Strategic Research Partnerships: What Have We Learned?

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Introduction. An extensive knowledge has accumulated about strategic research partnerships (SRPs). SRPs take many forms and have significant effects on innovative investment behavior and performance. In this short paper, I provide my perspective of what we have learned and our needs for more data. The overview is based on my understanding of the literature and on my own experience with research about R&D and technological change. My own work has focused on small pieces of the giant research puzzle about SRPs, so the task of setting out a perspective on what has been learned is especially daunting. Here are my summary thoughts, nonetheless. I shall attempt to provide short, summary answers to three questions that have been addressed in the literature. First, why, essentially, are SRPs socially useful? Second, what is the role for public policy with regard to SRPs? Third, what data initiatives are needed with regard to SRPs?

Why are SRPs socially useful? The literature has documented many reasons that I shall boldly combine to conclude that essentially, SRPs are socially useful because they expand the effective R&D resources applied in innovative investment. Why do they in effect expand the R&D resources applied? SRPs can achieve expansion of effective R&D for many reasons; Hagedoorn (2000) provides an excellent list, including, for example, that SRPs may make possible realization of economies of scale and scope in R&D. However, I shall emphasize one reason, because my own understanding of the theoretical work and the empirical work points to its great importance as a “reason behind the reasons” for the social usefulness of SRPs.

I conjecture that at the heart of much of the social benefit from SRPs is the importance of what the innovation literature has termed investment in absorptive capacity. Without a SRP, a firm must do R&D in a particular technology area to be able to benefit from the spillovers of R&D insights or innovative outputs generated by the R&D of other firms. Figure 1 illustrates the role of absorptive capacity.

Martin (2000b) has provided an insightful review of the literature about absorptive capacity. He has also modeled noncooperative equilibria with various forms of SRPs, taking into account the need to invest in absorptive capacity along with the effects of spillovers in R&D and appropriability difficulties because of imitation of innovation (Martin, 2000a). My first point is that our learning about absorptive capacity is a key, perhaps the crucial key, for understanding social gains from SRPs.

To illustrate the importance of investment in absorptive capacity, I have used patent citations to design a test of the absorptive capacity hypothesis. Absorptive capacity is increased by active participation in the markets where research is applied and by active R&D invested in the technologies for which R&D is borrowed. Therefore, we expect the multimarket contact of two firms will increase their expected cross-citations holding constant the expected citations associated with particular market locations and other characteristics for the citing and cited firms. We expect greater multimarket contact to be associated with additional citations, other things equal, because the R&D embodied in others’ patents is more useful to firms actually doing research in an area. I am assuming that the citations reflect the usefulness of the R&D embodied in the cited patents. Certainly, some citations may be for strategic reasons of protecting against potential litigation, although even then the need to use the citations for such protection suggests the usefulness of the R&D embodied in the cited patents. In any case, for the
test of the absorptive capacity hypothesis, my focus is on the citations as a reflection of the usefulness of the R&D of other firms.  

Table 1 provides the key evidence supporting the absorptive capacity hypothesis; the evidence is taken from a model of the citations of one firm of the patents of another (Scott, 2000b). With the effects of other variables held constant, Table 1 shows the incidence rate ratios (IRRs) for citations given completely insignificant congruence (the probability of more congruence is 1.0 against the null hypothesis of random meetings) of the citing and the cited firms’ operations as compared with completely significant congruence (the probability of more congruence is 0.0 given the null hypothesis). For product market contact, other things being the same the number of citations with insignificant contact are predicted to be 0.217 or 21.7 percent of the citations with significant contact. For innovation market contacts, other things being the same, the citations with insignificant contact are predicted to be 0.107 or 10.7 percent of the citations given significant contact. Both of these IRRs are estimated well, and the table shows their 95 percent confidence intervals.

These statistics use the estimates from a negative binomial model of the citations by firm i of the patents of firm j. The model controls for the firms’ numbers of patents, the science linkage of their patents, their product market diversification (as indicated by the industries where they have sales), their innovation market diversification (as indicated by the product categories where they have patents), their locations in product and innovation markets, and the significance of the congruence of their product market operations and their innovation market operations.

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2 The multimarket contact occurs across a large array of innovation and product markets. Therefore, the usefulness of the R&D embodied in the cited patents can result in vertical technology flows as well as horizontal flows of the R&D results for one firm to their uses for another firm.
The effect of multimarket contact on citations, given controls for the product and innovation market effects in citations, is expected because the R&D of other firms is most useful to a firm when it is actively involved in the same product and innovation markets as the firms whose R&D it borrows. The model controls for the effects of the cited firm being in particular product and innovation markets, and it controls for the effects of the citing firm being in particular markets. Holding constant those effects, congruence of two firms’ operations across the product and innovation markets of each is extraordinarily important for their ability to absorb each other’s research and development ideas.

The importance of congruence for absorptive capacity is evidenced by the greatly increased frequency of mutual citations apart from the effects associated with particular locations in the product and innovation markets. Imagine two firms that have completely congruent operations in product markets. Then even after controlling for the effect of that congruence, and even after sweeping out the effects associated with the particular locations in product and innovation markets, with the closeness to science and size of the patent portfolios, and with the diversification in product and innovation markets, the additional effect of significant congruence in innovation markets increases the expected citations by about nine (1/1.11) times.

In addition to the congruence result supporting the importance of investment in absorptive capacity, the negative binomial model of citations shows that diversification of firms across product and innovation markets increases the usability of research ideas — a possibility emphasized by Nelson (1959). Diversified firms cite other firms’ research outputs more frequently, and research outputs of diversified firms are more frequently cited (Scott, 2000b).
I make two inferences based on the evidence.

- If a firm’s R&D resources are actively involved in research in a technology area, the firm is more likely to find useful the R&D results from other organizations in that technology area. The evidence of the additional utility is based on additional citations, even after controlling for the other effects (such as the technology area effect itself) in citations that are the measure of usefulness here.

- Diversification of R&D effort across technology areas itself increases the usefulness of research outputs. Again, the evidence of additional utility as reflected in citations is even after control for the other effects in citations.

What then is the implication of the evidence for the social economic value of SRPs? The implication is: SRPs expand the effective R&D resources applied in R&D investment given actual scarce resources allocated to R&D. A priori, social economic value is created by SRPs because they expand the effective R&D resources applied in innovative investment. Bringing together the research resources of multiple organizations extends the range of potential research outputs.

Why would the amount of effective R&D resources devoted to innovative investment increase given the same amount of scarce resources devoted to R&D? Within a SRP, the resources of firm 1 are juxtaposed with those of firm 2, and the resources of each have the advantage of the active knowledge of the other’s resources. As Kealey and Al-Ubaydli (2000) observe, “because science moves so fast, and because it takes personal expertise at the cutting edge to discriminate usefully between different research papers, patents and products, . . . only active scientists have the judgement and tacit knowledge to capture others’ science efficiently.” Juxtaposing the active R&D resources of the
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partners, a SRP in effect increases the absorptive capacity of the partners given the resources that they bring together.

Figure 2 illustrates the point that SRPs expand effective R&D resources. Without a SRP, we expect just a portion (perhaps a proportion close to or equaling zero) of the effective R&D of others is appropriated. With a SRP, the active R&D of both firms, often in multiple technologies, is juxtaposed, and the effective R&D appropriated from a partner is expected to be much greater than would be the case without the SRP. Of course, the more a firm invests — apart from the investment in the SRP — in appropriate absorptive capacity, the more likely it will get additional benefits from a SRP that juxtaposes its active R&D with the active R&D of others.

What is the role for public policy with regard to SRPs? Given appropriate legal infrastructure (for example, intellectual property law and antitrust law), and given appropriate technology infrastructure (for example, traceable standards of measurement maintained in national laboratories), will private incentives be sufficient to provide all socially optimal SRPs? In answer to this second question, I have three observations.

First, appropriability difficulties are not sufficient justification for public funding of SRPs. Even extreme cases of spillover of R&D investments and imitation of innovations are consistent with socially optimal innovative investment based on private incentives alone (Martin, 2000a; Scott, 1993, chapter 8). The reason, most fundamentally, is that each firm among rivalrous R&D competitors invests in anticipation of its own returns without regard to the cannibalization of the expected returns of its rivals. As long as there is a quality dimension (the expected quickness of the time of introduction, for example) to R&D output that increases with R&D investment so that the
value of R&D increases with that investment, then a monopolist of R&D will underinvest from the social standpoint. Yet rivalrous competitors “overbidding” for the innovation can offset such underinvestment, although they do so imperfectly because of a loss of optimal R&D cost structures and over-shooting or under-shooting of the socially optimal investment. Nonetheless, when appropriability difficulties are severe, public policy may well be necessary to bring about the socially optimal amount of investment.

Second, partial public funding of privately performed SRPs or joint public/private SRPs will be needed to provide socially optimal SRPs when without public support the net social economic value of the SRP is positive but the net private value is negative. Following the discussion of Figure 2, I conjecture that an important reason for private underinvestment in socially valuable SRPs in the absence of public support will be the concerns of each private partner about juxtaposing its own active R&D resources with the active R&D resources of others. Those concerns would be expected when the gain from exposure to the active R&D of others exposes the partner to a potentially greater loss from opportunistic exploitation of its own active knowledge by the other partners. As Hicks and Narin (2000) explain in the context of their observation that joint patenting is rare, “Companies . . . seem to have a positive aversion to sharing intellectual property which they only rarely overcome . . .” (p. 11). When the active science of two firms is congruent across product and innovation markets, the R&D effort of each is more useful to the other. Public support for SRPs might be appropriate, then, if there are social gains—from juxtaposing the active R&D resources of different partners operating in different technological areas—that have not been realized given private incentives alone.

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1 Link and Scott (2000a) find that the probability of a licensing agreement — a type of SRP — between two firms increases with their citations of each other’s patents, other things being the same.
2 See Baldwin and Scott (1987), chapter 2. As explained there, exceptions are possible.
3 See Scott (1993, chapters 8 and 14).
Third, the condition for public support of SRPs is more likely to be met in certain cases, including the following.

- **Infrastructure technology** (Link and Scott, 1998): Social economic value from scarce resources is increased by widespread use of nonproprietary infratechnologies.\(^6\)

- **Generic technology** (Link and Scott, forthcoming): Spillovers from generic technologies increase social value beyond the value appropriated by innovators.

- **New science requiring university partnerships with industry** (Hall, Link, and Scott, 2000): The research problems are especially difficult, and although university involvement increases the chance of success, appropriability difficulties increase as well.

- **Monitoring costs that can be reduced by a public partner** (Leyden and Link, 1999): The public partner may lessen free-riding problems.

- **Financial market imperfections that prevent private funding of socially valuable research** (Link and Scott, 2000b; Audretsch, Link, and Scott, 2000).

- **Social rather than market-based goals for research outputs** (Scott, 2000a): Minority ownership or small business involvement, for example, may be social goals that would not be met by market solutions alone.

And, following the discussion about absorptive capacity in the present paper,

- **High risk of opportunistic exploitation of each partner’s active R&D knowledge when juxtaposition of active R&D assets for the partners will provide socially valuable extension of the application of existing R&D resources.**
What data initiatives are needed with regard to SRPs? From the literature\textsuperscript{7}, we have learned that SRPs have important effects on innovative investment behavior and performance. Further, we have learned that public policy can improve the performance of SRPs in certain cases. We also have learned that the data about SRPs are limited, not systematically gathered or coordinated, and uneven in quality. The implication for data initiatives is clear. To inform public policy, the public needs an ongoing documentation and reporting of the incidence of SRPs, their types, their research inputs and research outputs.

We have many outstanding individual efforts to assemble data about SRPs. Consider for example the data sets described in Audretsch (2000), in Dodgson (2000), in Feldman (2000), in Hagedoorn (2000), in Hagedoorn, Link and Vonortas (2000), in Link and Vonortas (2000), in Sakakibara (2000), and in Siegel (2000). However, for just one example, consider how much more understanding could be developed if the remarkable data about the incidence of SRPs over time described in Hagedoorn (2000) were augmented with good measures of the inputs and the outputs of those SRPs. As the discussion in Mowery (2000) makes clear, our data are incomplete even when we have data focused on particular types of SRPs and gathered by public institutions.

Siegel (2000) has surveyed the available and the needed data and proposed practical agenda for efficiently establishing systematic data about SRPs.\textsuperscript{8} Bozeman and Dietz (2000) discuss the complexity of developing indicators of SRP activity, and Hansen (2000) explains the challenges of gathering information to create indicators. Based on

\textsuperscript{6} See Tassey (1997) for careful and complete development of the importance of infratechnologies.
\textsuperscript{7} See the references in footnote 1 for review of the pertinent literature.
\textsuperscript{8} Again, see the papers listed in footnote 1 above for additional survey material, with particular reference to the previous experience with technology innovation indicators as described by Hansen (2000) and to the general needs for technology indicators as described in National Research Council (1997). Siegel (2000) has undertaken the task of surveying the SRP data considerations quite generally.
my own first-hand experience, I add only an emphasis on the need for development of our available measures of research outputs. Multiple measures, each reflecting the particular circumstances of a type of SRP, are useful and appropriate.

I shall give four examples. First, when evaluating SRPs with significant public performance in partnership with industry, benefits can be quantified by asking what would have been the cost to the private sector to accomplish the same thing (or as near as possible absent the government with its unique resources, and with the shortfall measured as well) without the government as a research partner. The costs avoided (and any outcome shortfall costs) are the benefits from the public’s investment in the projects (Link and Scott, 1998) — benefits that are then used to compute social rates of return to the public’s investments in technology innovation.

Second, when the public does not perform research, but instead provides funding for privately performed research, to our measures of actual post-investment outcomes, we can add the expected rate of return at the start of the research project. Both the expected social and private returns can be estimated (Link and Scott, forthcoming), using an investment model and an interview technique to assess the extent of spillover effects from R&D investment. Of course, even when expected social rates of return exceed the hurdle rates (which in turn exceed the expected private rates of return without public support), many projects worthy of public support will not turn out well, while a select few will have extraordinarily high returns.

Output measures may of course extend beyond formal measures of the social and private rates of return from innovative investment. Useful measures may tabulate the incidence of research outcomes that are correlated with social value. Further, the tabulation may be an estimate based on readily available data. For a third example, then,
I use the method in Link and Scott (2000a) which estimates the probability of a licensing agreement occurring between a pair of firms in specified industries. Systematic measures of the incidence of licensing agreements, an important means of technology transfer, are not available, and the method allows estimation of the incidence of licensing in the various technology areas by using readily available data about the patent portfolios of firms.

Finally, for a fourth example, research output measures based on total factor productivity can usefully measure the total factor productivity for groups of technologically close industries in addition to the traditional approach of measuring the total factor productivity for the individual industries. The effect of R&D on total factor productivity growth—the rate of return to R&D investment in the context of the model of productivity growth—is both larger and more significant statistically when the relation between R&D and total factor productivity growth is estimated across groups of industries with strong complementarities in R&D activity (Scott, 1993, pp. 128-131).

The foregoing examples from my own experience are of course a very small subset of the many types of SRPs and the many types of output measures that have been described or proposed. Our collective assessment of the literature and evidence about SRPs yields a clear answer to the third question. We need to develop systematic tracking of the incidence of the various types of SRPs, their research inputs, and their research outputs. Further, we need to develop a large number of measures of the research outputs of SRPs in order to capture and document their social benefits.
References


Figure 1. Absorptive Capacity for an R&D Performing Firm
Table 1. Incidence Rate Ratios for Citations Given Insignificant versus Significant Congruence of Product and Innovation Market Operations*

| Variable     | IRR   | Standard error | z      | Prob>|z| | 95% confidence interval |
|--------------|-------|----------------|--------|-------|------------------------|
| Prob(>Gprod) | 0.2168| 0.03874        | -8.555 | 0.000 | 0.1527 to 0.3077       |
| Prob(>Gpat)  | 0.1067| 0.03919        | -6.090 | 0.000 | 0.05190 to 0.2192      |

*Source: Scott (in Advances in Strategic Management, Vol. 18, forthcoming), available as Dartmouth College Working Paper 00-14, August 2000, at http://www.dartmouth.edu and then follow the links to teaching & research, social sciences, economics, and finally working papers. Details of the estimation are provided there.

Notes: The variable Prob(>Gprod) is the probability of a greater number of product market meetings (Gprod) for the citing and the cited firms given the null hypothesis of random diversification. Prob(>Gpat) is the probability of a greater number of meetings (Gpat) in the “innovation markets” — the categories to which patents are allocated. The z statistic is for the underlying coefficient in the negative binomial model. The IRR shows the estimated coefficient transformed to an incidence rate ratio. The standard error and the confidence interval shown here are appropriately transformed as well.
Figure 2. Effective R&D Resources Applied in R&D Investment*

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<td>SRP</td>
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*Here $x_i$ denotes the $i$th firm’s R&D investment and the functions $f(x_j)$ and $g(x_j)$ denote the portion of R&D effort by firm $j$ (possibly in another area of research although that need not be the case) that is appropriated by firm $i$ for use in firm $i$’s technology area in the absence of a SRP. The effect of the greater amount of resources and of their different types would be observed in the function linking inputs to the uncertain innovative outputs. That function might change given the SRP. Further, the SRP might find it optimal to change the amounts of resources $x_i$. The principal effect emphasized here is, however, the greater amount of R&D resources joined with active research in a given technology area and the resulting expectation that the functions $F$ and $G$ reflect greater effective cross-firm investments than $f$ and $g$ respectively.