U.S. Research Joint Ventures with International Partners

By: Stuart D. Allen, Albert N. Link

Allen, S., & Link, A. (2013) U.S. Joint Ventures with International Partners. *International Entrepreneurship and Management Journal.* doi: 10.1007/s11365-013-0281-4

Abstract:

In the United States, as in most industrialized nations, aggregate technological advancement declined during the 1970s and early 1980s. The U.S. Congress was quick to respond to this down turn by passing a number of technology- and innovation-related initiatives, one of which was the National Cooperative Research Act (NCRA) of 1984. It has been argued that this policy response is an example of government acting as entrepreneur because the enabling legislation was both innovative and characterized by entrepreneurial risk. In this paper we examine empirically covariates with the trend in the formation of research joint ventures (RJVs) promulgated by the NCRA and with the probability that a RJV will have an international research partner. We find that RJV formations seem to increase in times when industrial investments in research and development (R&D) decrease, and we conclude that RJVs might thus be a substitute for internal R&D activity. We also find that the probability of a RJV having an international research partner increases as the membership size of the RJV increases. We conclude that as membership size increases, the ability of any one member to appropriate the collective research contributions from the other members, and thus gain a competitive advantage, decreases. Thus, the cost of including in the RJV an international partner, which we argue could represent a potential intellectual capital leakage, decreases.

Keywords: Research joint venture | Strategic alliance | Technology | Innovation | Technological change | Entrepreneurship

Article:

Introduction

In the United States, as in most industrialized nations, aggregate technological advancement as measured by an index of total factor productivity (TFP) declined during the 1970s and early 1980s. The first and milder decline in the United States occurred during the recession of 1973–1974; the second and more pronounced decline lasted from 1978 through 1982, and it included

the double recessions of 1980 and 1981–1982. See Fig. 1. No decline in TFP occurred during the 2001 recession, but TFP declined slightly during the Great Recession of 2007–2009.

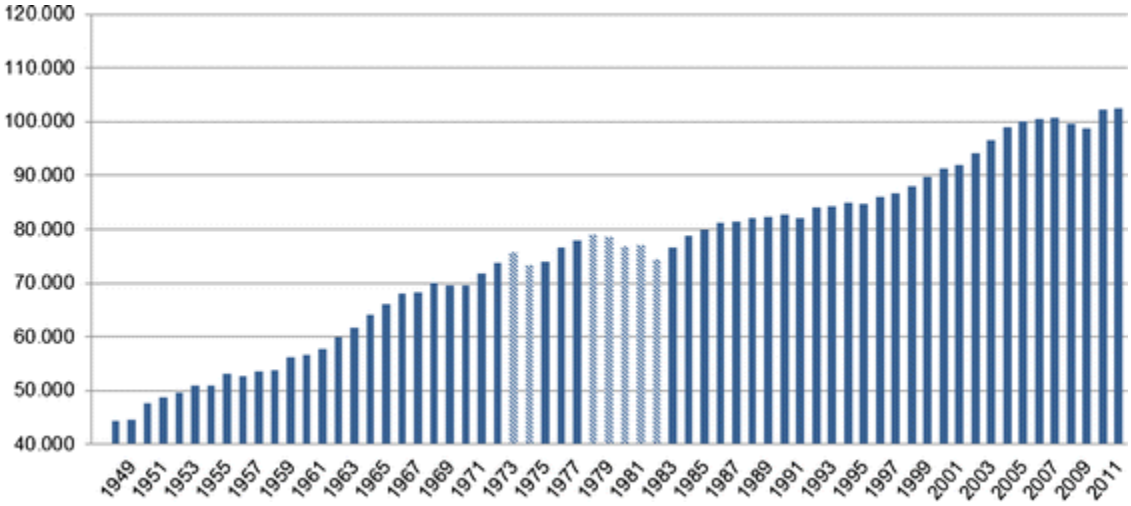

Fig. 1 U.S. total factor productivity index (2005 = 100). http://www.bls.gov/mfp/mprtech.htm

The slowdown in TFP in 1973 and 1974 has been attributed to the shock of the energy crisis of 1973 (Siegel*1979*) and also to the normal cyclical shock(s) to the economy (Link and Siegel *2003*). More important, from both an economic and a policy perspective, is the productivity slowdown that began in 1978 and ended in 1982. By the end of 1982, the TFP index was 74.401 (2005 = 100), only slightly higher that it had been a decade earlier. Many ex post explanations have been offered for this precipitous and unprecedented decline in technological advancement, as summarized in Link (*1987*) and Link and Siegel (*2003*). Link and Siegel (*2003*, p. 58) wrote:

In the early 1980s there was great concern among economists and policymakers in the United States regarding the pervasive slowdown in productivity growth and the concomitant decline in the global competitiveness of American firms in key high-technology industries. One of the alleged culprits of this productivity slowdown was a decline in the rate of technological innovation, which is a reflection of declining entrepreneurship.

The U.S. Congress was quick to act to the significant slowdown that began in 1978 through the passage of six technology- and innovation-related initiatives. These included the University and Small Business Patent Procedure Act of 1980 (known as the Bayh-Dole Act of 1980), the Stevenson-Wydler Technology Innovation Act of 1980, the Economic Recovery Tax Act (ERTA) of 1981 (the part that relates specifically to the productivity slowdown literature is the R&E Tax Credit of 1981), the Small Business Innovation Development Act of 1982, the National Cooperative Research Act (NCRA) of 1984, and the Omnibus Trade and Competitiveness Act of 1988.

In this paper we focus specifically on the NCRA of 1984. We examine the trend in research joint ventures (RJVs) formed in the United States under the NCRA and the propensity for those RJV to have an international research partner as a member. The motivation for our focus on U.S. research joint ventures, or more generally on research cooperation, comes from the renewed policy interest in collaborative research and development (R&D) in response to the Great Recession (December 2007 to June 2009). As one focused example, the President's Council of Advisors on Science and Technology (PCAST) submitted to the White House in June 2011 its *Report to the President on Ensuring American Leadership in Advanced Manufacturing*. Therein, the Nanoelectronics Research Initiative (NRI) was signaled out as one example of a key joint research initiative in nanoelectronics to improve U.S. competitiveness in manufacturing.[1]

As a second example, the Obama Administration, through the Department of Energy, initiated the Clean Energy Manufacturing Initiative in 2013 to "bring together … private sector [research] partners to map out and implement a strategy to ensure that U.S. manufacturers are competitive in the global marketplace [by increasing clean energy technology]."[2]

And, the motivation for our focus on international research partners in U.S. RJVs comes from, among other sources, INSEAD's newly released (in 2013) *The Global Innovation Index 2013: The Local Dynamics of Innovation*. Therein, cluster formations and joint ventures/strategic alliances are emphasized as an important pillar of innovation input throughout the world. The report also notes that there were over 4,000 such linkages worldwide in 2012, a number that has been increasing since 2009. Although the INSEAD report does not address the international composition of these cooperative research relationships, it is a logical issue to address, and it is one that has not yet been considered in the extant academic or policy literatures due to, perhaps, a paucity of identifying information. In this paper we examine the likelihood that a U.S. RJV will have an international firm as a research partner.

The remainder of the paper is outlined as follows. In "The National Cooperative Research Act of 1984" section, we detail relevant specifics of the NCRA, and we tie that policy initiative to what we call government acting as an entrepreneur. In "Patterns in U.S. research joint ventures" section, we document patterns in U.S. RJV formations over time, and we investigate empirically covariates with that trend. In "Research joint ventures with international partners" section, we document the prevalence of international partners in U.S. RJVs over time, and we investigate empirically covariates with the probability that a U.S. RJV will have an international research partner. Others have examined the partner composition of a RJV, but they have done so only with regard to domestic firm or institutional partners (e.g., Hall et al. *2003*; Kirby and Kaiser *2005*; Link *1996*,*2005*; Link and Scott *2005*; Zutshi and Tan *2009*). To our knowledge, our analysis that follows is the first to examine empirically the international composition of a RJV's membership. Finally, we conclude the paper in "Concluding remarks" section with summary remarks and our views for a future research agenda on this topic.

The National Cooperative Research Act of 1984

Several bills were introduced, in response to the TFP decline, during the 98th session of Congress that focused explicitly on R&D joint ventures. The Thurmond bill would have excused all R&D joint ventures from existing provisions of antitrust law related to any treble damages that could have been assessed after successful litigation. The Glenn and Rodino bills went even further; they argued for a relaxation of all antitrust regulations that were serving as barriers to the formation of R&D joint ventures. The Mathias bill was still even more comprehensive; it included a proposal for sharing patent and royalty rights among cooperative research ventures.

To emphasize Congressional interest in cooperative research, one House report, the High Technology Research and Development Joint Ventures Act of 1983 (H.R. 3393), stated:

A number of indicators strongly suggest that the position of world technology leadership once firmly held by the United States is declining. The United States, only a decade ago, with only five percent of the world's population was generating about 75 % of the world's technology. Now, the U.S. share has declined to about 50 % and in another ten years, without fundamental changes in our Nation's technological policy … the past trend would suggest that it may be down to only 30 %. [In hearings,] many distinguished scientific and industry panels had recommended the need for some relaxation of current antitrust laws to encourage the formation of R&D joint ventures. … The encouragement and fostering of joint research and development ventures are needed responses to the problem of declining U.S. productivity and international competitiveness. According to the testimony received during the Committee hearings, this legislation will provide for a significant increase in the efficiency associated with firms doing similar research and development and will also provide for more effective use of scarce technically trained personnel in the United States.

In yet another House report, the Joint Research and Development Act of 1984 (HR 5041), the presumed benefits of joint research and development were, for the first time, clearly articulated:

Joint research and development, as our foreign competitors have learned, can be procompetitive. It can reduce duplication, promote the efficient use of scarce technical personnel, and help to achieve desirable economies of scale. … [W]e must ensure to our U.S. industries the same economic opportunities as our competitors, to engage in joint research and development, if we are to compete in the world market and retain jobs in this country.

These early initiatives culminated on October 11, 1984 with the passage of the National Cooperative Research Act (NCRA) of 1984, Public Law 98–462. The preamble to the law states that this Act will "promote research and development, encourage innovation, stimulate trade, and make necessary and appropriate modifications in the operation of the antitrust laws." The Act defined a "joint research and development venture" in the following manner:

[A joint research and development venture is] any group of activities, including attempting to make, making, or performing a contract, by two or more persons for the purpose of—

(A) theoretical analysis, experimentation, or systematic study of phenomena or observable facts,

(B) the development or testing of basic engineering techniques,

(C) the extension of investigative findings or theory of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, prototypes, equipment, materials, and processes,

(D) the collection, exchange, and analysis of research information, or

(E) any combination of the purposes specified in subparagraphs (A), (B), (C), and (D), and may include the establishment and operation of facilities for the conducting of research, the conducting of such venture on a protected and proprietary basis, and the prosecuting of applications for patents and the granting of licenses for the results of such venture … .

The NCRA of 1984 created a registration process under which joint research and development ventures, or more simply research joint ventures (RJVs), can voluntarily disclose their research intentions to the U.S. Department of Justice; all disclosures are then made public in the *Federal Register*. RJVs gain two significant benefits from filing with the Department of Justice under the NCRA: one, if the venture were subjected to criminal or civil antitrust action, the courts would evaluate the alleged anticompetitive behavior under a rule of reason rather than presumptively ruling that the behavior constituted a per se violation of the antitrust law, and two, if the venture were found to fail a rule-of-reason analysis it would be subject to actual damages rather than treble damages.[3]

It has been argued that the NCRA is an example of government acting as an entrepreneur. For example, Link and Link (*2009*, p. 4) argued, based on the historical perspective of who the entrepreneur is and what he/she does, from a technology-based perspective, that:

Government acts as entrepreneur in the provision of *technology infrastructure* when its involvement is both *innovative* and characterized by *entrepreneurial risk* [emphasis added]. … Thinking of government as entrepreneur is a unique lens through which we characterize a specific subset of government policy actions. As such, our viewpoint underscores the purposeful intent of government, its ability to act in new and innovative ways, and its willingness to undertake policy actions that have uncertain outcomes.

The NRCA is, according to Link and Link (*2009*), an initiative that created a *technology infrastructure*conducive for cooperative research. This act represents an *innovative* policy action, through its interpretation of antitrust laws, to stimulate private sector R&D; and, the initiative is characterized by *entrepreneurial risk* if, on the basis of a retrospective evaluation, the benefits to firms participating in an RJV outweigh the costs.[4]

Though NCRA generated increased collaborative research and production activities, surprisingly little is known about economic factors that influence the trend in RJVs or the composition of

RJVs in the United States. The National Science Foundation established in 1994 the CORE (COllaborative REsearch) database in an effort to understand better the fundamental characteristics of RJVs. The CORE database defines the RJV to be the relevant unit of observation; the database contains summary information about each RJV as determined from *Federal Register* filings, supplementary data, and interviews with key research participants.[5]

Patterns in U.S. research joint ventures

Figure 2 shows the pattern of RJV formations beginning in 1985 and ending in 2012. There are at least two specific and one general observation related to these data. First, the number of filings in 1985, the first year after the NCRA, was greater than in any year from 1986 through 1990. Perhaps the number of filings in 1985 represents RJV activities in that year as well as in previous years that were disclosed to the Department of Justice only after the passage of the NCRA.

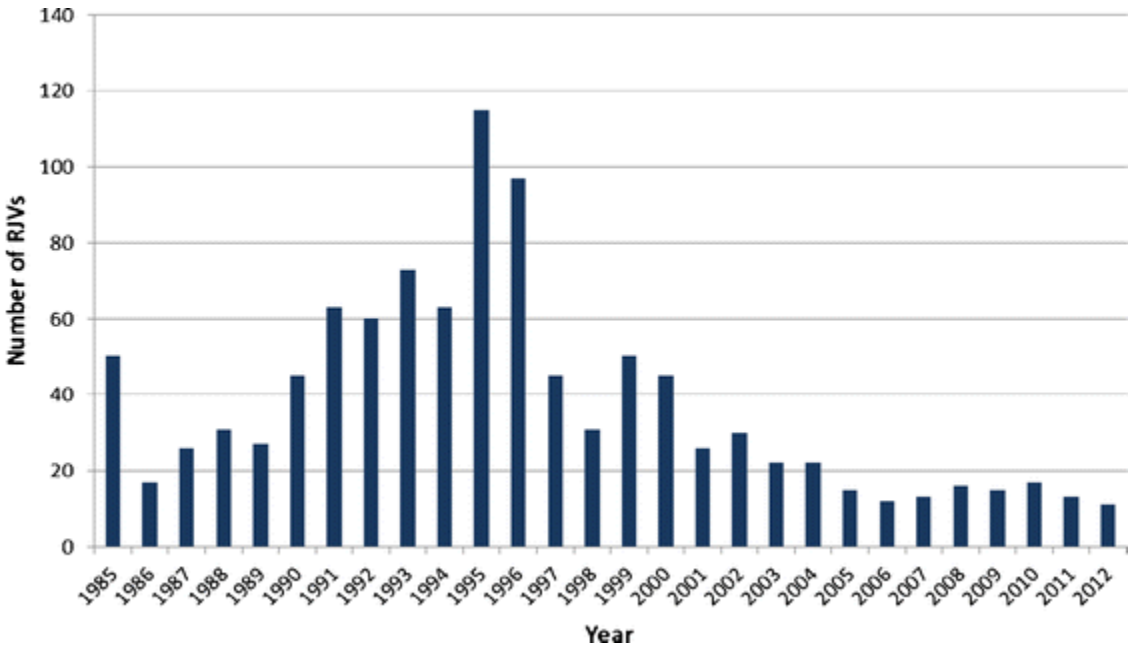

Fig. 2 Pattern of RJV formation in the United States (1985–2012). *Federal Register* filings

Second, the number of filings in 1995 is visually large compared to any previous or subsequent year. Based on personal correspondence with the Department of Justice while collecting RJV filing information under the sponsorship of the National Science Foundation, it was learned that the individual who handled the publication of RJV filings in the *Federal Register* went on personal leave during part of 1994 and part of 1995. Thus, the number of filings that were processed for publication in 1994 understates actual RJV activity in that year, and the number of published filings in 1995 overstates actual RJV activity in that year.

And our third general observation is that since 1995 the number of published filings in the *Federal Register*has declined, reaching an apparent steady state of less than 20 new filings per year since 2005.

Our model of the time trend in RJV filings includes the following variables. Three specific binary variables are included to account for the events in the 3 years discussed above. *D 85* equals 1 for 1985 and 0 otherwise; *D94* equals 1 for 1994 and 0 otherwise; and *D 95* equals 1 for 1995 and 0 otherwise. Based on Fig. 2, the estimated coefficient for *D 85* and *D 95* should be positive, and that on *D 94* should be negative.

IndRD, measured in logarithmic terms, represents the total annual amount of industry-funded R&D ($2005), as reported by the National Science Foundation.[6] Our hypothesis is that participation in an RJV is a substitute for conducting R&D internally, and thus the sign on the estimated coefficient for this variable should be negative.

GDPgr is the annual growth rate in real Gross Domestic Product (GDP), as reported by the Federal Reserve Bank of St. Louis. It is included in the model to control for macroeconomic effects over time that could influence firm strategies related to R&D activities. We offer no hypothesis about the sign for the estimated coefficient for this variable.

Finally, a linear and a quadratic trend variable are included in our model to account for what might be called learning-by-doing. Prior to the passage of the NCRA, a RJV was not a traditional venue for conducting R&D either in the United States, and thus over time firms learned from their own collaboration experience and from the experiences of other firms. Based on this hypothesis the estimated coefficient for the linear trend variable should be positive; we offer no hypothesis about the sign on the quadratic trend coefficient.

Descriptive statistics on these variables are presented in Table 1.

Table 1. Descriptive statistics on variables in the count models of number of RJV formations (1985–2011), (National Science Foundation data on industry R&D are only available through 2011) $n = 27$

Variable	Mean	Standard deviation	Range
RJVs	38.48	26.48	12–115
D 85	0.037	0.192	0/1
D 94	0.037	0.192	0/1
D 95	0.037	0.192	0/1
IndRD	166426.96	49741.24	94131–238244
GDPgr	2.743	1.732	−2.802–4.847
trend	14.00	7.937	1–27

The results from the estimation of a Poisson and a negative binomial model of the trend in RJV formations are presented in Table 2. The findings across the two specifications are similar. In both, the sign on the estimated coefficients for the binary variables are as hypothesized. The estimated coefficients on *D 85* and *D95* are positive and significant; the estimated coefficient on *D 94* is negative but not significant.[7]

Table 2. Poisson and negative binomial regression results for RJV formations (1985–2011), $n = 27$

Variable	Poisson coefficient (standard error)	Negative binomial coefficient (standard error)
D 85	1.266 (0.213)[a]	1.175 (0.366)[a]
D 94	−0.214 (0.162)	−0.145 (0.312)
D 95	0.422 (0.123)[a]	0.501 (0.281)[b]
IndRD	−2.839 (0.680)[a]	−2.686 (1.095)[c]
GDPgr	−0.056 (0.025)[c]	−0.045 (0.040)
trend	0.416 (0.055)[a]	0.379 (0.091)[a]
trend 2	−0.013 (0.001)[a]	−0.011 (0.002)[a]
intercept	34.996 (7.661)[a]	33.311 (12.320)[a]
Log likelihood	−108.07	−98.63
alpha	–	0.050 (0.023)[c]

[a]significant at .01 level
[b]significant at .10 level
[c]significant at .05 level

Across the two specifications, the estimated coefficient for *IndRD* is negative, but it is only marginally significant in the Poisson model. Thus, our hypothesis that as industry funded R&D increases, participation in RJVs decreases is only weakly supported. That is, additional research is needed to more convincingly conclude that participation in a RJV is a substitute for investing in internal R&D activity.

Similarly, the estimated coefficient for *GDPgr* is negative in both specifications but only significant in the Poisson model. Again, additional research is needed to quantify if any broad-based macroeconomic effects, such as shifts in the job creation, influenced RJV formations.

Lastly, the trend variables are also significant, with the coefficient for the linear trend term being positive and for the quadratic trend term being negative. This suggests that some learning-by-doing took place during a defined period of time. Noting the precipitous decline in RJV formations after 1995, one might infer that firms learned that the benefits from their participation in an RJV did not outweigh the costs.

Research joint ventures with international partners

Figure 3 shows, by year, the percent of all filed RJVs with at least one international research partner. Of the 1,046 reported RJV formations from 1985 through 2012, just over 30 % have at least one international research partner. Among the 315 RJVs with at least one international partner, a Japanese firm is present in 32 % of them, a UK firm in 22 %, and either a Canadian or a German firm in another 20 %.

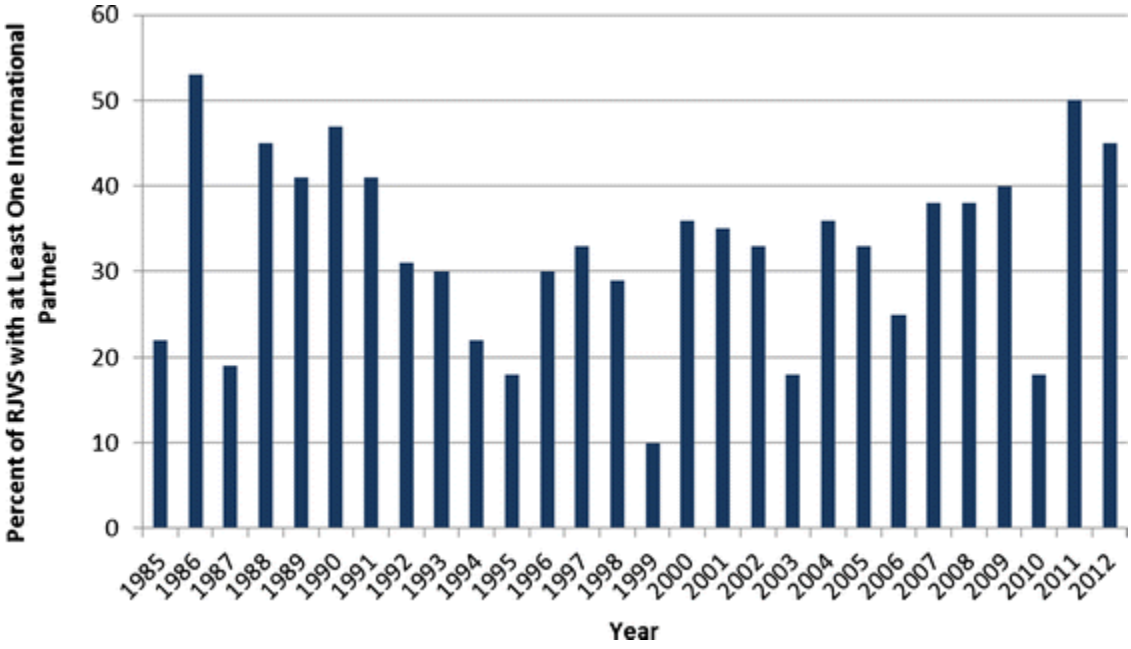

Fig. 3 Percent of RJVs with at least one international partner (1985–2012)

Others have examined the partner composition of a RJV, but they have done so only with regard to domestic firm or institutional partners.,[8 9] To our knowledge, the analysis that follows is the first to examine empirically the international composition of a RJV's membership. Specifically, we estimate the probability that a RJV has at least one international research partner as a member. *IntlPart* equals 1 if this is the case, and 0 otherwise.

Our statistical model includes the following independent variables. *Memb* represents the membership size of the RJV at the time of its filing, and *Memb 2* is its square. Our hypothesis is that the larger the membership of the RJV the greater the probability that an international firm will be invited to participate in the cooperative research. Following Baldwin and Link (*1998*) and Leyden and Link (*1999*), the larger the membership the less likely that any one member can appropriate the collective research contributions and gain a competitive advantage. Therefore, the relative potential loss in gains in competitive advantage from inviting an international partner to be involved in the RJV, which could represent an intellectual capital leakage, decreases as the membership size of the RJV increases.[10]

Several control variables are also in the model. The research output of a RJV can either be a product technology or a process technology. *Prod* is a binary variable equal to 1 if the research

of the RJV is directed toward a product technology, and 0 otherwise. We offer no hypothesis about the sign on the estimated coefficient for this variable.

Also held constant is the technology area of the research. The following binary variables are included; each equals 1 if it is descriptive of the technology area of research, and 0 otherwise: *ManDmy* (manufacturing equipment), *SofDmy* (computer software), *TelDmy* (telecommunications), *ComDmy* (computer hardware),*ItDmy* (information technology), CheDmy (chemicals), *TrnDmy* (transportation), *ErnDmy* (energy), *TamDmy*(test and measurement), *EnvDmy* (environmental). Again, we offer no hypothesis about industry effects on the probability of a RJV including an international firm as a research partner.

Finally, if a U.S. federal laboratory is involved as a direct research partner and/or as an indirect funding partner, *FedLab* equals 1, and 0 otherwise. Our hypothesis is, again following Baldwin and Link (*1998*) and Leyden and Link (*1999*), that a federal laboratory will act as an honest broker and possibly mitigate any attempt by an international research partner to violate a priori intellectual capital agreements.[11] Thus, *FedLab*should enter the model negatively.

Descriptive statistics on these variables are presented in Table 3, and the estimated probit results are presented in Table 4. The findings support our hypothesis that the larger the size of the RJV the more likely the membership will include at least one international research partner. But, that relationship diminishes. The effect of membership size on the estimate probit coefficient becomes negative at a membership size of 337; the mean membership size of an RJV is 13. Thus, within the relevant range, size has the predicted positive effect.

Table 3. Descriptive statistics on variables in the probability model of an international partner in a RJV, $n = 1046$

Variable	Mean	Standard deviation	Range
IntlPart	0.301	0.459	0/1
Memb	12.93	32.68	2–539
Prod	0.406	0.491	0/1
ManDmy	0.084	0.227	0/1
SofDmy	0.086	0.280	0/1
TelDmy	0.143	0.350	0/1
ComDmy	0.031	0.175	0/1
ItDmy	0.016	0.127	0/1
CheDmy	0.068	0.251	0/1
TrnDmy	0.082	0.274	0/1
ErnDmy	0.001	0.031	0/1
TamDmy	0.071	0.258	0/1
EnvDmy	0.071	0.258	0/1
FedLab	0.119	0.323	0/1

Table 4. Probit regression results for probability of an international partner in an RJV

Variable	Probit coefficient (standard error)
Memb	0.027 (0.003)[a]
Memb 2	−0.00004 (7.895e-6)[a]
Prod	−0.077 (0.089)
ManDmy	−0.170 (0.180)
SofDmy	0.372 (0.164)[b]
TelDmy	0.201 (0.134)[c]
ComDmy	0.032 (0.253)
ItDmy	0.706 (0.316)[b]
CheDmy	0.188 (0.179)
TrnDmy	−0.039 (0.169)
ErnDmy	−3.806 (138.8)
TamDmy	0.096 (0.176)
EnvDmy	0.039 (0.175)
FedLab	−1.090 (0.196)[a]
intercept	−0.782 (0.089)[a]
Wald ratio χ^2 (14 df)	104.80[a]
Log pseudolikelihood	169.11[a]
Pseudo R^2	0.212

[a]significant at .01 level
[b]significant at .05 level
[c]significant at .15 level

The product/process technology focus of the RJV is not an important factor that influences the composition of the RJV's membership.

The likelihood of international research partners is greater in RJVs aimed at technologies in computer software, telecommunications, and information technology. Broadly speaking these are technology areas for which the state-of-the-art changes rapidly and thus the long-run impact of any loss of intellectual property to an international partner would be minimal.

Finally, as hypothesized, the presence of a U.S. federal laboratory as a member does decrease the likelihood that the membership will include an international research partner.

Concluding remarks

Generalizations based on our empirical results should be made with caution. Not only is additional research on the topic of RJV formations and member composition warranted, it is not unreasonable to expect that the CORE database, albeit the national database on RJV activity used by the National Science Foundation, understates collaborative research activity in the United States. From Table 2, we interpreted the negative coefficient for the quadratic trend variable to

mean that over time firms learned that the benefits of collaborative did not outweigh the cost of collaboration, and thus the number of filings decreased.

An alternative interpretation is also possible. Over time, firms might have learned that the cost of filing and publicly disclosing their research agenda and partners, and possibly a dimension of their research strategy, might not outweigh the probability of a possible antitrust violation. If this is true, then it is not unreasonable to suspect that collaborative research in the United States is more prevalent that the behavior in Fig. 2 suggests.

Certainly, more research on these issues is needed. And, that research could entail not only more in-depth data collection efforts but also detailed case studies to understand the nuances of the decision of a firm to collaborate in research and to do so with what other types of partners.

References

Baldwin, W. L., & Link, A. N. (1998). Universities as research joint venture partners: does size of venture matter? *International Journal of Technology Management, 15*, 895–913.

Caloghirou, Y., Ioannides, S., & Vonortas, N. S. (2003). Research joint ventures. *Journal of Economic Surveys, 17*, 541–570.

Combs, K., & Link, A. N. (2003). Innovation policy in search of an economic foundation: the case of research partnerships in the United States.*Technology Analysis & Strategic Management, 15*, 177–187.

Hagedoorn, J., Link, A. N., & Vonortas, N. S. (2000). Research partnerships. *Research Policy, 29*, 567–586.

Hall, B. H., Link, A. N., & Scott, J. T. (2003). Universities as research partners. *Review of Economics and Statistics, 85*, 485–491. Also published as NBER Working Paper No. 7643, April 2000.

Kirby, D. A., & Kaiser, S. (2005). SME foreign direct investment: an examination of the joint venture experience of German and U.K. small and medium sized firms in china. *International Entrepreneurship and Management Journal, 1*, 83–104.

Leyden, D. P., & Link, A. N. (1999). Federal laboratories as research partners. *International Journal of Industrial Organization, 17*, 575–592.

Link, A. N. (1987). *Technological change and productivity growth*. Char: Harwood Academic Publishers.

Link, A. N. (1996). Research joint ventures: patterns from federal register filings. *Review of Industrial Organization, 11*, 617–628.

Link, A. N. (2005). Research joint ventures in the United States: a descriptive analysis. In A. N. Link & F. M. Scherer (Eds.), *Essays in honor of Edwin Mansfield: the economics of R&D, innovation, and technical change*. Boston: Springer.

Link, A. N., & Link, J. R. (2009). *Government as entrepreneur*. New York: Oxford University Press.

Link, A. N., & Scott, J. T. (2005). Universities as research partners in U.S. research joint ventures. *Research Policy, 34*, 385–393.

Link, A. N., & Siegel, D. S. (2003). *Technological change and economic performance*. London: Routledge.

National Science Board. (semi-annual). *Science & engineering indicators*. Arlington: National Science Foundation.

Siegel, R. (1979). Why has productivity slowed down? *Data Resources U.S. Review, 1*, 59–65.

Vonortas, N. S. (1997). *Cooperation in research and development*. Boston: Kluwer Academic Publishers.

Zutshi, R. K., & Tan, W. L. (2009). Impact of culture on 'partner selection criteria' in East Asian international joint ventures. *International Entrepreneurship and Management Journal, 5*, 369–393.

Footnotes

1. Current organizations in the NRI joint venture include GlobalFoundaries, IBM, Intel, Micron Technology, and Texas Instruments. The mission of NRI is to: "Demonstrate non-conventional, low-energy technologies which can outperform CMOS [Complementary Metal–Oxide–Semiconductor technology] on critical applications in ten years and beyond." <http://www.src.org/program/nri/about/mission/>

2. <http://www1.eere.energy.gov/energymanufacturing/news_detail.html?news_id=19111>

3. The National Cooperative Research and Production Act (NCRPA) of 1993, Public Law 103–42, amended the NCRA by extending the safe harbor to RJVs involved in production as well as in research. The NRCA was amended again in 2004 under the Standards Development Organization Advancement Act of 2004, Public Law 108–237, to encourage the activities of standards setting organizations and participating firms.

4. For a review of the benefits and costs of participation in an RJV, from a theoretical perspective, see Hagedoorn et al. (*2000*), Caloghirou et al. (*2003*), and Combs and Link (*2003*).

5. The CORE database was constructed and maintained by Link at the University of North Carolina at Greensboro through 2008 from support from the National Science Foundation (NSF). The CORE database was used to document for policy purposes the formation of RJVs through 2008, as summarized in the *National Science Board's Science and Engineering Indicators*. Because the database was constructed from NSF's support, it is publically available on request from the authors. The database was updated through 2012 to facilitate the analysis in this paper. Studies based on earlier versions of the CORE database include Link (*1996*, *2005*) and Link and Scott (*2005*). See Vonortas (*1997*) for related empirical analyses based on *Federal Register* filing information.

6. The most recent data on industry funded R&D are for 2011.

7. In an alternative specification, the number of filings in 1994 and 1995 were numerically averaged and that average value replaced the 1994 datum and the 1995 datum. The model that underlies Table 2 was re-estimated with *D 85* , and the estimated coefficient for it was positive and significant. The findings discussed below related to the other variables in the model are unchanged. These results are available from the authors on request.

8. See, for example, Hall et al. (*2003*), Kirby and Kaiser (*2005*), Link (*1996*, *2005*), Link and Scott (*2005*), and Zutshi and Tan (*2009*).

9. The CORE database does not contain information relevant to an understanding of the strategic intent of including an international firm as a RJV member, but certainly this is an important area for future research.

10. We thank an anonymous referee for pointing out that horal hazard could accompany the decision to invite an international partner into a RJV and that adverse behavior could result. Unfortunately, information in the CORE database is insufficient to account for either the timing of the invitation to the international partner, their motivation for joining the RJV, or their behavior (or that of other members) after joining. This is certainly an important strategic issue for future consideration.

11. Baldwin and Link (*1998*) for university research partners and Leyden and Link (*1999*) for government research partners argue that such partners act as honest brokers when so involved. Thus, when so involved, there is more assurance that the research results will be shared and will not remain proprietary in the hands of any one partner.