}_A, a_{Bk0} > a_{Ak0} \ \ for\ k \in \mathrm{P}_B, m_{Aj0} > m_{Bj0} \ \ for\ \ j \in \Theta_A, m_{Bj0} > m_{Ak0} \ \ for\ \ j \in \Theta_B \quad (2.15)$$

as well as of their superior opportunities for purchasing inputs at the most favourable price, so that:

$$\kappa_{Ah0} < \kappa_{Bh0} \ \ for\ h \in \Omega_A, \kappa_{Bh0} < \kappa_{Ah0} \ \ for\ h \in \Omega_B \quad (2.16)$$

We will assume that there are externally driven (positive, negative or zero) growth rates $g_{ij\theta}$ and $g_{ih\kappa}$ in the demand parameters θ^o_{it} and input prices κ_{iht} respectively facing firm i, such that:

$$\theta^o_{it} = \theta^o_{i0} \exp(g_{i\theta^0} t) \ \ for\ i = A, B, J \quad (2.17)$$

$$\kappa_{iht} = \kappa_{ih0} \exp(g_{ih\kappa} t) \ \ for\ h \in \Omega, i = A, B\ with\ g_{Ah\kappa} < g_{Bh\kappa} \ \ for\ h \in \Omega_A \ and\ g_{Bh\kappa} < g_{Ah\kappa} \ \ for\ h \in \Omega_B \quad (2.18)$$

for all values of $t = 0, ..., \infty$, so that the cost advantage of partner A providing inputs within the set Ω_A and partner B providing inputs within the set Ω_B is preserved over the life of the joint venture.

We will also assume that improvements take place over time in the technological and management capabilities a_{ikt} of firms $i = A, B$ and in their levels of market-related skills and knowledge m_{ijt} through a process of learning that may proceed at possibly different rates when the firms are acting as partners within the joint venture compared to when they act as stand-alone firms. Such differences in learning rates can reflect positive (and varying) degrees of the transfer of technological knowledge, management skills, and market-relevant intelligence between the partners because of their participation in the joint venture and closer proximity to the activities of the other partner within the joint venture. In this paper we will assume that such a transfer is a function of the time spent within the joint venture, thereby avoiding the considerable additional complexities (see e.g. Thompson [2010]) which would arise if it were a function of its cumulative output. Specifically we will assume that within the joint venture for partners $i = A, B$:

$$a_{ikt} = a_{ik0} \exp(\ell_{ika} t) \ \ for\ \ell_{ika} \geq 0\ and\ k \in \mathrm{P}_i, m_{ijt} = m_{ij0} \exp(\ell_{ijm} t) \ \ for\ \ell_{ijm} \geq 0\ and\ \ j \in \Theta_i \quad (2.19)$$

for values of t between 0 and T, where $t = T$ denotes the joint venture's termination date. (2.19) implies non-negative rates of learning within the JV for each partner that boost its capabilities in the directions in which it specialises within the JV. These rates of learning may themselves include good use being made of the benefits of technical progress and improvements in the state of technical knowledge to which the specialist partner has access. For the capability directions in which the partner does not specialise within the joint venture, we will assume that for $t = 0, ..., T$, $i = A, B$ and $i' \in \{A, B\} - i$:

$$a_{ikt} = a_{ik0} \exp(\ell^{'}_{ika} t) \ \ for\ \ell^{'}_{ika} \equiv \ell_{ika} + f_{ika}(a_{i'k0} - a_{ik0}, \ell_{i'ka}) \quad for\ k \in \mathrm{P}_{i'} \quad (2.20)$$

$$m_{ijt} = m_{ij0} \exp(\ell^{'}_{ijm} t) \ \ for\ \ell^{'}_{ijm} \equiv \ell_{ijm} + f_{ijm}(m_{i'j0} - m_{ij0}, \ell_{i'jm}) \quad for\ \ j \in \Theta_{i'} \quad (2.21)$$

In addition to learning at their own rates ℓ_{ika} and ℓ_{ijm} within the joint venture in their non-specialist directions, (2.20) and (2.21) include the possibility of the progressive diffusion of knowledge and expertise within the joint venture from the specialist partner to the non-specialist partner in each relevant direction. The rate of such diffusion within the life of the joint venture depends here upon the gap between the initial capabilities of the specialist partner and the non-specialist partner in the specialist direction, and upon the specialist partner's own learning rates $\ell_{i'ja}$ and $\ell_{i'jm}$ in management and technology capabilities and in market-relevant skills. If the relevant f functions in (2.20) and (2.21) are simple positive linear functions of these variables, the respective coefficients on these variables will reflect firstly the *permeability of the 'knowledge membrane'* surrounding the specialist partner's initial body of expertise *in the direction of the non-specialist partner* for each specific dimension of expertise, and secondly the rate at which the non-specialist partner can achieve *spillovers* from the new knowledge and skill acquisition that the specialist partner themselves acquire within the joint venture. These spillovers may then flow at different rates in different directions according to which partner is the specialist partner in the particular direction of expertise concerned.

The empirical importance of learning and knowledge transfer as a motive for participation in EJVs and similar strategic alliances is underlined by the series of 74 detailed interviews which Hamel [1991] conducted of key participants in 11 such ventures. In particular, asymmetric initial endowments of skills between the partners, and differences in their cultural backgrounds and internal organisation, were found to generate scope for asymmetric rates of learning and knowledge transfer within the strategic alliance. The dependency of the rates of learning and knowledge transfer upon organisational and cultural factors within a joint venture and its participating firms is emphasised also by Lane, Salk and Lyles' [2001] empirical study of international joint ventures that had Hungarian partner firms. However, empirical evidence (see Mowery, Oxley and Silverman [1996]; Cohen and Levinthal [1990]) also suggests that a greater technological gap between the initial state of knowledge and skills of the non-specialist partner and the specialist partner will tend to reduce the 'absorptive capacity' of the non-specialist partner to acquire and internalise knowledge and skills from the specialist partner, making the relevant f functions in (2.20) and (2.21) potentially non-linear in the magnitude of these gaps, and reducing the overall rates of learning in (2.20) and (2.21) if the initial gaps are large.

If the firms go it alone after the break-up of the joint venture, they may face possibly different subsequent rates of learning and associated increases in their capabilities to those they can achieve within the joint venture, such that:

$$For\ t > T\ and\ i = A, B : a_{ikt} = a_{ikT}\exp(\ell''_{ika}t)\ \ for\ \ell''_{ika} \geq 0, k \in \mathrm{P};\ m_{ijt} = m_{ijT}\exp(\ell''_{ijm}t)\ \ for\ \ell''_{ijm} \geq 0, j \in \Theta \quad (2.22)$$

However, their previous time within the joint venture is of value to them as stand-alone firms, since it boosts their initial capabilities when they make this transition, as reflected in the a_{ikT} and m_{ijT} terms in equation (2.22), that themselves result from the process of learning and knowledge transfer within the joint venture in equations (2.20) and (2.21), and from which they subsequently benefit through their expanded capabilities in equation (2.22).

3. The Individual Optimal Durations

From equations (2.9), (2.13) – (2.19), we may derive the net revenue for the joint venture at time $t = 0,...,T$ to be given by:

$$\pi^*_{Jt} = \pi^*_{J0}\exp(g_J t) \text{ where } g_J = \gamma_J g_{J\theta} - \vartheta_J g_{Jc},\ g_{J\theta} = g_{J\theta^o} + \sum_{j\in\Theta_A}\iota_{Jj}\ell_{Ajm} + \sum_{j\in\Theta_B}\iota_{Jj}\ell_{Bjm} \tag{3.1}$$

$$\textit{and } g_{Jc} = g_{Jc^o} - \left(\sum_{k\in P_A}\varsigma_{Jk}\ell_{Aka} + \sum_{k\in P_B}\varsigma_{Jk}\ell_{Bka}\right) \textit{ where } g_{Jc^o} \equiv \left(\sum_{h\in\Omega_A}\alpha_{Jh}g_{Ah\kappa} + \sum_{h\in\Omega_B}\alpha_{Jh}g_{Bh\kappa}\right)/\alpha_J \tag{3.2}$$

With the EJV's net revenue growing in (3.1) at the overall rate g_J between its start date at $t = 0$ until its break-up at time T, it has a present value at $t = 0$ of:

$$V_{JT} = \int_{t=0}^{T}\pi^*_{J0}e^{g_J t}e^{-rt}dt = \pi^*_{J0}(1 - e^{(g_J - r)T})/(r - g_J) \tag{3.3}$$

where r is the prevailing rate of interest.

From equations (2.9) – (2.22), the net revenue for each firm $i = A, B$ going it alone for $t = T,...,\infty$ after the break-up of the joint venture is given by:

$$\pi^*_{it} = \pi^*_{iT}\exp(g_i t') \textit{ for } g_i = \gamma_i g_{i\theta} - \vartheta_i g_{ic},\ g_{i\theta} = g_{i\theta^o} + \sum_{j\in\Theta}\iota_{ij}\ell''_{ijm},\ g_{ic} = \left(\sum_{h\in\Omega}\alpha_{ih}g_{ih\kappa}/\alpha_i\right) - \sum_{k\in \mathrm{P}}\varsigma_{ika}\ell''_{ika} \tag{3.4}$$

$$\textit{where } t' = t - T,\ \pi^*_{iT} = \pi^*_{i0}\exp(g_{iJ}T),\ g_{iJ} = \gamma_i g_{iJ\theta} - \vartheta_i g_{iJc},\ g_{iJ\theta} = g_{i\theta^o} + \sum_{j\in\Theta_i}\iota_{ij}\ell_{ijm} + \sum_{j\in\Theta_{i'}}\iota_{ij}\ell'_{ijm} \tag{3.5}$$

and $$g_{iJc} = g_{iJc^o} - \left(\sum_{k\in P_i}\varsigma_{ika}\ell_{ika} + \sum_{k\in \mathrm{P}_{i'}}\varsigma_{ika}\ell'_{ika}\right) \textit{ for } i' \in \{A, B\} - i \textit{ and } g_{iJc^o} \equiv \left(\sum_{h\in\Omega}\alpha_{ih}g_{ih\kappa}/\alpha_i\right) \tag{3.6}$$

The initial net revenue, π^*_{iT}, of firm i going it alone after the termination of the joint venture at time *T* here benefits from external growth at the rate $g_{i\theta^o}$ in its demand prospects, though offset by increases at the rate $g_{ihw}(>,=,<0)$ in the input prices it faces. It also benefits by learning at the rates ℓ_{ijm} and ℓ_{ika} respectively in its specialist market-related, management and technology-related knowledge and skills, as well as learning at the rates ℓ'_{ijm} and ℓ'_{ika} in its non-specialist capabilities, as boosted by knowledge transfers from the specialist partner in these directions in equations (2.20) and (2.21).

From (3.4) – (3.5), the present value at time t = 0 of firm i's net revenue as a go-it-alone venture starting at time *T* after it breaks away from the joint venture is given by:

$$V_{iT} = \int_{t=T}^{\infty}\pi^*_{i0}\exp(g_{iJ}T)\exp(g_i(t - T))\exp(-rt)dt = \pi^*_{i0}\exp((g_{iJ} - r)T)/(r - g_i) \textit{ for } i = A, B \tag{3.7}$$

where $r > g_i$ for a finite value to (3.7).

If firm i owns a fraction $1 > \varpi_i > 0$ of the shares in the equity joint venture, firm i's optimal choice of the break-up date *T* is that which solves:

$$\max_T W_{iT} \equiv \varpi_i V_{JT} + V_{iT} \quad for\ i = A, B \tag{3.8}$$

generating the first-order condition:

$$W_{iT}' = \varpi_i V_{JT}' + V_{iT}' = 0 \ \text{ where } \ W_{iT}' \equiv (\partial W_{iT} / \partial T), V_{JT}' \equiv (\partial V_{JT} / \partial T), V_{iT}' \equiv (\partial V_{iT} / \partial T) \tag{3.9}$$

$$\text{with } \ V_{JT}' = \pi_{J0}^* \exp((g_J - r)T), \ V_{iT}' = ((g_{iJ} - r)/(r - g_i))\pi_{i0}^* \exp((g_{iJ} - r)T)\ and\ g_{iJ} < r \tag{3.10}$$

implying that at firm i's optimal finite termination date $T = T_i^*$ for the EJV:

$$G_{iRT} \equiv \varpi_i \pi_{J0}^* \exp(g_J T) + g_{iJ} \Upsilon_{iT} = G_{iQT} \equiv \pi_{i0}^* \exp(g_{iJ} T) + g_i \Upsilon_{iT}\ where\ \Upsilon_{iT} \equiv \pi_{i0}^* \exp(g_{iJ} T)/(r - g_i) \tag{3.11}$$

The components of the gain, G_{iRT}, from partner i remaining in the EJV for another unit of time are firstly partner i's share of the period's net profits of the EJV at time T, and secondly the additional growth, at the rate g_{iJ}, in the present value Υ_{iT} at time T of partner i's go-it-alone alternative. The components of the gain, G_{iQT}, to partner i if they quit the EJV just before the start of this unit of time are firstly partner i's net profits in their go-it alone venture, and secondly the additional growth, at the rate g_i, in Υ_{iT}, which they would achieve outside the EJV during this unit of time. At firm i's optimal termination date $T = T_i^*$, the gain G_{iQT} to partner i if they quit the EJV has risen to equal the gain, G_{iRT}, from partner i remaining in the EJV for another unit of time, with zero net gain from staying for this extra unit of time. The second-order condition for (3.8) is that at $T = T_i^*$:

$$\partial^2 W_{iT} / \partial T^2 = \partial [\varpi_i V_{JT}' + V_{iT}'] / \partial T = (g_J - g_{iJ}) \varpi_i V_{JT}' = \partial (G_{iRT} - G_{iQT}) / \partial T < 0 \tag{3.12}$$

using (3.9), with G_{iQT} therefore increasing faster over time than G_{iRT} under condition (3.12). From (3.1) and (3.5), (3.12) will be satisfied if and only if:

$$g_{iJ} > g_J \ \text{ and hence } \ \gamma_i (g_{iJ\theta} - g_{J\theta}) + (\gamma_i - \gamma_J) g_{J\theta} - \vartheta_i (g_{iJc} - g_{Jc}) - (\vartheta_i - \vartheta_J) g_{Jc} > 0 \tag{3.13}$$

It is important to note here that condition (3.13) for a finite optimal duration of the EJV is not automatically fulfilled. Thus if the joint venture and the firms acting alone face the same coefficients on the importance of their capabilities and other inputs, such that $\varsigma_{ik} = \varsigma_{Jk}\ for\ k \in \mathrm{P}$, $\iota_{ij} = \iota_{Jj}\ for\ j \in \Theta$, and $\alpha_{ih} = \alpha_{Jh}\ for\ h \in \Omega$ for $i = A, B$, we have for $i' \in \{A, B\} - i$:

$$g_{iJ\theta} - g_{J\theta} = g_{i\theta^o} - g_{J\theta^o} + \sum_{j \in \Theta_{i'}} \iota_{Jj} [\ell_{ijm} + f_{ijm}(m_{i'j0} - m_{ij0}, \ell_{i'jm}) - \ell_{i'jm}] \tag{3.14}$$

$$g_{iJc} - g_{Jc} = \sum_{h \in \Omega_{i'}} (\alpha_{Jh} / \alpha)(g_{ih\kappa} - g_{i'h\kappa}) - \sum_{k \in P_{i'}} \varsigma_{Jk} [\ell_{ika} + f_{ika}(a_{i'k0} - a_{ik0}, \ell_{i'ka}) - \ell_{i'ka}] \quad (3.15)$$

Conditions (3.13) will then be satisfied by sufficiently high rates of knowledge transfer to firm i in its non-specialist capabilities within the joint venture, as reflected in the f_{ijm} and f_{ika} functions in (3.14) and (3.15). However, for (3.14) and (3.15) to be positive these rates of knowledge transfer will need to be high enough to outweigh any superiority in the learning rates of the other partner i' in partner i''s specialist capabilities over the learning rates that partner i would enjoy, in the absence of such knowledge transfers, in partner i's non-specialist directions. Moreover, these rates of knowledge transfer will need to even higher here if the joint venture experiences a higher exogenous growth rate in its demand, and/or the other partner i' enjoys a lower overall growth rate in the prices of the inputs to which they have superior access, than partner i would going it alone.

If we assume that the market power of the joint venture is greater than that of firm i going it alone, according to the index M_L in (2.6), and that firm i faces the same degree of returns to scale parameter as the joint venture, we have:

$$\varepsilon_i > \varepsilon_J \text{ with } \alpha_i = \alpha_J = \alpha \;\; for\ i = A, B \quad (3.16)$$

From equations (2.5) and (2.9) we then have that

$$\gamma_i (>,=,<) \gamma_J \;\; as\ \alpha (>,=,<) 1 \;\; with\ \vartheta_i > \vartheta_J \;\; under\ condition\ (3.16) \quad (3.17)$$

Under condition (3.16), the joint venture has a greater market power to pass on any overall positive increase in the cost parameter c without such a high proportionate impact on its profits in (2.9) as would firm i going it alone. Particularly if decreasing returns to scale prevail, further hurdles are then placed by (3.16) and (3.17) for the strength of the knowledge transfers in (3.14) and (3.15) to surmount if condition (3.13) is to hold. As noted above, empirical studies suggest that the strength of the knowledge transfer on non-specialist skills will be weaker if the 'absorptive capacity' of the non-specialist partner is reduced by a greater difference in the initial endowment of their capabilities in such directions. We must therefore expect to find cases where condition (3.13) for the existence of a finite optimal duration of the EJV does not hold. Instead greater advantages may flow from the continuing existence of the EJV, which, as in (3.14) and (3.15), will be greater the higher are the learning rates of the specialist partners in their own specialist directions. In this context, it is notable that Mowery, Oxley and Silverman [1996] and Nakamura, Shaver and Yeung [1996] found empirical evidence of cases of the 'divergence development' of the two partners where the partners became even more specialised in their knowledge and skills within the joint venture, with low rates of knowledge transfer between them, in addition to cases where higher rates of knowledge transfer led to the 'convergent development' of the two partners' capabilities. In an empirical study of 70 European co-operative agreements, 55 per cent of which were formal joint ventures, Mariti and Smiley [1983] found technological complementarity to be the predominant motivation for the agreement in 41 per cent of cases, with technology transfer the main motive in just 29 per cent.

Under conditions (3.11) and (3.13), we have:

$$T_i^* = (1/(g_{iJ} - g_J))[\ln(r - g_i) - \ln(r - g_{iJ}) + \ln \varpi_i + \ln \pi_{J0}^* - \ln \pi_{i0}^*] \quad (3.18)$$

Differentiation of (3.18) using (2.9) and (2.10) yields the following comparative static results:

$$\partial T_i^* / \partial \varpi_i > 0, \partial T_i^* / \partial \theta_{J0} > 0, \partial T_i^* / \partial g_{J\theta^o} > 0, \partial T_i^* / \partial \tau_i > 0, \partial T_i^* / \partial c_{i0} > 0, \partial T_i^* / \partial c_{J0} < 0, \partial T_i^* / \partial \theta_{i0} < 0 \quad (3.19)$$

where $\tau_{iJ} \equiv (1-\tau_J)/(1-\tau_i)$, $j \in \Theta_{i'}$ and $k \in P_i$. Partner i's optimal length of stay in the EJV is therefore an increasing function of their percentage shareholding in the equity joint venture, of the initial level of the θ demand parameter that the EJV enjoys,, of the EJV's exogenous growth rate in demand, of the after-tax profit retention rate for the EJV compared to going-it-alone and of the initial unit cost parameter of firm i going it alone. However, it is a decreasing function of the joint venture's initial unit cost parameters and of the initial demand partner i would face as a stand-alone venture. We also have from (3.13) and (3.18):

$$\partial T_i^* / \partial g_{iJ} \ (>,=,<)\ 0 \ as \ T_i^* \ (<,=,>)\ T_i^o \equiv 1/(r - g_{iJ}) \quad (3.20)$$

T_i^* is therefore an increasing function of the rates of learning and knowledge transfer within the JV in partner i's non-specialist capabilities which themselves boost g_{iJ} in (3.1) and (3.2), so long as T_i^* is less than the critical value T_i^o value in (3.20). However, if T_i^* is greater than this critical value, a smaller value of g_{iJ} yields a longer optimal stay within the EJV in order to obtain the advantages of learning and knowledge transfer in non-specialist capabilities which remaining within the EJV for longer can obtain. It is notable in this context that in China, where EJVs have been the predominant form of foreign direct investment (see Campbell and Zhang [1994], p. 5), the average duration of EJVs is 13 years (see Van den Bulcke and Zhang [1994], p. 172), with the initial cost and productivity advantages of the EJVs in combining advanced machinery with local low cost labour in the production of international standard products tending to boost the optimal duration of the EJVs in a way that has not been undermined by very high rates of transfer of specialist technological knowledge (see Barnowe, Yager and Nengquan [1994], p. 132).

We may also show from (2.3) – (2.5):

$$\partial \ln \pi_{i0}^* / \partial \varepsilon_i = -\ln p_{i0}^* - (1/\varepsilon_i \beta_i) < 0 \ for \ p_{it}^* \ge 1 \ \& \ \partial \ln \pi_{i0}^* / \partial \alpha_i = (1-\varepsilon_i)/\alpha_i \beta_i < 0 \ for \ i = A, B, J \quad (3.21)$$

An increase in the degree of returns to scale α_i reduces the ratio of marginal to average cost and has a negative impact upon net profits for a given value of the price elasticity ε_i and the associated Lerner index of market power based upon the excess of price over marginal cost. From (2.9) and (3.1):

$$\partial g_J / \partial \varepsilon_J = [(\alpha_J - 1) g_{J\theta} - \alpha_J g_{Jc}] / \alpha_J^2 \beta_J^2, \ \partial g_J / \partial \alpha_J = (\varepsilon_J - 1)(g_{J\theta} - \varepsilon_J g_{Jc}) / \alpha_J^2 \beta_J^2 \quad (3.22)$$

The impact on the growth rate g_J of the net profits of the joint venture of an increase in its market power, M_{LJ}, according to the Lerner index, will therefore be positive if returns to scale are diminishing or constant and there is non-negative growth in its demand parameter θ_{Jt} and its cost parameter c_{Jt} is increasing over time. In such a case T_i^*, for each partner $i = A,B$, is an decreasing function of ε_J. However, the cost parameter c_{Jt} may be declining over time, particularly if there are high rates of learning by the two partners in their specialist capabilities $k \in P_i$ in (2.13) and (2.19). If the degree of returns to scale exceeds the critical value $\alpha_J^o \equiv g_{J\theta} / (g_{J\theta} - g_{Jc})$ for $g_{J\theta} > g_{Jc}$, an increase in the market power of the joint venture, according to the Lerner index, in contrast implies a lower growth rate in the net profits of the joint venture in (3.22) , and a declining profit-maximising price in (2.5) for the output of the joint venture. The increased market power of the joint venture associated with a lower price elasticity of demand is then a double-edged sword, since it implies a reduced responsiveness of the volume of demand to such price reductions and a consequent lower ability to reap the combined advantages of returns to scale greater than the critical value and a lower market price. In such a case, we have from (3.18), (3.21) – (3.22) that for $i = A,B$ and $l = A,B,J$:

$$\partial T_i^* / \partial \varepsilon_J \ (>,=,<)\ 0 \ as\ T_i^* (>,=,<)\ T_{J0} \quad where\ T_{l0} \equiv \alpha_l^2 \beta_l^2 [ln\ p_{l0}^* + (1/\varepsilon_l \beta_l)] / [(\alpha_l\text{-}1) g_{l\theta} - \alpha_l g_{lc}] \qquad (3.23)$$

so that if the optimal duration of the EJV exceeds the critical value T_{J0} an increase in the elasticity of demand facing the EJV would increase its optimal duration T_i^*, with the initial negative impact of an increase in ε_J on the EJV's initial profits π_{J0}^* in (3.21) offset by the beneficial impact of a greater price elasticity on the growth rate g_J in the presence of increasing returns to scale once the EJV's duration has exceeded T_{J0}. Similar logic implies that from (3.19), (3.21) – (3.22):

$$\partial T_i^* / \partial \alpha_J \ (>,=,<)\ 0 \ as\ T_i^* (>,=,<)\ T_{J1} \ where\ T_{l1} \equiv \alpha_l \beta_l / (g_{l\theta} - \varepsilon_l g_{lc}) \quad for\ l = A,B,J\ and\ i = A,B \quad (3.24)$$

Increases in the rate of learning ℓ_{ijm} in firm i's specialist capabilities $j \in \Theta_i$ can be shown to increase T_i^* under condition (3.16) given $\iota_{ij} = \iota_{Jj}\ for\ j \in \Theta_i$ whenever returns to scale are not increasing. However, under increasing returns, we may show that for $i = A,B$:

$$\partial T_i^* / \partial \ell_{ijm}\ (>,=,<)\ 0\ as\ T_i^*\ (<,=,>)\ T_{i2} \equiv \gamma_i / [(r - g_{iJ})(\gamma_i - \gamma_J)] > 0\ where\ \gamma_i > \gamma_J\ and\ \ j \in \Theta_i \qquad (3.25)$$

so that if T_i^* is initially less than the critical value T_{i2} in (3.25), a higher rate of learning in partner i's specialist capabilities whilst in the joint venture would raise its optimal duration of the joint venture. However, if T_i^* already exceeds this critical value, a higher rate of learning for partner i in its specialist capabilities whilst in the joint venture implies a reduction in their optimal length of participation in the joint venture, with more to be lost from not realising sooner the greater benefits to going-it-alone from the higher rate of learning in these specialist capabilities which has already taken place within the joint venture. A similar critical value exists for the effect of increases in rate of learning ℓ_{ika} in the specialist capabilities $k \in \mathrm{P}_i$ given condition (3.16) and $\varsigma_{ik} = \varsigma_{Jk}$ *for* $k \in \mathrm{P}_i$ whether returns to scale are increasing, decreasing or constant. In carrying out empirical analysis of the determinants of the duration of EJVs in regression-based studies, care must therefore be taken not to assume that the underlying relationships with structural variables that are related to the EJV's degree of scale economies, market power and learning rates, and to the growth rates in the profitability of the go-it-alone options, are monotonic ones.

4. The Joint Optimum

We may note from (3.18) that in general there will be disagreement amongst the partners as to their desired duration times. Unless there is a binding contract at the formation of the joint venture to prevent it from occurring, the partner with the smallest value to their respective T_i^* has an incentive to break up the joint venture before the other partner's optimal duration time. From (3.18), differences in the two partners' optimal duration times may arise because of differences in the growth rates g_{iJ} of their own prospects, and associated rates of learning and knowledge transfer in (2.20) - (2.21) and (3.5) – (3.6) within the joint venture, in their go-it-alone growth rates g_i, in their initial profit levels π_{i0}^*, and in their equity shares ϖ_i in the EJV.

In order to examine the scope for advantageous bargaining and contracting between the two partners on an agreed duration time for the joint venture, we will consider next the optimal duration time, T^*, which maximises the total value of the two partners' wealth, given by:

$$\max_T W_T \equiv V_{JT} + V_{AT} + V_{BT} \tag{4.1}$$

Using (3.10), the first-order condition for (4.1) yields:

$$S_T + L_{AT} + L_{BT} = D_T \equiv D_{AT} + D_{BT} \tag{4.2}$$

where $$S_T \equiv \pi_{J0T}^* - \pi_{A0T}^* - \pi_{B0T}^* \ \textit{where}\ \pi_{J0T}^* \equiv \pi_{J0}^* \exp(g_J T), \pi_{i0T}^* \equiv \pi_{i0}^* \exp(g_i T)\ \textit{for}\ i = A, B \tag{4.3}$$

S_T is the degree of *synergy* that results from the joint venture at time *T*, measured in terms of the excess of the net revenue at time *T* that the joint venture generates over the sum of the net revenues that would have resulted if partners A and B had gone it alone since time t = 0. The extent of the synergy is dependent upon a number of underlying economic factors. From (3.21) and (3.22), the first source of increased synergy arises from the increased market power of the joint venture under condition (3.16), compared to each individual partner acting alone, if there are constant or diminishing returns to scale, their profit-maximising prices are not less than unity, the growth rate in their demand parameters is non-negative and in their cost coefficients is positive. However, if the degree of returns to scale exceeds $\alpha_i^o \equiv g_{i\theta} / (g_{i\theta} - g_{ic})$ for $i = A, B$ and J, with $g_{i\theta} > g_{ic}$, the greater degree of market power for the joint venture under condition (3.16) can be shown to result in a reduction of the degree of synergy from the joint venture once the duration T of the joint venture exceeds T_{l0} in (3.23) for $l = A,B$ and J.

A second potential source of increased synergy arises if the joint venture is able to reap a greater degree of returns to scale than the firms acting alone. From (3.21), (3.22), (3.24) and (4.3) we have:

$$\partial S_T / \partial \alpha_T \;(>,=,<)\; 0 \; as \; T(>,=,<)\; T_{J1} \tag{4.4}$$

so that the EJV needs to last longer than T_{J1} for the reduction in the base line net profits π^*_{J0} from greater economies of scale for a given value of its price elasticity of demand to be outweighed by the positive impact which increased returns to scale have on the growth rate of the joint venture in boosting S_T. If a greater degree of returns to scale α prevails for the technology available to both the EJV and the individual firms going it alone, there will be a range $T_{J1} < T < T_{i1}$ for $i = A \& B$ over which S_T is an increasing function of α, provided that $(g_{J\theta} - \varepsilon_J g_{Jc})/(g_{i\theta} - \varepsilon_i g_{ic}) > \beta_J / \beta_i$ for $i = A \& B$ and $g_{J\theta} > \varepsilon_J g_{Jc}$. However, outside of this range, S_T will not in general be an monotonically increasing function of α.

Increased synergy in (4.3) and (2.3) would nevertheless come from any more favourable rate of tax τ_J that the joint venture may be able to secure compared to those facing the firms going it alone. The degree of synergy will be further boosted by an increased level of the demand parameter θ_{Jt} for the joint venture, compared to those for the individual partners acting alone, due to condition (2.14) and a superior overall growth rate $g_{\theta J}$ in the demand parameter for the joint venture compared to that for the partners acting alone associated with making more efficient use of their specialist market-related skills and knowledge. A fifth source of increased synergy is that associated with a lower level of the cost parameter c_{Jt} for the joint venture, compared to those for the individual partners acting alone, from equations (2.12) –(2.13), (2.15) – (2.16), and a lower overall growth rate g_{Jc} in this cost parameter for the joint venture in (3.1) – (3.2) when it makes more efficient use of the inputs and technological and management skills in which each partner has a comparative advantage.

However, in addition to the synergy S_T at time T, we also have in (4.2):

$$L_{iT} \equiv (g_{iJ} - g_i)\pi^*_{i0T} \exp((g_{iJ} - g_i)T)/(r - g_i),\; D_{iT} \equiv \pi^*_{i0} \exp(g_{iJ}T) - \pi^*_{i0T} \;\; for\; i = A, B \tag{4.5}$$

where L_{iT} is the value at time *T* of the higher rates of learning and knowledge transfer for their capabilities in running their own go-it-alone ventures which partner i receives from continuing for a further unit of time in the joint venture in (2.20) – (2.21) and (3.5) - (3.6) compared to their going-it-alone learning rates in (3.4), with $L_{iT} > 0$ when $g_{iJ} > g_i$. $D_{iT} > 0$ for $g_{iJ} > 0$ on the other hand is the foregone additional net revenue, compared to their having gone it alone throughout, which partner i loses by not breaking away from the EJV just before time *T*. Condition (4.2) thus implies that the optimal break-up date of the joint venture to maximise the total partners' wealth is not when the synergy from the joint venture drops to zero, but rather when the total value of the synergy together with the additional learning and knowledge transfer which the joint venture generates per unit of time *for the partners' abilities to pursue their own stand-alone ventures* equals the rising additional net revenue which the partners could earn during that unit of time from *capitalising on their increasing stock of accumulated learning and knowledge transfers within the joint venture by breaking away from it* slightly sooner to make use of their enhanced capabilities in their own ventures.

Thus whilst the empirical study by Hamel [1991] found some managers who regarded their strategic alliances as a 'race to learn' from such knowledge transfers, these transfers form only part of an optimal calculation of the benefits of staying within the EJV and must be brought into balance alongside the above economic sources of synergy from which both partners can benefit.

From (3.9), (3.18) and (4.1) we have for $i = A, B$:

$$T_A^* \ (>,=,<)\ T_B^* \ \textit{as}\ \varpi_{\mathrm{A}}\ (>,=,<)\ \varpi_{\mathrm{A}}^{\mathrm{o}} \quad \textit{where}\ \varpi_{\mathrm{i}}^{\mathrm{o}} \equiv ((\mathrm{r}-\mathrm{g}_{\mathrm{iJ}})\pi_{\mathrm{i0}}^* / (\mathrm{r}-\mathrm{g}_{\mathrm{i}})\pi_{\mathrm{J0}}^*)\exp((\mathrm{g}_{\mathrm{iJ}}-\mathrm{g}_{\mathrm{J}})H) \tag{4.6}$$

$$\textit{and}\ T_A^* = T_B^* = T^* = H \ \ \textit{if}\ T_A^* = T_B^*,\ \ T_i^* < T^* < T_{i'}^* \ \ \textit{if}\ T_i^* < T_{i'}^* \ \ \textit{for}\ i' \in \{A, B\} - i \tag{4.7}$$

where H is a parameter that is scaled so that $\varpi_A^o + \varpi_B^o = 1$. Thus if both partners have the same individually optimal duration for the joint venture, their individual optimal durations are also the same as the jointly optimal duration for the joint venture. In such a case, we have the second-order condition for (4.1):

$$(\partial^2 W_T / \partial T^2) = (g_J - r)V_{JT}^{'} + (g_{AJ} - r)V_{AT}^{'} + (g_{BJ} - r)V_{BT}^{'} < 0 \tag{4.8}$$

satisfied from (3.10) – (3.13). From (3.18), (4.6) – (4.7) imply that the proportional shareholding ϖ_i^o of partner i in the equity joint venture that is needed to secure their agreement upon the jointly optimal duration of the EJV is *ceteris paribus* an increasing function of both π_{i0}^* and g_i, both of which increase the net present value of the profits which partner i could earn by going it alone. An increased proportional shareholding in the EJV provides a compensating incentive for partner i to remain within the EJV for the target duration in response to any such greater value of π_{i0}^* and g_i. A greater rate of learning and knowledge transfer that boosts the value of g_{iJ}, however, will increase ϖ_i^o in (4.6) if $T_i^* > 1/(r - g_{iJ})$. Again there is a need here for an increase in ϖ_i^o to offset the greater incentive that partner i has to break away from the EJV as a result of an increase in g_{iJ} if they have had enough time to accumulate substantial additional knowledge and skills from such learning and knowledge transfer within the EJV. However if $T_i^* < 1/(r - g_{iJ})$, ϖ_i^o can be shown to be a decreasing function of g_{iJ} in (4.6), with a decrease in ϖ_i^o offsetting the increased incentive partner i has to remain longer within the EJV under higher rates of learning and knowledge transfer within the EJV if partner i has not had enough time to accumulate substantial additional knowledge and skills from such learning and knowledge transfer. The proportionate ϖ_i^o shareholdings are here those in the net profits of the joint venture. There are then various mechanisms for distinguishing these profit shares from the relative operational control of the two partners over the management and financing of the joint venture, such as through detailed management agreements, the use of non-voting shares and of shares with special dividend rights (see e.g. Hewitt [2008], p. 45).

For the case where there is a symmetric overall rate of learning and knowledge transfer within the EJV:

$$g_{oJ} = g_{AJ} = g_{BJ} \tag{4.9}$$

that benefits the go-it-alone options of both partners, we obtain their jointly optimal duration of the EJV to be given explicitly by:

$$T^* = (1/(g_{oJ} - g_J))\ln(\pi^*_{J0} / [(N_A + N_B)(r - g_{oJ})] \; where \; N_i \equiv \pi^*_{i0} / (r - g_i) \; for \; i = A, B \tag{4.10}$$

As Reich and Mankin [1986] emphasise for many empirical cases of U.S.-Japanese joint ventures, the overall rates of learning and knowledge transfer within the joint venture may, however, not be symmetric. More generally, we therefore have from (4.6) that if $T_i^* \neq T^*$ for any $i = A, B$, then $T_A^* \neq T_B^*$, so that if any individual partner's optimal duration differs from the joint optimum, it also differs from the other partner's optimal duration of the joint venture. One of the partners, such as partner A, will then prefer an earlier termination of the joint venture than the other partner, and, in the absence of a binding agreement to the contrary, will break away from the joint venture before the other partner's desired termination date for the equity joint venture, so that without such an agreement, the payoff to the two partners is given by the 'disagreement pair':

$$d = (d_A, d_B) \text{ where } d_A = W_{AT_A^*}, \; d_B = W_{BT_A^*} \tag{4.11}$$

As a result, the other partner, here partner B, suffers an economic loss from a lower resultant total return, W_{AT}, from their participation in the joint venture than if the termination date had been closer to their individual optimal duration T_B^*, with

$$W'_{iT} = \varpi_i \pi^*_{J0} \exp((g_J - r)T)[1 - \exp((g_{iJ} - g_J)(T - T_i^*))] \; (<,=,>) \; 0 \text{ as } T \; (>,=,<) \; T_i^* \; for \; i = A, B \tag{4.12}$$

from (3.11) and (3.13).

If a legally enforceable agreement between the two firms, with appropriate sanctions for non-fulfilment, is feasible, there is then scope for mutually beneficial bargaining between the two firms to reach an agreed duration of the joint venture. However, since from (4.12) any agreed duration T' that is greater than T_A^* but closer to T_B^* will in itself reduce firm A's overall net wealth whenever $T_B^* > T_A^*$, firm A will require compensation for agreeing to any such increased duration of the joint venture. If this compensation takes the form of a cash payment from firm B to firm A of an amount y and their underlying utility functions are linear in their respective net financial wealth, the set of their net payoffs that may result from a binding agreement on the duration of the joint venture is given by:

$$\Xi = \{(s_A, s_B) \in \mathbb{R}^2 : s_A + s_B \leq W_{JT^*}, \, s_A = W_{AT'} + y \geq d_A, \, s_B = W_{BT'} - y \geq d_B, T_A^* \leq T' \leq T_B^*\} \tag{4.13}$$

which is a closed and bounded convex set that contains also the disagreement point d. Solving

$$\max_{s_A,\, s_B} (s_A - d_A)(s_B - d_B) \tag{4.14}$$

over the set Ξ yields the Nash bargaining solution (see Gravelle and Rees [1992], pp. 380 -386):

$$s_A + s_B = W_{JT^*} \ \text{ and } \ y = 0.5[(W_{BT^*} - W_{BT_A^*}) + (W_{AT_A^*} - W_{AT^*})] \tag{4.15}$$

in which both sides agree to the efficient and jointly optimal duration T^* and partner B gives up half of their gain from the increased duration of the project beyond A's individually optimal duration T_A^* to partner A, and additionally compensates partner A for half of the loss which A suffers from this increased duration of the joint venture beyond T_A^*. An alternative possibility to a cash-time bargaining solution is for firm B to give firm A an increase of ψ in A's share of the equity joint venture in return for firm A agreeing to a longer duration T' for the joint venture than T_A^*. The set of possible agreements now becomes:

$$X = \{(\psi, T') \in \mathbb{R}^2 : 0 \le \psi \le \varpi_B, T_A^* \le T' \le T_B^*\} \tag{4.16}$$

with an associated set of feasible payoffs given by:

$$\Psi = \{(s_A^o, s_B^o) \in \mathbb{R}^2 : s_A^o = (\varpi_A + \psi)V_{JT'} + V_{AT'}, s_B^o = (\varpi_B - \psi)V_{JT'} + V_{BT'}, T_A^* \le T' \le T_B^*, 0 \le \psi \le \varpi_B\} \tag{4.17}$$

that is again a closed and bounded convex set that contains the disagreement point d. Solving

$$\max_{s_A^o, s_B^o} (s_A^o - d_A)(s_B^o - d_B) \tag{4.18}$$

over the set Ψ yields the Nash bargaining solution:

$$T' = T^* \ \text{ and } \ \psi = 0.5[(W_{BT^*} - W_{BT_A^*}) + (W_{AT_A^*} - W_{AT^*})]/V_{JT^*} \tag{4.19}$$

which attains the same efficient pair of outcomes for the two partners as the cash-time agreement. From (4.6), we therefore obtain an equality between the individually optimal durations T_A^* and T_B^* and the jointly optimal duration T^*, with (4.6), (4.7) and (4.9) then implying that under the new ratio of their shareholdings in the equity joint venture:

$$\varpi_A' / \varpi_B' = \varpi_A^o / \varpi_B^o \quad \textit{for } \varpi_A' = \varpi_A + \psi, \varpi_B' = \varpi_B - \psi, \textit{ with } \varpi_A^o / \varpi_B^o = N_A / N_B \textit{ if } (4.9) \textit{ holds} \tag{4.20}$$

In the symmetric learning and knowledge transfer case (4.9), a share exchange that makes the ratio of the partners' shareholdings equal to the ratio of the present values of their net profits if they had gone it alone from time $\mathrm{t} = 0$ will therefore secure mutual agreement to pursue the jointly optimal duration of the joint venture, with this ratio required more generally to equal ϖ_A^o / ϖ_B^o in (4.6) for such a mutually beneficial agreement.

The above model of optimising behaviour that under specified conditions predicts the optimal finite duration of the EJV can provide a benchmark for an empirical analysis of the behaviour of EJVs and their partners. The prediction of the EJV's optimal duration for each partner in eqn (3.18) provides a potentially testable formulation based upon several relevant measurable underlying variables. These include the initial level of net profits of the joint venture, π^*_{J0}, the growth rate, g_J, in the net profits of the EJV over time, the prevailing interest rate, r , the proportional shareholding, ϖ_i, of firm i in the EJV, and the growth rate, g_i, in firm i's net profits once they have left the EJV and gone it alone. In addition an assessment is needed of the initial level of net profits, π^*_{i0}, that firm i could have achieved if they had gone it alone in the relevant market initially without entering into the EJV. Given also knowledge of the actual level of net profits, π^*_{iT}, of firm i immediately after breaking away from the EJV, an assessment can then be made of the annual growth rate, g_{iJ}, in firm i's profitability as a stand-alone venture whilst partner i is in the joint venture. The resultant value of T^*_i from eqn (3.18) can then be compared with that for the other partner in the EJV to assess whether equality of the two has been achieved by the given pattern of proportional shareholdings of the two partners in the EJV, and hence whether these relative shareholdings are consistent with a jointly optimal duration of the EJV being achieved. The resultant values of the EJV's optimal duration for the two partners can also be compared with the actual duration of the EJV to assess the extent of any departure of the actual duration from the predicted optimal durations, and to further investigate the reasons for any such departure. As in the empirical studies by Sim and Yunus Ali [2000] and by Tidd and Izumimoto [2002], and the two-period theoretical study by Roy Chowdhury and Roy Chowdhury [2001], the reasons for the break-up of a joint venture in the absence of any initial agreement on its duration may include a failure to initially resolve conflicts between the two partners on the intended strategic direction of the joint venture, underlying cultural differences between the partners' long-term orientations, and the moral hazard risk of one partner failing to deliver the expected complementary inputs if an enforceable contract between the two partners is not possible.

5. The Socially Optimal Duration

From the viewpoint of economic policy, it is also of interest to determine the socially optimal duration of the joint venture, and the nature and extent of any deviation from the social optimum which a privately determined duration will produce. The social optimal duration T^{**} of the joint venture will be defined here as

$$\arg\max_{T} \; F(T) \equiv w_1 CS(T) + w_2 PS(T) + w_3 X(T) \tag{5.1}$$

$CS(T)$ in (5.1) is the present value of the consumer surplus generated by the joint venture and by firms A and B going it alone when the duration of the joint venture is T years, and $w_1 > 0$ in (5.1) is the weight placed upon consumer surplus in the economic policy objective. From (2.1), (2.5) and (2.9), we have the consumer surplus that is generated by firm $i = J, A, B$ at time $t = 0, ..., \infty$ to be given by

$$CS_{it} \equiv \int_{p_{it}=p_{it}^{*}}^{\infty} q_{it} dp_{it} = \pi_{it}^{*} \upsilon_i \; where \; \upsilon_i \equiv \upsilon_i^{'} / (1-\tau_i), \upsilon_i^{'} \equiv \varepsilon_i / (\alpha_i \beta_i (\varepsilon_i - 1)) \tag{5.2}$$

$PS(T)$ in (5.1) is the present value of the total producers' surplus in the form of the net profits generated by the joint venture and by firms A and B going it alone, when the duration of the joint venture is T years, and $w_2 > 0$ in (5.1) is the weight placed upon producers' surplus in the economic policy objective.

$X(T)$ in (5.1) is the present value of the tax revenue generated by the joint venture and by firms A and B going it alone when the duration of the joint venture is T years, and $w_3 > 0$ is the weight placed upon tax revenue in the economic policy objective. From (2.9), (3.3) and (3.7) we have:

$$X(T) = \sum_{i=J,A,B} \tau_i V_{iT} / (1-\tau_i) \tag{5.3}$$

From (3.3), (3.7) and (5.2), (5.1) may therefore be written as:

$$\arg\max_{T} \; F(T) = \sum_{i=J,A,B} \varphi_i V_{iT} \; with \; \varphi_i \equiv w_1 \upsilon_i + w_2 + (w_3 \tau_i / (1-\tau_i)) \; for \; i = J, A, B \tag{5.4}$$

(5.4) involves the solution to the first order condition:

$$\partial F(T) / \partial T = \sum_{i=J,A,B} \varphi_i V_{iT}^{'} = 0 \tag{5.5}$$

When the duration of the EJV is socially optimal, the social benefit of the joint venture lasting slightly longer, as reflected in $\varphi_J V_{JT}^{'}$ in (5.5) and the economic policy objective in (5.4), is equated to the social benefits foregone by the two partners not breaking away from the joint venture slightly sooner, as reflected in $-\varphi_A V_{AT}^{'} - \varphi_B V_{BT}^{'}$ in (5.5). The case where there is a symmetric overall rate of learning and knowledge transfer by both partners within the joint venture, as in (4.9), is again of particular interest in yielding an explicit analytical solution, with the socially optimal duration of the joint venture then given from (5.5) by:

$$T^{**} = (1/(g_{oJ} - g_J)) \ln(\varphi_J \pi_{J0}^{*} / [(r - g_{oJ}) \sum_{i=A,B} \varphi_i N_i]) \tag{5.6}$$

From (4.10) and (5.6), we have that the socially optimal duration of the joint venture exceeds, equals, or is less than the privately joint optimal duration according to the criterion:

$$T^{**} (>,=,<) \, T^{*} \text{as} \; \varphi_J (N_A + N_B) (>,=,<) \; \varphi_A N_A + \varphi_B N_B \tag{5.7}$$

In the case where the two partners going it alone would face the same tax rate $\tau_A = \tau_B$ and the same elasticities of demand $\varepsilon_A = \varepsilon_B$ and degree of returns to scale $\alpha_A = \alpha_B$, we have from (5.2), (5.4) and (5.7):

$$T^{**}(>,=,<)T^{*} \; as \; \tau_A - \tau_J \; (>,=,<) s_{JA} \equiv [(1-\tau_A) w_1 (\upsilon_J^{'} - \upsilon_A^{'}) / (w_1 \upsilon_A^{'} + w_3)], \; s_{JA}(>,=,<)\, 0 \; as \; \upsilon_J^{'}(>,=,<)\upsilon_A^{'} \quad (5.8)$$

s_{JA} is here the level of the corporate tax break enjoyed by the joint venture, compared to the tax rate facing the two partners if they go it alone, that would bring their privately joint optimal duration of the EJV into line with the socially optimal duration. If the actual tax break offered to the EJV is less than s_{JA}, the privately joint optimal duration of the EJV will fall short of the socially optimal duration.

Even if the symmetry condition (4.9) does not hold and the individual partners face different demand elasticities when they go it alone, we may still derive the optimal corporate tax rate τ_J^{*} for the EJV that will bring the privately joint optimal duration of the EJV into line with the social optimum. From Sections 3 and 4 above, we have for the privately joint optimal duration of the EJV: $V_{iT}^{'} + \varpi_i^{o} V_{JT}^{'} = 0 \; for \; i = A, B$. It then follows from (5.2) – (5.5) that:

$$\tau_J^{*} = (\Gamma - w_1 \upsilon_J^{'}) / (\Gamma + w_3) \;\; where \; \Gamma \equiv \sum_{i=A,B} \varpi_i^{o} (w_1 \upsilon_i^{'} + w_3 \tau_i) / (1 - \tau_i) \quad (5.9)$$

If the two partners going it alone do face the same corporate tax rate τ_o, (5.9) implies that the optimal corporate tax break for the joint venture equals:

$$s_J^{*} = \tau_o - \tau_J^{*} = (1 - \tau_o)[w_1 \sum_{i=A,B} \varpi_i^{o} (\upsilon_J^{'} - \upsilon_i^{'})] / [\sum_{i=A,B} w_1 \varpi_i^{o} \upsilon_i^{'} + w_3] \quad (5.10)$$

From (5.2), (5.4) and (5.10), we have under condition (3.16):

$$s_J^{*} > 0 \; if \;\; \alpha < [\varepsilon_i \varepsilon_J / (\varepsilon_i \varepsilon_J - 1)] \equiv \alpha_{oi} \;\; for \; i = A \; and \; B \quad (5.11)$$

Thus if returns to scale are diminishing, constant, or increasing less than the critical degree indicated by α_{oi} for each partner, the level of the optimal tax break for the EJV that succeeds in bringing the privately joint optimal duration of the EJV into line with the joint venture's socially optimal duration is positive. However, if the degree of returns to scale available to each firm exceeds the critical value α_{oi} in each case, a higher tax rate on the EJV than on the firms going it alone is needed in (5.10) to bring the privately joint optimal duration of the EJV into line with the socially optimal value. With a lower price elasticity of demand facing the EJV than the partners going it alone under condition (3.15), the EJV is less willing to reduce its price to achieve economies of scale through increased demand than are the partners going it alone. The coefficient $\upsilon_J^{'}$ that influences the magnitude of the consumer surplus that accompanies a given level of pre-tax profits in (5.2) and (5.4) can then be shown to be smaller for the EJV than the corresponding value $\upsilon_i^{'}$ for each partner i going it alone, with s_J^{*} then negative in (5.10).

It is moreover notable that if $\upsilon_A^{'} = \upsilon_B^{'}$, the magnitude of the optimal tax break for the joint venture in (5.10) is independent of the growth rates g_J, g_i and g_{iJ} for $i = A, B$, and of the learning and knowledge transfer rates which influence them. These rates will affect both the EJV's privately joint optimal duration T^*, as in (4.10), and its socially optimal duration T^{**} as in (5.6). They will also in general affect the partners' jointly optimal shares ϖ_i^o in the EJV, though in the symmetric learning and knowledge transfer case (4.9) each ϖ_i^o will depend only on the go-it-alone growth rates g_A and g_B, as in (4.20). However, if $\upsilon_A^{'} = \upsilon_B^{'}$ these relative shareholdings do not affect the optimal tax break for the joint venture in (5.10), and neither do the growth rates g_J, g_i and g_{iJ} for $i = A, B$. The economic policy goal for the joint venture's tax break is here to bring the privately joint optimal duration of the EJV, which relates to maximising the total present values of the partners' net profits when in and out of the joint venture, into line with the EJV's socially optimal duration, which relates to maximising the total present value of a wider set of social benefits from their activities, as in (5.1). The relative trade-off between the partners' pre-tax profits and this wider set of social benefits varies according to whether the partners are continuing in the joint venture or are going it alone, and with the corresponding elasticities of demand, returns to scale and corporate tax rates they face in each case. A choice of the relative corporate tax rates, and the associated tax break for the joint venture, that makes appropriate adjustments for these elasticities of demand and the degree of returns to scale facing each firm, which affect the values of $\upsilon_J^{'}, \upsilon_A^{'}$ and $\upsilon_B^{'}$ in (5.1), can then bring T^* into line with T^{**}.

6. Conclusions

Rather than being a random unpredictable event, the break-up of an equity joint venture after a finite time can be modelled as the predictable consequence of underlying economic parameters under conditions of complete certainty. There is then scope for both partners in the equity joint venture to gain from bargaining in the initial formation of the equity joint venture to achieve an agreed termination date of the joint venture, with side payments in the form of cash or equity transfers whenever the underlying economic parameters result in differences in the initial individual optimal durations of the joint venture between the two partners. In addition, there is scope for a differential corporate tax rate on the joint venture, compared to that on the go-it-alone businesses of the two partners, in order bring the two partners' privately optimal durations into line with the socially optimal duration of the joint venture.

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