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Coordination costs and research joint ventures☆

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ABSTRACT

We consider a simple oligopoly model where firms engage in cost-reducing R&D and compare two R&D regimes: R&D competition and R&D cooperation in the form of a research joint venture (RJV). We introduce coordination costs for the RJV and examine how these affect the equilibrium outcomes.
We find that the performance of the RJV in comparison to R&D competition is sensitive to the level of coordination costs. Although the RJV may no longer conduct a unit of R&D at a lower cost compared to an independent firm in the non-cooperative R&D regime, RJV members can still make savings on their own R&D outlay through information sharing. We establish that there can be profitable but welfare-reducing RJVs and that R&D competition can generate a better outcome depending on the extent of coordination costs.

1. Introduction

Competing firms collaborate in their R&D strategies and activities for a variety of reasons. Collaborating enables firms to share costs (and risks) and to have access to each others' technology, markets and products. Together the partner firms can exploit economies of scale and scope in the generation and distribution of R&D, and benefit from the synergies from exchanging and sharing information and know-how. But successful collaboration requires coordination, and coordination incurs costs (Cassiman and Veugelers, 2002). The larger the number of collaborators, the larger these coordination costs are likely to be.[1] A study of US government-funded RJVs (Dyer and Powell, 2001) concluded that one of the main factors detracting from a project's success was the cost of coordinating the venture's R&D activities, which were found to increase with the consortium size.[2] Governments have long recognized the externalities associated with R&D and the potential benefits of R&D collaboration among firms. While some governments have been generous in their financial support of RJVs, this support has often acknowledged, at least implicitly, the importance of coordination costs to the collaborations' success.[3]

To the best of our knowledge, there has been very little theoretical work on modeling explicitly the *cost associated with forming or running an RJV*. Most standard multi-stage models assume implicitly that cooperation is costless (e.g., Atallah, 2005; D'Aspremont and Jacquemin,

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[1] In a study of joint ventures in the United States, Kogut (1989) finds that 54% were terminated within the first seven years. A study by Arthur Andersen (Alliance Analyst, 1996) found that 30% of alliances were reported as outright "failures" and another 27% were "unsatisfactory". Harrigan (1985) found that almost 50% of alliances ended in failure.

[2] For example, one strong opinion noted that "When we joined the ATP [Advanced Technology Program] we didn't realize there would be so many participants. From my perspective, there were just too many. First, it took so long getting to know everyone. In addition, scheduling meetings was a nightmare; we had to schedule meetings a year in advance. It was too difficult to coordinate…" (Dyer and Powell, 2001).

[3] Campbell et al. (2009) emphasize the role of coordination costs in fashioning joint venture size for the 142 R&D joint ventures funded by the ATP between 1990 and 2004. In a study of Spanish RJV participants within the EUs R&D Framework Programme, Barajas and Huergo (2010) show that factors relating to coordination costs (geographical distance, prior experience in R&D cooperation and the coordination capacity of the consortium leader) had a significant influence on the probability of the venture receiving funding from the EU.

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1988; De Bondt et al., 1992; Gil Moltó et al., 2005; Kamien et al., 1992; Poyago-Theotoky, 1995).[4]

We fill this gap in the literature by asking how the coordination costs of operating the RJV affect its performance and to what extent an RJV is preferable or not when compared to independent R&D competition. Since coordination costs tend to increase with the size of the research joint venture, we postulate that the marginal cost of R&D increases with the number of participants.

We find that coordination costs not only decrease an RJV-firm's profit but alter a firm's expectation of the benefit from being an RJV member. For a given size of the RJV, its members decrease their own R&D as coordination costs increase. This results in lower output and profits. On the contrary, the non-RJV firms increase their R&D in response to the fall in the RJV firms' R&D and supply larger quantities to the market and profit more, unless spillovers are very large. We show how the performance of the RJV (in terms of R&D, profit and welfare) in comparison to R&D competition is sensitive to the level of coordination costs. Indeed, we establish that *there can be profitable but welfare-reducing RJVs and that R&D competition can generate a better outcome* depending on coordination costs. This result points out the role a government or regulator can play in disallowing and/or controlling RJVs while at the same time encouraging R&D competition when coordination costs are relatively high. Alternatively, measures could be taken to reduce the coordination costs and thus restore congruence between private and social incentives. As the formation of an RJV is not always welfare enhancing, policy measures that are intended to deter/encourage RJVs should be carefully evaluated, paying particular attention to industry characteristics, such as the number of operating firms and the extent of coordination costs within RJVs.

Coordination costs in research joint ventures are rather well documented in the managerial and business literature.[5] There is thus a clear need to provide a theoretical explanation and understanding of their effects. Despite this need the relevant theoretical literature is scant apart from the contributions of Vilasuso and Frascatore (2000), Manasakis and Petrakis (2009) and Fabrizi and Lippert (2012). Vilasuso and Frascatore (2000) were the first to incorporate explicitly the cost arising from forming an RJV. Their analysis is cast in a duopoly and the cost of forming an RJV is modeled as fixed and does not depend on the scale of R&D output. They find that the perceived superiority of RJVs may not hold anymore and that firms' and society's interests may not be aligned, a point that the present paper reinforces and elaborates further. Nevertheless, issues pertaining to the size of a research joint venture and coordination costs that can vary according to the R&D activities undertaken and the number of RJV participants were not addressed. This is where the present paper differs in that it generalizes the number of firms and concentrates on the way in which RJV-specific coordination costs are modeled. Manasakis and Petrakis (2009), still in a duopoly setting, introduce the effects of alternative labor union organization and the costs imposed by unions on the performance of an RJV. The issue of variable coordination costs is not dealt with. Rather, the RJV costs in Manasakis and Petrakis (2009) are fixed too. They also find that RJVs are not always welfare enhancing. In the present paper a similar result is obtained but in an oligopoly setting with a partial RJV with the mechanism leading to this result being substantially different as it relies on the interplay between RJV members and outsiders and the severity of the explicit and variable coordination costs.

In a rather different vein, Fabrizi and Lippert (2012) examine how information asymmetries within firms affect the final decision to cooperate in R&D as well as the incentives to innovate offered to researchers. They clearly point out the impact of the costs associated with the formation and operation of RJVs stemming from information asymmetries within the firms and the RJV. In the context of a duopoly and within an agency framework they focus on the consequences of additional information asymmetries in RJVs in relation to independent firms and explore the implications of involving researchers within firms in the due diligence process of assessing the costs and benefits associated with the formation of the RJV.

The paper is organized as follows. In Section 2 we examine the R&D competition regime in the oligopolistic framework. The model of a research joint venture with general coordination costs is formalized in Section 3 while Section 4 compares the two R&D regimes. Section 5 extends the analysis to allow for interfirm spillovers. Finally, concluding remarks are provided in Section 6. Proofs of the various propositions appear together with a summary of the notation used in the Appendix A.

[4] Also see De Bondt (1996) for an excellent survey.

[5] As discussed above; see also Footnotes 1–3.

2. R&D competition

In this section we discuss briefly a standard model of deterministic R&D competition in an oligopolistic environment. There are n identical firms selling a homogenous product in a market with linear inverse demand $P = A - \sum_{i=1}^{n} q_i$, where P, A and q_i denote price, market size and firm i's output respectively. Consumer surplus is $CS(Q) = \frac{Q^2}{2}$, where $Q = \sum_{i=1}^{n} q_i$. As a benchmark for comparison and to focus solely on the role of coordination costs, we assume here that intellectual property rights are well protected, so that firms cannot free ride on each other's R&D (i.e., there are no R&D spillovers between firms).[6] In addition, there are no fixed costs and firm i's marginal cost of production (c_i), can be reduced by R&D, which, in the absence of R&D cooperation, is equal to the firm's own R&D investment (x_i). Hence, firm i's unit cost of production is $c_i = c - x_i$, where c is a base cost (i.e., if the firm undertakes no R&D) and $0 < c < A$. The R&D cost function takes the form: $R_i = \gamma \frac{x_i^2}{2}$, where R_i denotes firm i's R&D cost and $\gamma(> 0)$ captures R&D efficiency.[7]

We consider a two-stage game. Firms make decisions independently and simultaneously on R&D in the first stage, taking each others' R&D decisions as given. They then compete in quantity in the second stage, on the basis of the marginal production costs from the previous stage. We use the subgame perfect equilibrium concept, solving the game backwards.

In the second stage, each firm chooses its output to maximize profits, yielding equilibrium output

$$q_i^* = \frac{A - nc_i + \sum_{i \neq j}^{n} c_j}{n+1} \tag{1}$$

with associated equilibrium price, $p^* = \frac{A + \sum_j^n c_j}{n+1}$, and equilibrium profits

$$\pi_i^* = \left[q_i^*\right]^2. \tag{2}$$

Substituting for unit costs, expression (2) can be written as $\pi_i^* = \left[\frac{K + nx_i - X_{-i}}{n+1}\right]^2$, where $X_{-i} = \sum_{i \neq j}^{n} x_j$ and $K \equiv A - c > 0$ measures the 'effective' market size.

In the first stage, each firm chooses R&D to maximize second stage profit net of R&D costs, i.e.,

$$\max_{x_i} v_i = \max_{x_i} \left[\left(\left(\frac{K + nx_i - X_{-i}}{n+1}\right)^2 - \frac{\gamma x_i^2}{2}\right]\right.$$

[6] In Section 5 we relax this assumption and allow for imperfect appropriability and hence spillovers.

[7] We build on the d'Aspremont and Jacquemin (1988) model, where spillovers operate on the R&D output (results) as opposed to Kamien et al. (1992) where they operate on the R&D input (efforts). The two ways of modeling R&D spillover are not equivalent in general (Amir, 2000; Amir et al., 2008). However with $\beta = 0$ (no spillovers) the two approaches yield the same results in the R&D competition case. As most related papers on the topic of this paper follow the AJ specification, we stick with it and leave aside an extension to the alternative KMZ specification.