

The National Cooperative Research and Production Act
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Abstract: This chapter examines the National Cooperative Research and Production Act (NCRPA) – the 1993 successor to the National Cooperative Research Act (NCRA) of 1984 that reduced the potential antitrust liabilities for research joint ventures (RJVs). The chapter reviews the theory and evidence about RJVs and the NCRPA and then addresses the question of whether there is a need for the relatively new antitrust law embodied in the statute. The review explains the controversial possibility that the NCRPA provides unnecessary, and perhaps even too much, protection from antitrust litigation.

I. Introduction

The National Cooperative Research and Production Act (NCRPA) of 1993 amended the National Cooperative Research Act (NCRA) of 1984 that reduced the potential antitrust liabilities for research joint ventures (RJVs). The NCRPA extended the coverage of the NCRA to production as well as research joint ventures.¹ Scholars have yet to address whether the Act provides unnecessary or even too much protection from antitrust litigation. The issue is important because, as explained in this chapter, the Act may stimulate cooperative ventures that reduce socially desirable competitive pressures for industrial research.

The joint ventures filed under the NCRPA have generally been RJVs. The exceptions are those ventures filed under the Standards Development Organization

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¹ The NCRPA was enacted as Public Law 103-42, 107 Stat. 117 (1993), 15 U.S.C. §§ 4301-4306. It amended the original NCRA that was enacted as Public Law 98-462, 98 Stat. 1815 (1984). The NCRPA was further amended by the Standards Development Organization Advancement Act of 2004 – Public Law 108-237, 118 Stat. 663 (2004) – that added, to the joint ventures covered by the NCRPA, the standards development activity of standards development organizations.

Advancement Act (SDOAA) of 2004 that amended the NCRPA.² Theory and evidence about the NCRA and the NCRPA have focused on the RJVs. After the 2004 amendment, the DOJ issued an update of its description of the NCRPA and the notification filing procedure.³

The NCRPA mandates a “rule of reason” standard when joint ventures are challenged under the antitrust laws, stating in 15 U.S.C. § 4302:

In any action under the antitrust laws, or under any State law similar to the antitrust laws, the conduct of – (1) any person in making or performing a contract to carry out a joint venture, or (2) a standards development organization while engaged in a standards development activity, shall not be deemed illegal per se; such conduct shall be judged on the basis of its reasonableness, taking into account all relevant factors affecting competition, including, but not limited to, effects on competition in properly defined, relevant research, development, product, process, and service markets. For the purpose of determining a properly defined, relevant market, worldwide capacity shall be considered to the extent that it may be appropriate in the circumstances.

In *Antitrust Guidelines for Collaborations Among Competitors*, issued jointly by the Federal Trade Commission (FTC) and the Department of Justice (DOJ) in April 2000, the enforcement agencies provide an informative discussion of the distinction between “per se” analysis and “rule of reason” analysis in the context of cooperative activity among competitors.⁴ It is important to remember that “rule of reason” analyses take different

² Albert N. Link, who created and maintains the Cooperative Research (CORE) database for the National Science Foundation, provided the assessment in personal correspondence, July 27, 2005, using the CORE database as described in Link (2005).

³ See “NCRPA Update for June 2004” and “Filing a Notification Under the NCRA (06/1004)” at <http://www.usdoj.gov/atr/public/guidelines/guidelin.htm>.

⁴ Importantly, the discussion in the *Antitrust Guidelines for Collaborations Among Competitors*, at <http://www.ftc.gov/os/2000/04/ftcdojguidelines.pdf>, explains how the enforcement agencies view the different analyses in the context of Supreme Court precedent and their own guidelines. The agencies explain how they distinguish cases to be considered as collaborations – for example, a research joint venture – rather than as mergers.

forms with different types of behavior and in the interpretation and application of different antitrust laws.

To be covered by the NCRPA, the law requires (§ 4305) that a joint venture file with the DOJ and the FTC a written notification identifying the parties to the venture and stating the venture's nature and objectives. Standards development organizations must file the name and place of business of the organization and state the nature and scope of the standards activity. The Act, in § 4305, further specifies that the DOJ or the FTC will publish in the *Federal Register* the information about a venture's participants and its objectives. Should subsequent antitrust litigation establish a liability for the venture, § 4303 specifies details about the recovery of damages by a prevailing claimant, limiting the recovery of damages to actual damages rather than treble damages when the claim under the antitrust laws results from conduct within the scope of the notification filed. In § 4304 details about the award of costs, including possible recovery of attorneys' fees, are specified. In § 4306, the law requires that principal production facilities be in the United States and that controlling parties be U. S. persons or, if foreign, from countries with antitrust laws accommodating U. S. persons appropriately.⁵

Cooperative research can take many forms. The NCRPA specifies in § 4301 the meaning of "joint venture" as covered in the Act. The definition is broad, covering cooperative efforts in R&D, production, application for patents, granting licenses for the venture's results, and the management quite generally of the proprietary interests of the venture. A list of activities not covered by the term "joint venture" is provided as well; those things include the exchange of information – for example, about prices or sales or

⁵ In "NCRPA Update for June 2004" at <http://www.usdoj.gov/atr/public/guidelines/guidelin.htm>, the DOJ discusses what the appropriate treatment by foreign laws entails.

profits – not reasonably required to carry out the venture’s purposes, or agreeing to restrict the sale of products, processes, or services not developed through or produced by the venture. In the economics literature, the definitions of various types of research joint ventures complement the definition provided in the NCRPA. Hagedoorn, Link, and Vonortas (2000) provide a taxonomy of research partnerships; Hagedoorn (2001) provides useful definitions and categorizations of cooperative research and documents major trends and patterns worldwide. Link (2005) describes the actual NCRPA joint ventures through 2003. Through calendar year 2004, 935 research ventures had filed under the NCRPA.⁶

There are many reasons and much evidence to support the expectation that RJVs promote productivity and social economic welfare. Yet, surprisingly, there is no strong evidence to suggest that the promotion of such economic benefits requires the relatively new antitrust law embodied in the NCRPA. Section II will review the historical origins of the Act. Section III assesses the usefulness – for NCRPA evaluation – of theoretical and empirical evidence about RJVs. Then, Section IV contrasts evidence about the original NCRA RJVs with evidence about RJVs more generally, emphasizing the possibility that the ventures covered under the NCRPA may have a significant downside. Section V then concludes by addressing the question of whether there is any real need for the NCRPA.

II. Historical Origins of the NCRPA

⁶ In 2004, there were 226 ventures filed, but 204 of them were under SDOAA and were not strictly research ventures. (Albert N. Link, personal correspondence, August 8, 2005, using the CORE database.)

Early statements about the historical background of the NCRA that led to the current NCRPA, along with assessments of its likely impact, are provided by Link and Bauer (1989) and Scott (1988, 1989). Assessments after the NCRPA amendments in 1993 are provided in Link (1996) and then again in Link (2005) after the amendments in 2004. Link and Scott (2005) emphasize the historical context in which the NCRA was born – namely, the concern that U.S. industry was losing its competitive advantage in global markets. The NCRA was part of the early 1980s response to the productivity slowdown of the 1970s. However, as explained in Link and Scott (2003), the NCRA was just one policy among several technology initiatives.

These policies included, in chronological order, the Bayh-Dole Act of 1980 which reformed federal patent policy by providing increased incentives for the diffusion of federally-funded innovation results; the research and experimentation (R&E) tax credit of 1981 which underwrote, through tax credits, the internal cost of increases in R&E in firms; and the National Cooperative Research Act of 1984 which encouraged the formation of research joint ventures, as well as numerous state policies that coincided with the adoption of science parks. These technology policies, and others, were a public sector reaction to both the productivity growth slowdown that began in the early 1970s and to the associated precipitous decrease in the competitive position of many U.S. technology-based industries. (Link and Scott, 2003, pp. 1333-1334)

III. Theoretical and Empirical Literatures and Evaluation of the NCRPA

Large theoretical and empirical literatures address the performance of cooperative research. Soon after the passage of the NCRA, thoughtful articles – for prominent examples, Katz (1986) and Katz and Ordover (1990) – appeared and developed understanding about the economic performance implications of research joint ventures. Combs and Link (2003) and Martin (2003) examine that literature with the goal of evaluating the performance of cooperative research endeavors and understanding how

public policy can be used to support their performance. Combs and Link (2003, p. 181) review many prominent theoretical analyses about research partnerships and observe that the industrial organization literature reaches differing conclusions that depend upon the specific modeling assumptions.⁷ They cite Vonortas (1997, p. 77) who observes “It is improbable that the one-fits-all theoretical exercise will be built anytime soon.”

Martin (2003, pp. 159-160) observes how specialized the literature is, explaining, for example, how one of the seminal papers – d’Aspremont and Jacquemin (1988) – on which much of the theoretical work about RJVs has been built is really too specialized to be useful in addressing the questions about appropriate public support for research joint ventures. He observes that important alternative approaches – such as the model of Kamien, Muller, and Zang (1992) – are limited in important ways as well. He concludes that for much of the recent theoretical literature about R&D cooperation, the “theoretical research . . . is a largely self-contained activity, firmly insulated from the vagaries of evidence about the subjects it analyzes” (Martin, 2003, p. 159). Because the theory is oriented toward special cases, he decides (Martin, 2003, p. 162) “to examine selected portions of the empirical literature for regularities that might appear and offer some insight into possibilities for measuring the impact of public support on technological performance.”

Indeed, in addition to the large theoretical literature, there is a large empirical literature that examines cooperative research. Siegel (2003) reviews 47 of these studies –

⁷ See, for example, the careful analysis of Yi (1996) where the effect of R&D cooperation on R&D spending and on social economic surplus differs depending on whether the spillovers in research (the R&D investments of its rivals make a firm’s own R&D investments more effective) are high or low or something in between. Further, the results depend on the elasticity of the slope of the inverse demand function. Finally, the entire analysis is focused not only on cost-reducing R&D investments, but is additionally focused on those investments in the context of Cournot oligopoly. See also Yi’s references for other prominent and careful studies that illustrate the general point, being made by Combs and Link (2003) and Martin (2003), about the specialization of the literature.

many of them using data sets based on the NCRA and NCRPA filings – to develop understanding of the data that would be needed to obtain accurate assessments of the effects of the cooperative research on private and social returns. That perspective is especially helpful for the purposes of evaluating what the studies have told us about the effects of RJVs on economic performance – key knowledge to bring to the discussion of the importance and efficacy of the NCRPA. Siegel (2003, p. 207) observes a dramatic increase in the numbers of research partnerships during the last two decades, and he specifically mentions the “relaxation of antitrust enforcement related to collaborative research” as a potential contributor to the observed growth in cooperative research. He concludes that despite the many partnerships to study and the large number of studies available for his review, the evaluation of the impact of the cooperative research on economic performance is difficult because of the limitations of the data available to researchers. He observes (Siegel, 2003, p. 207) that the lack of appropriate data is unfortunate because the assessment of policy initiatives such as the NCRPA “ultimately depends on our ability to derive accurate estimates of the private and social returns” to the cooperative research.⁸

It will of course be difficult to develop the accurate estimates that Siegel recommends. Martin (2003) turned to the empirical literature to look for the regularities that could help gauge the impact of public policy toward cooperative research. Yet, in

⁸ Of course, researchers have made assessments of the private and social return to cooperative research. Link and Bauer (1989) use interviews as well as data for total factor productivity and R&D investment with and without cooperative activity. Their estimation (p. 89) shows much higher rates of return to the R&D from firms with cooperative R&D as compared to firms without such activity. In conjunction with the findings from their interviews with industry as well as other data and a priori reasoning, they interpret their findings as showing that the private and social benefit of cooperative R&D is to increase the efficiency of private R&D. Link and Scott (2001) estimate private and social rates of return for some of the research ventures supported in part by the Advanced Technology Program at the National Institute of Standards and Technology. They find both private and social benefits from the cooperative activity because it generates socially valuable spillovers of knowledge.

the end (Martin, 2003, p. 171), he has a “litany of limitations” with the empirical evaluations. He emphasizes that he does not recommend abandoning the evaluation of the public policies, but rather wants to point up the results of the empirical evaluations are imperfect and should be used with appropriate caution. The challenges and the limitations are not surprising. As Martin (2003, p. 169) observes:

The purist approach to measuring the impact of strategic alliances on sectorial performance would be to specify and estimate a complete (demand-side and supply-side) structural model, allowing for firm-specific rates of technical progress and allowing those rates to depend on explanatory variables measuring both the firm’s own participation in strategic alliances and on the sector-average frequency of strategic alliances. The data requirements to carry out such a study would be severe.

Martin then continues, explaining further the severity of the data requirements.

On the whole, then, the expert reviews of both the theoretical and the empirical literature imply that the literature does not provide a conclusive answer to the question of whether or not the antitrust law enacted in the NCRPA is needed to promote the desirable performance of cooperative ventures doing research and development, production, or standards development. The present essay will not change that expert opinion made in the context of evaluating our knowledge of the measured impacts on performance of strategic research partnerships. However, by changing the context and posing differently the questions, we may make progress in the evaluation of the NCRPA.

Regarding the large theoretical literature assessing the impact of research joint ventures, the literature is so large yet so focused on special circumstances – allowing modeling of effects of a cooperative research venture on static and dynamic efficiency – that it is easy to miss the obvious question of interest when evaluating the NCRPA. That

obvious question is: Granted that there will be various efficiency reasons for a cooperative venture, what of value is lost because of the research cooperation? The obvious answer is that some competitive pressure in R&D investment will typically be lost. Then, what are the implications of that lost competitive pressure for R&D performance? In my opinion, an astigmatic look (that is, looking for the big picture without getting lost in details that are arguably unimportant) at the complete literature that has evolved since Scherer's seminal work (1965, 1967a, 1967b) does yield a conclusion about the broad implications for industrial R&D investment of lessening competitive pressure through prominent cooperative research ventures combining significant proportions of the R&D-doing firms in a given area of industrial research. The conclusion is that for a broad range of circumstances there would be less R&D investment as competitive pressure is lessened; and, further, *socially valuable* R&D investment is lessened. That broad view of the efficacy of competition as a stimulus to socially valuable innovative investment is consonant with the broad idea that antitrust law, by promoting competition, engenders, among other things, good economic performance.

In the view that Scherer (1965, 1967a, 1967b) introduced, greater competition is accompanied by greater R&D investment until the point when anticipated competitive erosion – from imitators or competing innovations, patented or not – of post-innovation profits is severe enough to cause some firms to avoid R&D altogether. Thus, from Scherer's theoretical and empirical insights, an inverted-U relation between R&D intensity (typically measured as R&D to sales) and the extent of competition (typically measured inversely by seller concentration) was anticipated, although from the outset

Scherer observed that the relation would be less important for R&D investment than differences in opportunities for R&D across the different industrial settings.⁹ Baldwin and Scott (1987) review Scherer's work in the context of the literature that it spawned, and Martin (2002a) provides further review and development of the literature.

Scherer's conjecture about the typical impact of competition on R&D investment holds up under a variety of models given sensible settings for the industrial environment. The results hold not only for the case – as explicated in Scherer's (1970, pp. 366-370) classic text – where individual firms respond to various degrees of exogenous competitive pressure. As well, Scherer's conjecture – that up to a point increased competition will result in an increase in a market's overall R&D investment – can be seen to hold for reasonable parameterizations of the Nash noncooperative free-entry equilibrium model of Loury (1979) as developed by Lee and Wilde (1980). Scott (1993, chapter 8) parameterizes their model and simulates the free-entry Nash noncooperative equilibrium, and essentially Scherer's vision emerges for the results. The example is of course just one parameterization of the general problem modeled, but nonetheless is a plausible example – one of countless specific examples that conform to the basic conditions of technological and market uncertainty, economies of scale and scope, and incomplete appropriation of returns. Thus, the problem illustrated (Scott, 1993, pp. 111-112):

. . . is a general problem that could reasonably be expected to plague many cooperative R&D ventures. The basic conditions create situations in which society would prefer only one firm or an industrywide cooperative venture if only the single decision-making

⁹ Empirical evidence supporting Scherer's insights and observations has accumulated over the years. Evidence suggests both the presence of the "inverted-U" relation and also the attenuation of the relation given controls for differences in the opportunity for R&D. See Scott (1984; 1993, chapters 7 and 10) and Levin, Cohen, and Mowery (1985).

entity would choose the socially optimal values for the number of R&D trials and the periodic expenditure for each. However, the monopolist or industrywide cooperative venture chooses to underinvest in R&D, and, because of that choice, free-entry noncooperative rivalry produces an R&D expenditure pattern that results in better R&D performance from society's standpoint.

In sum, for a world of incomplete appropriability and uncertainty, a monopolist may do too little R&D, while competition may result in roughly the right amount of R&D, with the noncooperative individual firms collectively providing socially valuable parallel R&D paths in the sense of Nelson (1961, 1982). An individual firm is discouraged from doing R&D by the prospect that other firms may get much of the return, but the concern that a competitor will be the first to introduce an innovation is a stimulus to do R&D. To the extent that R&D joint ventures allow monopoly-like coordination of R&D, one can conclude that R&D joint ventures protected by the NCRPA may decrease socially desirable R&D spending.

Competition implies diversity in R&D efforts, and joint ventures may undermine some of the benefits of diversity. One benefit is simply the parallel paths of multiple trials in the context of uncertainty.¹⁰ The parallel paths are "identical R&D trials" yet because of the uncertainty about their outcomes the duplication is not necessarily wasteful. Just as we could flip additional "identical" coins, yet improve the probability that at least one of them has the favorable outcome, additional R&D trials can improve the probability of success on at least one. If the social value of innovation exceeds the

¹⁰ Of course, in any particular venture, the diversity may not be lost. Link *et al.* (1996, pp. 749-750) report that the semiconductor firms participating in SEMATECH would independently pursue parallel research paths in search of a technological breakthrough. Member firms conducted their own parallel R&D in case the cooperative research approach was not technically successful. Thus, even with cooperative R&D, there remained diversity. Link *et al.* (1996, p. 750) observe that the behavior "is not surprising because, while SEMATECH's research is at the generic end of the research spectrum, the member companies are still competing with each other in terms of new and improved market projects."

private value, a joint venture weighing the marginal benefit and marginal cost for an additional trial might stop short of the socially optimal number of trials, while noncooperative rivalry might get closer to the socially optimal number of trials. As Martin (2003, p. 161) observes with citations to several articles: “A frequent justification for promoting R&D cooperation is that it eliminates ‘wasteful duplication’. This justification should by now be thoroughly discredited. It fails both theoretically and empirically.”

Another aspect of benefits from a diversity of research efforts follows because appropriability problems may be accentuated when there are multi-industry applications of research outputs. Scott (1989) observes, because of spillovers to consumers and other firms, the ratio of net social value to net private value of innovative investment is expected to increase as the multi-industry nature – that is, the extent – of the innovation increases. More areas of technology are involved and the possibilities for applications other than those controlled by the investing firm increase. The proportion of returns to R&D that are not appropriated by the firm doing the R&D are expected to increase as the multi-industry span of the innovation increases. Then, one can show (Scott, 1989, p. 76) that at the monopolist’s optimal extent of innovation, the extent of innovation is less than socially optimal. Conversely, at the socially optimal extent of innovation, the monopolist considers the extent of innovation to be greater than optimal. We expect that a monopolist will do too little investment in innovations spanning multiple industries. As pointed up in the discussion below, the cooperative research protected by the original NCRA combined R&D across industries in ways similar to the previously existing diversified R&D of individual firms. NCRA consortia combined R&D efforts that

spanned sets of industries; and, further, those sets had been combined previously by individual firms investing on their own.

Such consortia then could be improving private returns to R&D by eliminating competition that is socially optimal. Competition can stimulate firms to undertake strategies increasing the expected multi-industry span – the extent – of innovation toward socially desirable levels that would not be reached in the absence of competition. Whether the concern is for the optimal extent of innovation, or simply for the optimal expenditure on an innovation particular to a given industry, given that even a consortia would be unable to appropriate all of the returns to its innovative investment, the overbidding (from the private perspective of the firms) of competitors can move R&D investment toward the social optimum. Whether or not it does depends on the extent to which competition entails truly wasteful, duplicative efforts (rather than optimal multiple trials in the context of uncertainty) and the extent to which competition erodes the competitors' appropriation of returns. (Scott, 1989, pp. 76-77)

Additionally, the rivalry of numerous competitors may cause those competitors to establish unique research strategies. The competitors would pursue different variations of the same general type of innovation, and the competitors would use different methods of search. Considering that possibility, Scott (1991; 1993, chapter 11) posits that greater structural competition is associated with a larger number of sellers, each of which is monopoly-like in the sense that each has a unique R&D strategy. The evidence presented in support of the hypothesis shows firm effects in R&D strategies and a correlation between structural competition and the significance of monopoly-like distinctions among sellers in their R&D activity. The diversity in the R&D strategies that is created by R&D competitors can be socially beneficial, just as product differentiation by monopolistically competitive firms can create social benefits.

With a theoretical vision of the benefits of competitive R&D pressure, we turn next to the evidence. Regarding the complications encountered with the empirical

literature as observed by Siegel (2003) and Martin (2003), I recommend asking a different question for the purpose of evaluating the specific policy of the NCRPA. Rather than trying to evaluate the performance implications of RJVs directly – as Martin (2003) has explained the task is extraordinarily demanding and fraught with imperfections in any actual application – instead ask if there are marked differences in the circumstances where NCRA or NCRPA RJVs occur as compared with the circumstances for cooperative research ventures more generally. If there are such differences, then we can think about what the differences tell us about the NCRPA policy.

IV. Are NCRPA RJVs Different from Other RJVs?

Literature reviews such as those provided by Combs and Link (2003) and Hagedoorn, Link, and Vonortas (2000) have developed a lengthy list of the many possible efficiencies that can come from cooperative research, as well as a list of the complementary reasons that governments have promoted and supported research partnerships. Among other things, Hagedoorn, Link, and Vonortas (2000, pp. 582-583) observe that RJVs can reduce transactions costs, broaden the scope of research, create efficient networks, combine complementary resources, internalize spillovers of knowledge and increase the appropriation of the value of research, lower costs, and pool risks. They observe (p. 583) that governments have encouraged RJVs to correct market failures that would cause underinvestment in R&D, believing that RJVs could speed up technological innovation and increase the exchange of technological information among firms, universities, and public research institutes. Nonetheless, after their review of the literature, they conclude (p. 583):

Theory clearly warns public authorities, technology policy authorities in particular, to be cautious and to be aware of the downside effects associated with collaboration. With all their benefits, partnerships have the negative potential to block competition and create various kinds of static and dynamic monopolies (in existing and future markets, respectively).

Given the difficulties that Martin (2003) and Siegel (2003) have identified for measurement of RJV performance, many empirical studies have used indirect evidence of the efficiencies created by RJVs. Brod and Link (2001, p. 107) suggest alternatives for “direct and encompassing evaluation of the success of the NCRA,” but then observe “requisite data for such analyses are certainly not available in the public domain, and have not been reported in the survey-based literature as reviewed by Hagedoorn, Link, and Vonortas (2000).” For their own contribution, Brod and Link (2001) provide indirect evidence by observing factors correlated with the trend in NCRA and NCRPA RJVs through time, interpreting their results as showing that firms rely on cooperative research as a substitute for internal research, rely on cooperative research more during downturns in the economy and corporate investment, and are more likely to file during periods when antitrust enforcement activity is more aggressive as measured by a count through time of *Wall Street Journal* articles related to joint venture and antitrust issues. The finding about the effect of their measure of an aggressive legal environment on NCRPA filings certainly supports the belief that the NCRA and then the NCRPA made necessary modifications in the antitrust laws to mitigate the concerns of firms about potential antitrust litigation against their joint ventures. Other examples of the indirect approach to evaluating NCRPA ventures include Hall, Link, and Scott (2003), who find evidence of the efficiency enhancing role of universities cooperating with industry in joint ventures

funded in part by the Advanced Technology Program and filed under the NCRPA. Link and Scott (2005) then use the complete set of NCRA and NCRPA filings to develop understanding of the efficiency effects of university participation in the RJVs.

Certainly, looking at research ventures in general, there are many reasons to expect them to promote efficiency. Perhaps at the heart of the social benefits from cooperative research is the importance of what the literature, following Cohen and Levinthal (1989), has called investment in absorptive capacity. Absorptive capacity is the ability to learn from other firms including research partners. Research partnerships are alternatives to in-house R&D as sources of absorptive capacity. In effect, the cooperative venture makes the absorptive capacity from the in-house R&D of the firm's partner available to the firm, thereby expanding the firm's own absorptive capacity. Together the research partners are better able to learn from others and develop successful innovations. Martin (2002b) models noncooperative equilibria, with various forms of cooperative research, taking into account the need to invest in absorptive capacity and the effects of spillovers in R&D and the appropriability difficulties because of imitation of innovation. Scott (2003a) hypothesizes that absorptive capacity is a key to understanding the social gains from cooperative research. The hypothesis is supported by juxtaposing the multimarket contact of firms with their patents' cross-citations to provide a test of the absorptive capacity hypothesis in general and an indirect test of the hypothesis that research partnerships expand absorptive capacity.

In a different study examining primary data for a specific type of environmental R&D in U.S. manufacturing, Scott (2005, pp. 119-123) finds companies that cooperate with other firms in such R&D have – with other variables set at their means for the

typical firm with the environmental R&D – 127 percent more environmental R&D than firms that do not have such cooperative activity. Further, juxtaposing the evidence from models of the probability that a company will have cooperative R&D with the evidence of significantly greater R&D when cooperative R&D is present, Scott (2003b, pp. 103-112) finds evidence to support the claim that cooperative environmental R&D promotes efficiency:

Cooperative activity is especially likely for companies with low to moderate research intensity, for companies facing difficult appropriability conditions, and for companies facing great risks. . . . Further, there is no evidence that seller concentration has a strong effect on the probability of cooperation one way or the other. . . . Companies in the highly concentrated industries tend to spend more on environmental R&D And the companies in cooperative ventures spend more on environmental R&D, other things being the same. In all, the facts support the conventional views of efficiency from cooperation and do not suggest that cooperation is being used as a way to lessen environmental R&D by avoiding competition. . . . Companies appear to be cooperating to realize efficiencies in some broad sense, and there is no indication that the cooperation eliminates desirable competition. (Scott, 2003b, pp. 110-111)

However, my studies supporting the efficiency interpretations of cooperative activity were not only for a particular type of environmental R&D, they were for all cooperative emissions-reducing activity of the responding companies. As Hagedoorn (2001) emphasizes, cooperative research activity takes many forms. And as Hagedoorn, Link, and Vonortas (2000) emphasize and the simulations in Scott (1993) illustrate, some cooperative ventures have the potential to block desirable competition. If one looks at NCRPA ventures, rather than cooperative activity for a particular type of environmental R&D, a different view of the likely effects of the ventures protected by the NCRPA could emerge.

Indeed, looking at the first year and a half of filings under the NCRA, Scott (1988) finds evidence supporting the concern that the Act protects cooperative projects that reduce the net social benefit of R&D investment. First, the NCRA cooperative ventures were not predominately in unconcentrated industries where joint ventures would arguably be needed to overcome fragmentation of R&D effort. The industries where cooperative projects occurred were significantly more concentrated than those without NCRA activity. As Katz and Ordover (1990, p. 172) have observed, the firms in concentrated industries may perceive that their antitrust risks are higher; and therefore, those firms are more likely to register their ventures under the NCRPA. Second, the NCRA cooperative activity was not predominately in industries with lower productivity growth where joint ventures would arguably be needed to improve productivity. The industries where cooperative projects occurred had significantly higher productivity growth than industries without NCRA R&D. Third, NCRA cooperative ventures were not predominantly in industries where firms lacked appropriability advantages from purposive diversification to offset potential appropriability problems caused by competition in R&D. Quite the opposite was true; NCRA joint ventures were significantly more likely to be found in industry categories where there was purposive R&D diversification. Fourth, the NCRA joint ventures did not occur predominately in industries where company-financed R&D intensity had been low and where extra stimulus was arguably needed to get innovative investment. Instead, industries with NCRA activity had significantly higher R&D intensity than industries without NCRA R&D. Fifth, Levin *et al.* (1984) measures of appropriability were never significantly different for industries with cooperative R&D as compared with the remaining industries.

Hence, the evidence does not suggest that the cooperative R&D is in industries where there have been appropriability problems.¹¹ Sixth, to an extraordinary extent, the cooperative ventures protected by the NCRA combined R&D in the same industries that diversified firms combined individually. Multi-industry research coalitions were arguably a substitute for multi-industry firms exploiting R&D spillovers.

In all, then, for the ventures filing under the NCRA, I concluded (Scott, 1988, p. 183):

What we are seeing with the NCRA co-operative R&D appears to be very similar to diversification behavior except that some competition is eliminated. The co-operative R&D protected by the NCRA has occurred in industries that were, during the 1970s, concentrated, with higher productivity growth and having R&D activities purposively combined by diversified firms with R&D in other industries. Also, co-operative R&D has not been more prevalent in those industries for which Levin *et al.* (1984) found appropriability difficulties, and therefore the act does not appear to be fostering R&D where competing firms dared not invest because of appropriability problems. Further, co-operative R&D appears to be more likely in industries where diversified firms were already investing relatively heavily, and to be less likely in those industries where they had low R&D intensity. Finally, broad areas of R&D investment combined by the co-operative R&D projects protected by the NCRA in the mid-1980s parallel closely the areas combined by the diversified firms of the mid-1970s. It is then plausible that the NCRA will stimulate cooperative projects that . . . reduce the net social benefit of R&D investment.

V. Conclusions

When the participants in a NCRPA joint venture are pursuing innovations or standards development, it is perhaps difficult to understand why there is a need to have the law. Even for joint ventures that are purely production ventures, given the way the law carefully excludes certain types of behavior from coverage of the law, the NCRPA

¹¹ However, Katz and Ordover (1990, pp. 172-173) have an insightful argument suggesting that the Levin *et al.* (1984) appropriability measure may not be the one we want here. Scott (1993, pp. 180-181) discusses the Katz and Ordover observations which, among other things, support the expectation that environmental R&D would be an area of industrial research where cooperative ventures would promote efficiency. That expectation of Katz and Ordover turns out to be something that I was able to support with evidence many years later in Scott (1996, 2003b).

seems superfluous. Certainly, even without the NCRPA, one would expect any antitrust litigation prompted by the behavior of a venture – of the type covered and for behavior covered by the notification procedure – to be considered with a rule of reason or an analogous treatment depending on the procedural posture of the case. The NCRPA specifically excludes from its coverage the types of behavior, such as sharing information and making agreements about things not related to the venture, that might prompt *per se* cases where the courts would consider the behavior, in and of itself, to have violated antitrust law.

In § 4301, the statute clearly specifies behavior that is excluded from the definition of “joint venture” for purposes of the NCRPA. The excluded activities are the exchange of information about prices, sales, profits, marketing, and distribution when the exchange is not needed for the success of the venture, or restrictions on the other R&D behavior of the venture’s participants when such restrictions do not have to do with avoiding the misappropriation of the intellectual property developed in the venture, or entering into an agreement to allocate a market with a competitor, and so forth. Thus, the behavior excluded from the NCRPA’s coverage is behavior that if challenged by antitrust enforcement actions would be considered by the courts for *per se* treatment. In all, the behavior to which the NCRPA protections are extended is behavior that would ordinarily be subjected to rule of reason or analogous analysis even without the law, while behavior that is explicitly not covered by the NCRPA is the type of activity that would be eligible for *per se* treatment by the courts.

Further, although one would expect the activities covered by the NCRPA to be subject, even without the act, to rule of reason or analogous analysis if an antitrust case were brought, such cases may be unlikely. As Martin (2003, p. 161) observes for RJVs:

One of the motivations often cited for the US National Cooperative Research Act of 1984 is that it served to reduce business-sector anxiety about possible antitrust liabilities incurred because of participation in R&D joint ventures. It is difficult to know upon what such anxiety might have been based. The European Union has always had a positive attitude toward R&D cooperation. US antitrust, to the best of my knowledge, records one antitrust case involving an R&D joint venture.

Interestingly, that one case that Martin cites involved the government's theory that automobile manufacturers had used their R&D joint venture to slow the development of emission control equipment to improve the environmental performance of automobiles.¹² Ironically, that sort of research is precisely the type of research where my survey of all of manufacturing industry in the 1990s suggests a very positive role for cooperative research projects.¹³

For joint ventures that are purely production ventures, as contrasted with those where the firms in the RJV cooperate in the production of products or services using the venture's research results, under the NCRPA, antitrust litigation using the Sherman Act would also use rule of reason analysis for the activities covered by the NCRPA and not explicitly excluded in § 4301. In *Antitrust Guidelines for Collaborations Among*

¹² The case cited by Martin (2003, p. 173) is: *United States v. Automobile Manufacturers Association*, Civil Action No. 69-75-JWC, United States District Court for the Central District of California, 1969 Trade Cases (CCH) P 72,907 (consent decree), October 29, 1969, modified in *United States v. Motor Vehicle Manufacturers Association of the United States, Inc.*, No. CV 69-75-JWC, United States District Court, Central District of California, 1982-3 Trade Cases (CCH) P 65,175, October 28, 1982.

¹³ As pointed up in Scott (2003b, p. 112), the stark contrast of the automobile case with my characterization of 1990s U.S. environmental R&D as efficiency enhancing on the whole was observed by F. M. Scherer. On reading an earlier version of the material, he observed (personal correspondence) that my finding contrasts with the earlier U.S. evidence as recorded in the U.S. Congressional Record (May 18, 1971, p. H4063) that the automobile industry used cooperative R&D to delay environmental improvements.

Competitors, the DOJ and the FTC explain that the NCRPA mandates rule of reason analysis for collaborative production covered by the Act, but specifically excludes types of collaborative behavior that would be considered *per se* violations of the antitrust law. Further, in their *Antitrust Guidelines for Collaborations Among Competitors*, the DOJ and the FTC explain the distinction between cooperative activity to be treated as a joint venture as contrasted with behavior to be treated as a merger.¹⁴ In cases where the behavior was considered to be a merger, the litigation using Section 7 of the Clayton Act would of course not use a *per se* approach in any case, although if the venture entailed activities clearly excluded from the NCRPA's coverage and was challenged under Section 1 of the Sherman Act, a *per se* approach would be possible.

The enforcement agencies' guidelines are quite clear that there will be thoughtful consideration of the difference between a collaboration among competitors and a merger, with different standards applied to each. If the activity has the necessary permanence to be considered a merger, Section 7 of the Clayton Act would be the applicable law, and the agencies would apply their *Horizontal Merger Guidelines*. The Supreme Court's opinion in *United States v. Penn-Olin Chemical Co.*, 378 U.S. 158 (1964) illustrates the application of Section 7 of the Clayton Act to a production joint venture. The Court concluded that the joint venture to produce and sell sodium chlorate in the southeastern United States was subject to Section 7 of the Clayton Act. Further, the Court held that not only was there a need to evaluate whether *both* companies would have entered the market as individual competitors, but as well that the joint venture should be scrutinized to see if there was a reasonable probability that *either* of the competitors would have entered the market leaving the other as a potential competitor.

¹⁴ <http://www.ftc.gov/os/2000/04/ftcdojguidelines.pdf>.

By distinguishing joint ventures not covered by the Act from those for which antitrust litigation would apply a rule of reason, the NCRPA clarifies the law toward joint ventures. If the NCRPA is applied to a production joint venture, a more encompassing and complete analysis, somewhat different from the Penn-Olin analysis, would be used, since the analysis of the probability of competitive effect in a Section 7 case and the specific analysis set out by the Court in the Penn-Olin case are not strictly speaking “rule of reason” analyses. Also, at least with regard to production joint ventures (as contrasted with RJVs), the dissenting opinion in the Penn-Olin case could indeed raise concerns of antitrust litigation about joint ventures. In the sort of opinion that motivates joint ventures to express concern about antitrust liabilities, a dissenting opinion in the Penn-Olin case expressed the view that the joint venture was an agreement to divide a market and therefore a *per se* violation of Section 1 of the Sherman Act as well as a substantial lessening of competition within the meaning of Section 7 of the Clayton Act.

The discussion of the theory about cooperative ventures has pointed up their potential downside. It is then perhaps not surprising to find the dichotomy between the early NCRA evidence – supporting the possibility that the RJVs restrict desirable competition – and the evidence from the studies of environmental R&D – supporting expectations of efficiencies from RJVs. In any case, whether or not one interprets the evidence as support for a significant negative effect from many of the RJVs filing under the NCRPA while many RJVs more generally have a positive effect, reflection about the Act leads to the following observations.

- The stipulation for rule of reason analysis may be superfluous since for the activities covered by the Act, a rule of reason (or analogous treatment depending on the

procedural posture of the case) would be applied – weighing benefits against the possible costs of lost competition – even without the new law.

- However, substantial protection from antitrust litigation is provided by the stipulation that only single damages could be assessed if an antitrust violation were found using the rule of reason. That protection may indeed stimulate joint ventures. Further, it may also lessen a desirable impact of antitrust law – namely, the protection against treble damages may lessen desirable competition.
- Scarce resources are used by firms and the enforcement agencies to maintain the filing procedure.

Successfully weighing the costs of the filing procedure and the costs of lost competitive pressure against the benefits of the additional joint ventures that are formed is a formidable task.

Let me emphasize that I am not suggesting that government support for RJVs is not worthwhile. For the many reasons discussed in this paper, governments might find it advantageous to support cooperative research. Martin and Scott (2000) provide an analysis of ways that government can support research, and Scott (2003a, pp. 252-253) sets out the circumstances when public support for RJVs is justified and cases where the circumstances requiring public support are likely to be met. Those circumstances and cases are quite likely to be present for many socially valuable joint ventures. Where the NCRPA fits in the analysis of public support for cooperative research is (Scott, 2003a, p. 252) with the need for “appropriate legal infrastructure (for example, intellectual property law and antitrust law)”.

In my opinion, whether the NCRPA is the right policy – creating benefits from additional joint ventures without sacrificing competitive pressures with even greater benefits – must remain an open question. It is probably too facile to say the NCRPA is a benign policy. In fact, it may not be benign, because the provision for single rather than treble damages may take antitrust litigation out of the picture when a joint venture's behavior would merit the litigation but when private claimants would not bring suit given the prospect of recovering only single damages.

For example, consider the case of the automobile manufacturers delaying the development of emissions control equipment. Conceivably, in a case like that, firms that would have made sales of emissions control devices for the manufacture of the equipment would be harmed by the alleged slowing of the research and development program. Note that the slowing of the development by a research joint venture that includes an industry's major competitors is exactly what the theoretical model simulated in Scott (1993, chapter 8) predicts. Certainly a rule of reason analysis would be appropriate for such a case. But limiting potential claimants to recovery of single damages might take away the joint venture's incentive to speed the development of socially useful innovations as well as the claimants' incentive to bring an antitrust suit that had merit.

It is worth noting that as the Act is now structured, the independent firms joining in the RJV protected by the Act can effectively form a new entity to market the jointly researched and produced results protected by NCRPA. The specifications of the Act make clear the venture's ability to use patenting and licensing to control and manage the intellectual property produced by the venture. So, for example, the venture could license

the intellectual property for use by all comers, including the participants themselves, setting a royalty rate and other licensing terms that collected the profits a monopolist of the applications would achieve, and paying the royalties to the participants. Or the venture could sell the intellectual property to a new entity, with the new entity having a life of its own, and effectively follow the scenario of completely cooperative effort. Thus, the NCRPA could be considered a national cooperative research, production, marketing, and sales act *with regard to the ventures' activities covered by the NCRPA*. As the simulations in Scott (1993, 1995) show, although certainly the participants in the ventures gain, society may lose valuable competitive pressure – even when if society could make the investment decisions for the monopolist it would indeed choose a monopolist to do the research because of efficiencies of scale and scope.

Having asked and answered the obvious question of what of value is lost when a cooperative venture is formed, and recognizing that both the theory and the evidence about research joint ventures imply the importance of the efficiency enhancing aspects of cooperative research ventures, we confront a tradeoff. Evaluating the economic performance of the joint ventures will entail a tradeoff between positive aspects of the cooperation such as lowering and sharing costs and risks and the negative aspects from the lost competitive pressure. That, of course, is the usual sort of tradeoff characterizing the economics of antitrust cases using rule of reason analyses. Without the possibility of treble damages, however, claimants are unlikely to bring even the most meritorious cases.

In all, we expect that even without the NCRPA the courts would use a rule of reason – or analogous approach suited for the procedural posture of the case – to judge any alleged violation of the antitrust laws resulting from activities covered under the

NCRPA. The Act's key modification of antitrust law may be to restrict successful claimants' recovery to single damages. The reason for the Act appears to have less to do with compelling logic or evidence than with historical context within which the Reagan administration and the U.S. Congress conceived the original NCRA of 1984. As emphasized in Scott (1989; 1993, chapter 13), the context was one not only of concern with declining competitiveness of U.S. firms in global markets, *but importantly as well*, the context was the administration's overall push to relax antitrust laws and deregulate markets. Regarding the concern about declining competitiveness, Link observes¹⁵ that the intent of the NCRA and then the amendments to follow may simply have been to provide a low-cost signal – from the government to technology-based firms – urging the use of cooperation to shorten the time to market, because global competitors were doing it. He points to the testimony in support of the NCRA where witnesses observed that the Japanese were cooperating and therefore U.S. firms should do so as well. Possibly government was aware that cooperation at the basic or generic stage would not impinge on competition but would shorten the time to development and innovation. The difficulty of course is that the NCRPA is not at all limited to cooperative activities that entail basic or generic research.

The review of the theory and evidence in this chapter supports the controversial possibility that the NCRPA is not merely superfluous because antitrust cases for activities covered by the Act would use rule of reason or analogous analysis even without the Act. Rather, because the Act removes the possibility of recovery of treble damages in meritorious cases, the NCRPA may provide too much protection from antitrust litigation.

¹⁵ Personal correspondence, August 8, 2005.

That is, however, just a possibility. Whether the additional protection provided by the NCRPA is unnecessary or even excessive remains an open question.

References

- d'Aspremont, Claude, and Alexis Jacquemin, "Cooperative and Noncooperative R&D in Duopoly with Spillovers," *American Economic Review*, Vol. 78, No. 5 (December 1988), pp. 1133-1137.
- Baldwin, William L., and John T. Scott, *Market Structure and Technological Change*, in the series *Fundamentals of Pure and Applied Economics*, vol. 17, (Chur; London; Paris; New York: Harwood Academic Publishers, 1987).
- Brod, Andrew C., and Albert N. Link, "Trends in Cooperative Research Activity: Has the National Cooperative Research Act Been Successful?," in *Innovation Policy in the Knowledge-Based Economy*, edited by Maryann P. Feldman and Albert N. Link (Boston: Kluwer Academic Publishers, 2001), pp. 105-119.
- Cohen, Wesley M., and Daniel A. Levinthal, "Innovation and Learning: The Two Faces of R&D," *Economic Journal*, Vol. 99, No. 397 (1989), pp. 569-596.
- Combs, Kathryn L., and Albert N. Link, "Innovation Policy in Search of an Economic Foundation: The Case of Research Partnerships in the United States," *Technology Analysis & Strategic Management*, Vol. 15, No. 2 (June 2003), pp. 177-187.
- Hagedoorn, John, "Inter-Firm R&D Partnership – An Overview of Major Trends and Patterns since 1960," in *Strategic Research Partnerships*, edited by John E. Jankowski, Albert N. Link, and Nicholas S. Vonortas (Arlington, Virginia: National Science Foundation, 2001), pp. 63-92.

Hagedoorn, John, Albert N. Link, and Nicholas S. Vonortas, "Research Partnerships,"

Research Policy, Vol. 29, Nos. 4-5 (April 2000), pp. 567-586.

Hall, Bronwyn H., Albert N. Link, and John T. Scott, "Universities as Research

Partners," *Review of Economics and Statistics*, Vol. 85, No. 2 (May 2003), pp.

485-491.

Kamien, Morton I., Eitan Muller, and Israel Zang, "Research Joint Ventures and R&D

Cartels," *American Economic Review*, Vol. 82, No. 5 (December 1992), pp. 1293-

1306.

Katz, Michael L., "An Analysis of Cooperative Research and Development," *Rand*

Journal of Economics, Vol. 17, No. 4 (Winter 1986), pp. 527-543.

Katz, Michael L., and Janusz A. Ordover, "R&D Cooperation and Competition,"

Brookings Papers on Economic Activity: Microeconomics 1990, edited by M. N.

Baily and C. Winston (Washington, D.C.: The Brookings Institution, 1990), pp.

137-203.

Lee, Tom K., and Louis L. Wilde, "Market Structure and Innovation: A Reformulation,"

Quarterly Journal of Economics, Vol. 94, No. 2 (March 1980), pp. 429-436.

Levin, Richard C., Wesley M. Cohen, and David C. Mowery, "R&D Appropriability,

Opportunity, and Market Structure: New Evidence on Some Schumpeterian

Hypotheses," *American Economic Review*, Vol. 75, No. 2 (May 1985), pp. 20-24.

Levin, R. C., Alvin K. Klevorick, Richard R. Nelson, and Sidney G. Winter, "Survey

Research on R&D Appropriability and Technological Opportunity: Part 1,"

Working Paper, Yale University (July 1984).

- Link, Albert N., "Research Joint Ventures: Patterns from Federal Register Filings," *Review of Industrial Organization*, Vol. 11, No. 5 (October 1996), pp. 617-628.
- Link, Albert N., "Research Joint Ventures in the United States: A Descriptive Analysis," in *Essays in Honor of Edwin Mansfield: The Economics of R&D, Innovation, and Technological Change*, edited by Albert N. Link and F. M. Scherer (New York: Springer Science, 2005), pp. 187-193.
- Link, Albert N., and Laura L. Bauer, *Cooperative Research in U.S. Manufacturing: Assessing Policy Initiatives and Corporate Strategies* (Lexington, Massachusetts: Lexington Books, 1989).
- Link, Albert N., and John T. Scott, "Public/Private Partnerships: Stimulating Competition in a Dynamic Market," *International Journal of Industrial Organization*, Vol. 19, Issue 5 (April 2001), pp. 763-794.
- Link, Albert N., and John T. Scott, "U. S. Science Parks: The Diffusion of an Innovation and Its Effects on the Academic Missions of Universities," *International Journal of Industrial Organization*, Vol. 21, Issue 9 (November 2003), pp. 1323-1356.
- Link, Albert N., and John T. Scott, "Universities as Partners in U.S. Research Joint Ventures," *Research Policy*, Volume 34, Issue 3 (April 2005), pp. 385-393.
- Link, Albert N., David J. Teece, and William F. Finan, "Estimating the Benefits from Collaboration: The Case of SEMATECH," *Review of Industrial Organization*, Vol. 11, No. 5 (October 1996), pp. 737-751.
- Loury, Glenn C., "Market Structure and Innovation," *Quarterly Journal of Economics*, Vol. 93, No. 3 (August 1979), pp. 395-410.

- Martin, Stephen, *Advanced Industrial Economics*, Second Edition (Oxford: Blackwell Publishers, 2002a).
- Martin, Stephen, "Spillovers, Appropriability, and R&D," *Journal of Economics*, Vol. 75, No. 1 (2002b), pp. 1-32.
- Martin, Stephen, "The Evaluation of Strategic Research Partnerships," *Technology Analysis & Strategic Management*, Vol. 15, No. 2 (June 2003), pp. 159-176.
- Martin, Stephen, and John T. Scott, "The Nature of Innovation Market Failure and the Design of Public Support for Private Innovation," *Research Policy*, Vol. 29, Nos. 4-5 (April 2000), pp. 437-447.
- Nelson, Richard R., "Uncertainty, Learning, and the Economics of Parallel Research and Development Efforts," *Review of Economics and Statistics*, Vol. 43, No. 4 (1961), pp. 351-364.
- Nelson, Richard R., "The Role of Knowledge in R&D Efficiency," *Quarterly Journal of Economics*, Vol. 97, No. 3 (1982), pp. 453-470.
- Scherer, Frederic M., "Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions," *American Economic Review*, Vol. 55, No. 5 (1965), pp. 1097-1125.
- Scherer, Frederic M., "Market Structure and the Employment of Scientists and Engineers," *American Economic Review*, Vol. 57 (1967a), pp. 524-531.
- Scherer, Frederic M., "Research and Development Resource Allocation Under Rivalry," *Quarterly Journal of Economics*, Vol. 81, No. 3 (1967b), pp. 359-394.
- Scherer, Frederic M., *Industrial Market Structure and Economic Performance* (Chicago: Rand McNally, 1970).

Scott, John T., "Firm Versus Industry Variability in R&D Intensity," in *R&D, Patents, and Productivity*, ed. Zvi Griliches, (Chicago: University of Chicago Press for the National Bureau of Economic Research, 1984), pp. 233-245.

Scott, John T., "Diversification versus Co-operation in R&D Investment," *Managerial and Decision Economics*, Vol. 9, No. 3 (September 1988), pp. 173-186.

Scott, John T., "Historical and Economic Perspectives of the National Cooperative Research Act," in *Cooperative Research and Development: The Industry-University-Government Relationship*, edited by Albert N. Link and Gregory Tassef (Boston: Kluwer Academic Publishers, 1989), pp. 65-84.

Scott, John T., "Research Diversity Induced by Rivalry," chapter 9, pp. 132-151, in *Innovation and Technological Change*, edited by Zoltan J. Acs and David B. Audretsch (London: Harvester-Wheatsheaf, 1991).

Scott, John T., *Purposive Diversification and Economic Performance*, (Cambridge; New York: Cambridge University Press, 1993).

Scott, John T., "The Damoclean Tax and Innovation," *Journal of Evolutionary Economics*, Vol. 5, No. 1 (February 1995), pp. 71-89.

Scott, John T., "Environmental Research Joint Ventures among Manufacturers," *Review of Industrial Organization*, Vol. 11, No. 5 (October 1996), pp. 655-679.

Scott, John T., "Absorptive Capacity and the Efficiency of Research Partnerships," *Technology Analysis & Strategic Management*, Vol. 15, No. 2 (June 2003a), pp. 247-253.

Scott, John T., *Environmental Research and Development: US Industrial Research, the Clean Air Act and Environmental Damage*, (Cheltenham, UK; Northampton, Massachusetts: Edward Elgar Publishing, 2003b).

Scott, John T., "Public Policy and Environmental Research and Development," in *Essays in Honor of Edwin Mansfield: The Economics of R&D, Innovation, and Technological Change*, edited by Albert N. Link and F. M. Scherer (New York: Springer Science, 2005), pp. 109-127.

Siegel, Donald S., "Data Requirements for Assessing the Private and Social Returns to Strategic Research Partnerships: Analysis and Recommendations," *Technology Analysis & Strategic Management*, Vol. 15, No. 2 (June 2003), pp. 207-225.

Vonortas, Nicholas S., *Cooperation in Research and Development* (Norwell, Massachusetts: Kluwer Academic Publishers, 1997).

Yi, Sang-Seung, "The Welfare Effects of Cooperative R&D in Oligopoly with Spillovers," *Review of Industrial Organization*, Vol. 11, No. 5 (October 1996), pp. 681-698.