An economic analysis of R & D joint ventures

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Abstract:

A graphical model of co-operative R & D activity is presented, from which outcomes of R & D joint ventures are posited. The analysis predicts that R & D spending will increase as a result of co-operation and that the increment will tend to be in basic research more than applied or development.

Keywords: R and D | joint ventures | cooperative research | public goods

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INTRODUCTION

One factor frequently cited as a culprit for the slowdown in productivity growth during the 1970s is the curtailment of R & D spending.[1] Policy proposals for reversing the trend in R & D range from increasing governmental support for extramural research, to setting up new co-operative research centers, to stimulating industrial research through tax mechanisms.[2]

[1] There were really two slowdowns in productivity growth, one beginning around the mid-1960s and a second, more severe, one beginning in the early 1970s. R & D as a percentage of GNP peaked at 3.0% in 1964, then fell to 2.3% by 1975 and to an even slightly lower level by 1977, where it has approximately remained except for slight increases beginning in 1982.

[2] Tax incentives for R & D have long been part of the US Tax Code, beginning with the adoption of Section 174 in 1954. This provision allowed businesses to fully deduct research and experimental expenditures in the year incurred. The Economic Recovery Tax Act of 1981 (ERTA) added measurably to the preferential treatment given to R & D. Part of ERTA allowed for a 25% tax credit to businesses for increases in their base levels (three previous taxable years) of R & D spending. For more details, see Bozeman and link (1984).

Most recently, The National Co-operative Research Act of 1984 (P.L. 98-642) was passed. This Act, among other things, extended earlier Department of Justice rulings on R & D joint ventures.[3] In 1980 the Department of Justice took the position that 'the closer [any] joint activity is to the basic end of the research spectrum ... the more likely it is to be acceptable under the antitrust law' (1980, p. 3). The 1984 Act 'delineates the protected and unprotected activities and objectives of joint research and development ventures in terms of the antitrust laws [and] permits joint research and development ventures for the purpose of theoretical analysis, experimentation, or systematic study of phenomena or observable facts ...'[4]

Although theoretical work in the area of *per se* joint ventures dates at least to Fusfeld (1948) and Mead (1967), very little is known about R & D joint ventures.[5] The purpose of this note is to present a graphical model of co-operative R & D activity, and from it posit likely outcomes from R & D joint ventures.

A PUBLIC GOODS MODEL OF CO-OPERATIVE R&D

The maintained assumption of this model is that R & D is an investment into the production of technical knowledge, and that technical knowledge has the characteristics of a public good (Arrow, 1962). This assumption is motivated on the belief that technical knowledge is not fully appropriated by the firm conducting the R & D, and hence will, over time, diffuse throughout the industry and the economy. Technical knowledge can either diffuse as information *per se* or as information embodied in new vintages of capital.

We are implicitly treating R & Das a homogeneous input into the production of knowledge when, in fact, the activities broadly grouped under that rubric are quite heterogeneous. Research may be defined as the primary search for technical or scientific advancement; development is the translation of such advancements into product or process innovations. In the 1950s the National Science Foundation fostered a more detailed breakdown: basic research, applied research, and development.[6] In practice, industrial R & D is even more heterogeneous than these labels imply. Accordingly, not all categories of use of R & D yield the kind of knowledge that can be characterized correctly as a public good. It is the output from activities near the basic end of the R & D spectrum that is the least appropriable, and thus the most likely to be widely diffused (Arrow, 1962; Nelson, 1959).

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[3] The Act was also a response to the recent explosion in the formation of new joint ventures among US firms. Only once during the period from 1973 to 1980 were there more than 200 reported joint ventures. In 1982, 281 joint ventures were reported and in 1983 the number increased to 348. See Jacobs (1984).

[4] This Act is an outgrowth of several bills introduced by Congressmen Thurmond, Glenn and Rodino in the 98th session of Congress.

[5] A recent survey of empirical studies on *per se* joint ventures is in Berg *et al.* (1982). Related theoretical work is in Ordover and Willig (1985).

[6] Basic research represents original investigation for the advancement of scientific knowledge which does not have a specific commercial objective. Applied research represents investigation directed toward finding a new scientific knowledge which has a specific commercial objective, product- or process-related. Development is that technical activity concerned with non-routine problems encountered in translating research findings and general scientific information into products or processes (National Science Foundation, 1979).

Our model (Fig. 1) is based on a model of public goods first developed by Buchanan (1968) and later extended by Jeremias and Zardkoohi (1976).[7] An industry is assumed to be comprised of two firms, A and B. Both firms invest independently, in our model, in basic research. The technical knowledge obtained from the basic research is assumed to have the characteristics of public goods. Firm A has an initial endowment of resources (a numeraire good) denoted by *Oa* on the horizontal axis of Fig. 1 and firm B has an initial endowment of the numeraire good denoted by *Ob.* The initial endowment in each case can be thought of as the budgeted R & D which can be either spent on the applied component of R & D (i.e. a private good), on the basic component (i.e. a public good) or on any linear combination of the two. The specific transformation curves between the two components are denoted by *aa′* and *bb′* for firms A and B, respectively. The slope of these transformation curves represents the marginal cost of producing a unit of technical knowledge in terms of the applied component. The *X, Y, Z*, curves can be thought of as the isoprofit curves. The ray *00′* represents the locus of optimal investment choices for the two firms, acting independently.

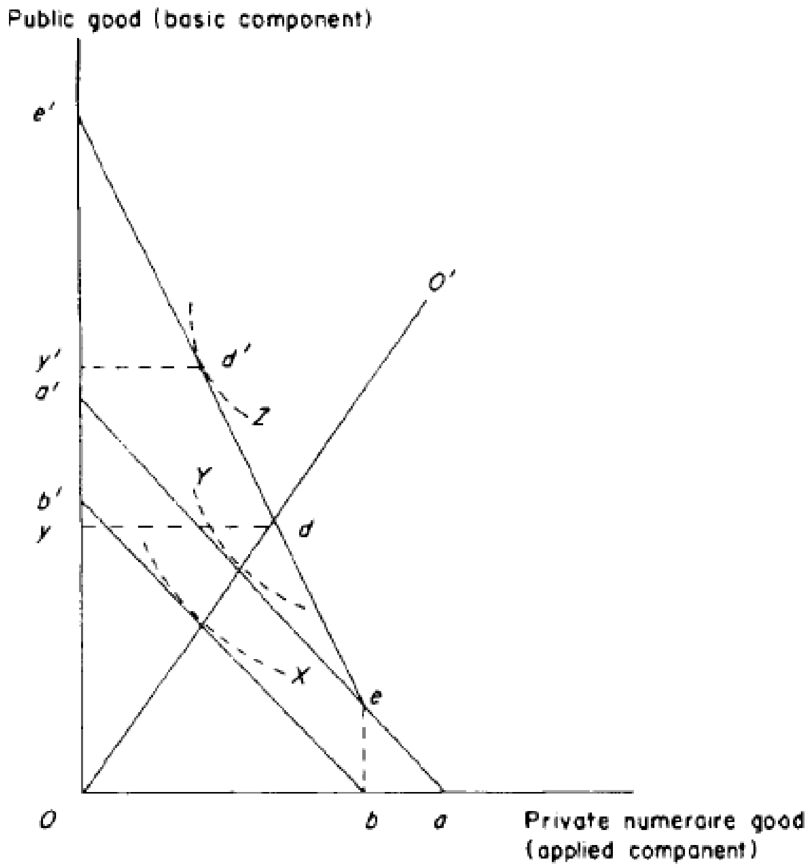

Figure 1.

Since the objective of our analysis is to compare the provision of the public good when investments are made both independently and jointly, we must determine each firm's investment choices under the two alternatives. If each firm invests its entire endowment of the numeraire

[7] See especially Chapter 2, pp.11-14 in Buchanan (1968). Buchanan's model analyzed consumption; however, we use a similar model to discuss the production of R & D.

good on the public good, the total amount provided will be $0e'$ (= $0a' + 0b'$) and each firm, assuming perfect diffusion, will have an allocation denoted by point *e'*. But, of course, point *e'* is away from the locus of optimal investment choices. Each firm maximizes profit, given its transformation curve, by attempting to reach an allocation on the optimal locus, *00'*. *Since each firm independently moves to the optimal investment locus 00', and since both firms eventually must use identical amounts of the public good (by definition), it necessarily follows that both firms must simultaneously reach an identical and unique allocation on 00'.* To find this unique allocation, we must first determine the locus of all possible allocations which both firms *can* reach simultaneously. The intersection of this latter locus and *00'* determines such a unique point (which both firms obtain simultaneously). Note that the unique (or identical) allocation implies that both firms end up having identical bundles of the two goods, regardless of their initial endowments of the numeraire good.

One allocation which both firms can obtain simultaneously is *e'*. If firm A invests *0a'* and B invests *0b'* in the public good, *0e'* will be the total amount produced and *e'* will be the allocation facing both firms. There are, of course, an infinite number of such allocations that both firms can obtain simultaneously. These can be found by taking feasible allocations on the horizontal axis that both firms can reach, and then finding the corresponding amounts of the public good which are obtained by the firms. Since firm B cannot obtain endowments exceeding *0b* the feasible points which can be attained by the firms must be limited to *0b*. Take, for example, point *b*. Firm B spends zero amount on the public good whereas firm A spends *ba* amount and provides *be*. Both reach the *e* allocation simultaneously, having identical amounts of both goods. Connecting *e* to *e'*, we find all the allocations which can be achieved by both firms simultaneously.

The intersection between *ee'* and *00'*, point *d*, determines the equilibrium allocations obtained by both firms, given independent adjustments.[8] The allocation at *d* is unique in that both firms reach that allocation simultaneously. It shows that the firms end up receiving identical amounts of the public good as well as the private good, although the initial endowments were different. The logic is that both firms attempt to find an allocation on the *00'* curve; furthermore, they, by definition, receive the same amount of the public good. Being on *00'* and receiving the same amount of the public good implies that the firms will reach an identical allocation simultaneously, identified as *d* in Fig. 1. The allocation at *d* is not, of course, an economically efficient allocation since the slope of *ee'* is different from that of *aa'* or *(bb')*. Both firms can be made better off by moving to the allocation at *d'*. This point can be reached only through co-operation, that is, through a joint research venture; otherwise, the free-rider problem would inhibit such move. Cooperation will increase the amount of technical knowledge from *0y* to *0y'*.

Adding additional firms to the model will not substantially change the results. The model in Fig. 2 includes three firms of sizes *0a, 0b* and *0c*. Line *dd'* is the locus of all points that firms A and B can reach at the same time, assuming that firm C produces no public good. Rays from the origin

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[8] The *00'* curve does not. of course, have to intersect the *ee'* curve. The set of optimal investment allocations could be such that the *00'* curve intersects the *aa'* curve below the allocation at point *e*. These will be cases where the private good (or the numeraire good) would be valued more intensively than that indicated by the *00'* curve in Fig. 1. Cases where the *00'* does not intersect the *ee'* transformation curve do not, of course, generate a unique or identical allocation enjoyed by both firms. Instead there will be two allocations, one for each firm. These allocations will contain equal amounts of the public good (technical knowledge), but different amounts of the numeraire good. Free-ridership would still be a problem and co-operation improves the efficiency of resource allocation.

intersecting line *ee'* will obtain full allocation equalization across the three firms, with each firm having equal amounts of the public good and, of course, the private good. However, rays intersecting line *de* will result in allocation-equalization for firms A and B, with firm C receiving identical amounts of the public good but only *0c* of the private good. In a multi-firm world with identical trade-off relationships between private and public goods, independent public goods investments will result in final allocation-equalization among these firms that provide the public good.

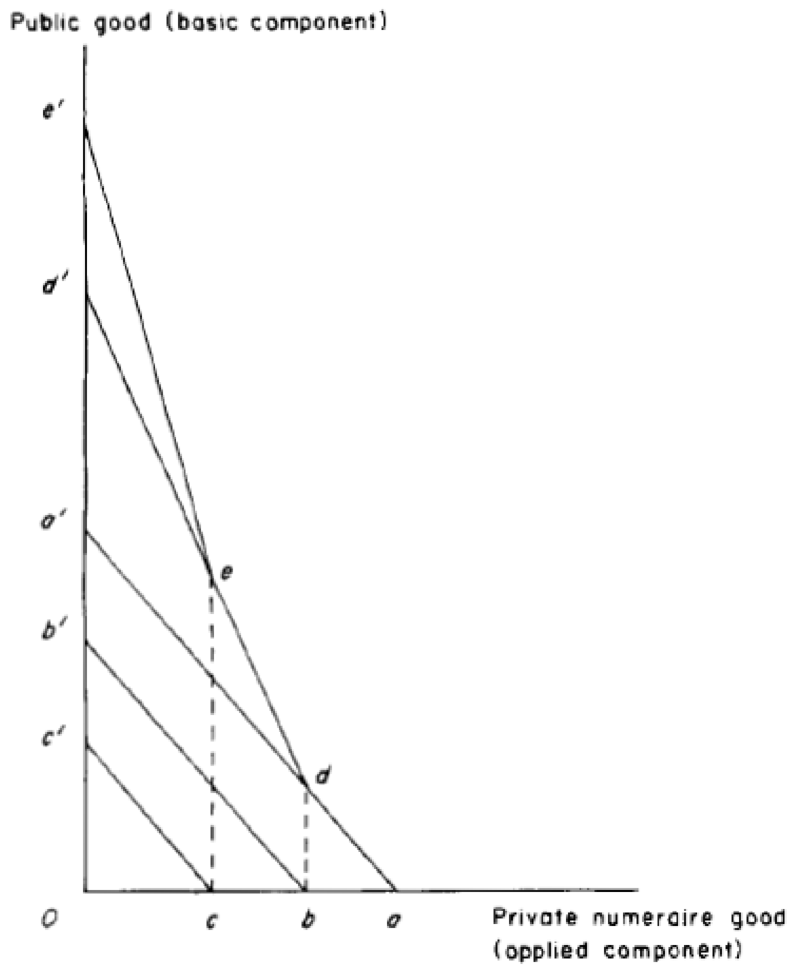

Figure 2.

Our model predicts that the total level of R & D spending between the two firms (within the same industry) will increase as a result of co-operation. We posit that firms engaging in co-operative R & D have their own incentives for directing the R & D toward basic. Since basic research has more public goods characteristics than applied research or development activities, firms would not be able to fully appropriate the resulting knowledge if the research were conducted privately. Hence, they may be more willing to share in those basic costs. We know there are financial economies of scale associated with R & D as a total, and thus it may be safe to conclude that, owing to the greater uncertainty of basic research, these financial economies are even greater toward basic research. Therefore, cost-sharing may be especially attractive for basic research activities, given the self-financing constraints firms face for R & D.

CONCLUSIONS

Our analysis predicts that total R & D spending will increase as a result of co-operation and that this increase will likely be toward the basic end of the R & D spectrum. To the extent that co-operation takes place through R & D joint ventures, as opposed to, say, consortia arrangements, the social benefits associated with the arrangement may show up in increased productivity growth, given that basic research makes a primary contribution (Mansfield, 1980; Link, 198l).

In addition to the incentives established for R & D joint ventures in The National Co-operative Research Act of 1984, how else might co-operative research arrangements be achieved?[9] When public goods exist, beneficiaries do have an incentive to free-ride. One obvious solution is to make free-ridership (or non-cooperation) costly. A role for the government could be to make appropriate tax adjustments such that firms will have an incentive to launch co-operative research ventures. Our model predicts that small firms, in an industry with different-sized firms, have an incentive to free-ride. In fact, the smaller the relative size of the firm, the greater the likelihood. For example, in an oligopolistic market with different-sized firms, R & D joint ventures may only emerge among the relatively larger firms.[10] This implies that a tax incentive afforded to the relatively small firms should be disproportionately greater than that for the relatively larger firms in order to induce the optimal amount of R & D. More work appears warranted in this policy area.

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[9] Of course, a tax credit directly aimed at stimulating additional basic research would be a possible solution; however, once the nature of basic research is understood such a policy would not be feasible. At any given point in time it is at best a subjective judgement as to what activities of the firm are directed toward basic.

[10] For example, Joskow and Schmalensee (1983, p. 87) maintain that: [D] is satisfaction with what some perceive to be inadequate R & D activity by the electric utility industry led to the creation of the Electric Power Institute (EPRI) in 1972. EPRI has a budget of about $250 million per year and finances and manages a wide range of long-term and short-term R & D projects conducted by others on behalf of the electric utility industry. *Most large utilities are members of EPRI and make an annual contribution to support its work.'*

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