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8507
2020

August 2020

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CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editor: Clemens Fuest
https://www.cesifo.org/en/wp
An electronic version of the paper may be downloaded
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CESifo *Working Paper No. 8507*

R&D Spillovers through RJV Cooperation

Abstract

We investigate the dimensions through which R&D spillovers are propagated across firms via cooperation through Research Joint Ventures (RJVs). We build on the framework developed by Bloom et al. (2013) which considers the opposing effects of technology spillovers and product market rivalry, and extend it to account for RJVs. Our main findings are that the adverse effects of product market rivalry are mitigated if firms cooperate in RJVs and that R&D spending is reduced among technologically close RJV participants.

JEL-Codes: L240, L440, K210, O320.

Keywords: spillovers, R&D, research joint ventures, market value, patents.

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August 4, 2020
The authors would like to thank Christian Michel, Jerney Copic, Mark Schankerman, Reinhilde Veugelers, and seminar participants at the University of Amsterdam for useful comments.

1 Introduction

Research and Development (R&D) spillovers have been a major topic of economic research over the last thirty years. The central point of this literature is that the knowledge generated in the R&D process is not entirely private to the innovating firm, but it usually spreads, or "spills over," to other firms through various channels. The types and relative strength of these channels, the reasons as to why some firms are more subject to spillovers than others, and the ability of firms to appropriate positive spillovers have been analyzed by a large number of studies in the fields of innovation, productivity and industrial organization (see e.g. Hall et al. (2010) for a review).

Bloom et al. (2013), hereafter referred to as BSV, develop a framework that recognizes that R&D generates at least two types of spillover effects on other (receiving) firms: technology spillovers, which benefit the firms that are technologically close, and product market spillovers, which harm firms that are close competitors. BSV construct two distinct measures of distance between firms, reflecting overlaps in the technology classes of their patents and in the industry segments of their sales, which allow them to distinguish empirically between technology and product market spillovers. Subsequently, they test the effects of these two types of spillovers on a range of firm performance indicators (market value, citation-weighted patents, productivity and R&D).

We extend Bloom et al. (2013) and consider a particular mechanism through which technology and product market spillovers can be potentially enhanced or mitigated: Research Joint Ventures (RJVs).[1] Firms participating in RJVs may, for instance, be more resilient to the effects of the product market spillovers, or benefit more from the technology spillovers because of their greater "absorptive capacity" (Cassiman and Veugelers (2002), Gomes-Casseres et al. (2006) and Kamien and Zang (2000)).[2] Firms may also benefit more from the technological spillover effects of their particular RJV partners because they can better internalise these spillovers. Furthermore, as RJVs may be conducive to collusive outcomes (Duso et al. (2014)), the negative effect from the R&D of a given competitor may be smaller if this particular competitor is in the same RJV.[3]

This paper analyzes, thus, if and how RJVs affect technology and product market spillovers and firm performance. We investigate, both, whether RJV membership make firms different in terms of overall spillover effects, and whether the spillover effects are different between RJV members.

[1] Other recent interesting additions that build upon this paper are Lucking et al. (2018), who replicate the Bloom et al. (2013) results to later time periods; Anton et al. (2018) who identify spillover channels through commonly owned companies; and Bena and Li (2014) who find that synergies obtained from combining innovation capabilities are important consequences of acquisitions.

[2] The seminal theory papers on the topic are d'Aspremont and Jacquemin (1988) and Kamien et al. (1992), who identify conditions for when RJVs are optimal, depending on the degree of spillovers and the dimensions of collaboration.

[3] In this direction, Branstetter and Sakakibara (2002) find that Japanese research consortia's patenting is positively associated with their level of technology closeness and negatively with their level of product market overlap.

More precisely, we analyse first whether firms participating in RJVs, the "insiders," are affected differently by (all) the other firms' research activities (the "total spillover pool") than the non-participating firms, the "outsiders". Second, we construct a measure of firm distance in the "RJV dimension," reflecting overlaps in the RJVs they participate, analogous to the BSV's distances in the technology and product market dimensions. We test whether the R&D of companies that meet inside RJVs. i.e., RJV partners generating a "partner spillover pool", generates different spillover effects than that of non-partners. For both channels, we explicitly account for the endogeneity of RJV participation through a selection model of endogenous treatment.

Two main findings stand out. First, we show that the positive impact of technology spillovers on firm value is larger – while the negative effect of the product market spillovers is smaller – for RJV insiders than for outsiders. This is consistent with the view that RJV participation increases absorptive capacity, thus creating benefits from the R&D of technology close firms, while it helps sheltering from the R&D of product market competitors. Second, we show that the pool of product market spillovers of closely related collaborators exerts a more positive effect on R&D expenses – making R&D activities more complementary– while the pool of technology spillovers of the same partners exerts a more negative effect on R&D expenses if compared to the same pools of less-closely related collaborators. These results are consistent with the idea that research collaborators are able to cut on wasteful duplication of R&D among technology close companies, but not among product market competitors.

The remainder of the paper is structured as follows. Section 2 explains the data and variable construction. Section 3 and 4 discusses our empirical setup and results, respectively, whereas Section 5 concludes.

2 Data and Measurement

2.1 Data Sources & Sample Selection

Our data are based on three sources: the NBER U.S. Patent Citations Data File (1970-2001), the Compustat North America Industrials database, containing firm-specific information on publicly traded U.S. firms (1986-2000), and the NCRA-RJV database, which holds information on RJVs and their participants under the National Cooperative Research Act (1985-1999).

A large part of this data – i.e. the Compustat balance sheet data as well as the patent data – overlaps with the dataset provided by BSV, which constitutes the base for our estimation sample. The BSV sample contains 830 firms in the technology space and 828 firms in the product market space. BSV merge these observations with information on R&D expenditures for the 1980-2001 period.

This dataset is then matched with information on RJV participation. The original NCRA-RJV database contains information on US-based RJVs during the 1985-1999 period (for a more detailed description, see Link (1996)).[4] It contains 5,755 NCRA for-profit entities, out of which we match 1,095 to firms in the Compustat North America Industrials database. The non-matched firms are mostly small and, in a few cases, non-U.S. firms. Out of these 1,095 firms, 185 are also contained in the BSV data. Thus, about a quarter of firms in the BSV data are engaged in RJVs, i.e., are "insiders," during the sample period. The sample of RJV "outsiders" in an industry in a given year is generated by taking all those firms which are part of the BSV database but did not participate in any RJV in that industry and the given year, where an industry is defined according to the firms' primary SIC4 codes.[5]

2.2 Measures of Proximity

Technology space

We start with the NBER patents database, containing around 2.3m patents in the 1970-1999 period. Of these patents, 443.490, belonging to 407 tech classes, can be matched to the 830 firms contained in the BSV's sample. We calculate the share of each firm's patents in each tech class, obtaining a 830 (firms) times 407 (technology classes) matrix, containing all firm-specific vectors $T_i = (T_{i1}, ..., T_{i407})$ with T_{ik} being the share of patents of firm i in the technology class k. From this matrix T, we calculate the correlations between all firms' technology portfolios as:

$$TECH_{ij} = \frac{T_i}{\sqrt{T_i T_i'}} \times \left(\frac{T_j}{\sqrt{T_j T_j'}} \right)'. \tag{1}$$

Thus, we know for each pair of firms (i, j) to which degree their technology portfolios are related. For $i \neq j$, the mean (median) correlation is .036 (.002) and the 95th (99th) percentile is .18 (.48).

Product market space

We link the average per-segment sales information from the Compustat database across 762 Standard Industry Classification (SIC) codes to 828 firms. Similar to above, we calculate first a

[4]The enactment of the NCRA in 1984 and its amended version, the National Cooperative Research and Production Act (NCRPA), have been created to stimulate R&D in the U.S. In particular, the act allows American firms to establish large RJVs that conduct pre-competitive R&D and has been implemented by the U.S. Congress as part of an industrial policy to improve international competitiveness of American companies and industries. Under the terms of the NCRA, a notice must be filed with both the U.S. Department of Justice and the Federal Trade Commission disclosing the RJV's principal research content and its initial members; subsequent notifications of changes in membership or research intent are also required. In return, certain antitrust exemptions are granted to the NCRA-RJVs, such as, for example, the application of the rule of reason instead of the per se rule and the exemption from treble damages when illegal behaviour is found. See Duso et al. (2014) for an exposition in this dimension.

[5]We exclude the firms that compete in industries with no RJV from our sample of outsiders, since these firms do not face any insiders.

828 (firms) $\times$ 762 (industries) matrix, containing all firm-specific vectors $S_i = (S_{i1}, ..., S_{i762})$ with S_{ik} being the share of sales of firm i in SIC industry k. From this matrix S, we calculate the correlations between all firms' per-segment sales as:

$$SIC_{ij} = \frac{S_i}{\sqrt{S_i S_i'}} \times \left(\frac{S_j}{\sqrt{S_j S_j'}} \right)'. \tag{2}$$

The correlation of firms' sales across segments is zero up to the 90th percentile, with the 95th (99th) percentile at .013 (.351) and a mean of .011.

RJV space

The 185 insiders participate in a total of 458 RJVs, where each RJV has an average (median) of eight (four) members. The firms enter these RJVs during the sample period, for 1/6th of RJV affiliations we also observe an exit date; RJV affiliations with exit date last for an average of 3.1 years.[6] We thus obtain a 185 (firms) $\times$ 458 (RJVs) matrix R_t, containing 185 firm-level vectors $R_{it} = (R_{i1t}, ...R_{i458t})$ with R_{ikt} being equal to 1 if firm i participates in RJV k in year t. This matrix contains information on whether two firms i and j were participants in the same joint venture in year t. As before, we calculate, from this matrix R_t, the correlation between firms' vectors of RJV participation:

$$RJV_{ijt} = \frac{R_{it}}{\sqrt{R_{it} R_{it}'}} \times \left(\frac{R_{jt}}{\sqrt{R_{jt} R_{jt}'}} \right)'. \tag{3}$$

However, there are two differences compared to the two metrics described above. First, while the measures of technology and product market relatedness are static, RJV links change every year with firms' entry and exit to and from RJVs. Thus, the RJV matrices R_t are calculated for every year t in the sample period and the correlation of firms in the RJV space changes over time. Second, while the previous metrics were calculated for all pairs of firms, RJV-relatedness is calculated only for the subsample of RJV participants.

2.3 Spillover measures

The time-varying (total) spillover pools for product market and technology relatedness are constructed by summing up, for every year and every firm, the R&D expenditures of all other firms in that year, weighted by their (time-invariant) proximity in technology or product market space. Thus, if firms i and j are have a non-zero correlation in the technology space (i.e., have patented in similar technology classes), then firm j's R&D enters firm i's spillover pool. Therefore,

[6]RJV affiliations without an exit date are assumed to last from the date of entry to the end of the sample period.

$$SPILLTECH_{it}^{tot} = \sum_{j \neq i} TECH_{ij} \times RD_{jt}, \tag{4}$$

where $TECH_{ij}$ denotes the technological correlation of firms i and j and RD_{jt} denotes firm j's R&D spending at time t. The product-market spillover pool is constructed analogously:

$$SPILLSIC_{it}^{tot} = \sum_{j \neq i} SIC_{ij} \times RD_{jt}. \tag{5}$$

These "total spillover" pools are identical to the ones considered by BSV. In addition, we create another set of "partner spillover" pools taking the RJV-relatedness of firms into account:

$$SPILLTECH_{it}^{par} = \sum_{j \neq i} RJV_{ijt} \times TECH_{ij} \times RD_{jt}, \tag{6}$$

and

$$SPILLSIC_{it}^{par} = \sum_{j \neq i} RJV_{ijt} \times SIC_{ij} \times RD_{jt}. \tag{7}$$

The partner spillover pools for RJV-insiders count only R&D expenditures by other RJV insiders and weigh them with how closely-connected they are in the RJV dimension.

2.4 The Estimation Samples

Since the first step in our analysis consists of exactly replicating BSV results, we follow their code and generate our estimation samples by dropping some observations with missing or jumping values on sales and employment. Further, we restrict the sample to the period 1985-2000. The final samples are unbalanced panels containing at most 700 firms and 9,994 observations. However, because some of the outcome measures (especially patents, sales, and R&D) are missing for a few firm-year observations, the samples used in the respective regressions are sometimes smaller than in BSV. Table 1 reports the preliminary statistics of the main variables used in the regressions.

[Insert table 1 about here]

3 Empirical Implementation

We identify two ways how RJVs might enhance or mitigate spillovers. To identify the effects of the participating firms, we separate out the effects of the *total spillover pool*, in both the technology and product market spaces, for RJV insiders and outsiders. Second, to account for the differential impact of the RJV partners, we include the effect of the *partner spillover pools*, again in both technology and product market spaces. This leads us to the following main specification:

$$
\begin{aligned}
\ln Q_{it} &= \beta_1 Out_{it-1} \times \ln SPILLTECH^{tot}_{it-1} + \beta_2 Ins_{it-1} \times \ln SPILLTECH^{tot}_{it-1} \\
&+ \beta_3 Out_{it-1} \times \ln SPILLSIC^{tot}_{it-1} + \beta_4 Ins_{it-1} \times \ln SPILLSIC^{tot}_{it-1} + \\
&+ \beta_5 Ins_{it-1} \times \ln SPILLTECH^{par}_{it-1} + \beta_6 Ins_{it-1} \times \ln SPILLSIC^{par}_{it-1} \\
&+ \beta_7 Ins_{it-1} + \beta_8 \mathbb{X}_{it-1} + u_{it}, \qquad (8)
\end{aligned}
$$

where Q_{it} is one of the firm performance indicators (market value, citation-weighted patents, productivity and R&D). Ins_{it-1} and Out_{it-1} are dummy variables, indicating whether firm i is an insider and an outsider, respectively, at time $t-1$. $\mathbb{X}_{it-1}$ contains control variables and fixed-effects. It includes a sixth-order Taylor approximation to a firms' R&D stock divided by its assets (Griliches, 1981; Bloom et al., 2013), industry sales and lagged industry sales as well as fixed effects for firms and for years. Finally, u_{it} is an error term which is allowed to be heteroskedastic and autocorrelated.

Equation 8 is the most comprehensive form of our model, encompassing four different specifications depending on the imposed restrictions. First, we replicate BSV's analysis by estimating the specification reported in table (2) of their paper, where the technology and product market spillover effects are the same for both RJV insiders and outsiders ($\beta_1 = \beta_2$ and $\beta_3 = \beta_4$) and all the RJV-related terms are set to zero ($\beta_5 = \beta_6 = \beta_7 = 0$).[7] Second, we separate out the effect of the (total) technology and product market spillovers for RJV insiders and outsiders, while adding to our model a dummy variable indicating whether the firm is an RJV insider. We thus include a differential effect for RJV participation, without distinguishing the spillover pools of the other firms (including both insiders and outsiders). Third, we estimate a specification allowing for incremental spillover pools of the RJV partners of the insiders, but without including a differential effect for RJV participation ($\beta_1 = \beta_2$ and $\beta_3 = \beta_4$). Fourth and finally, we allow for maximum heterogeneity by allowing the spillovers to have different coefficients between RJV insiders and outsiders, while at the same time including the incremental spillover effects of the partners in the model.

As RJV participation has to be treated as endogenous, we employ a set of exclusion restrictions. Specifically, we implemented a model of endogenous treatment, where the firm's RJV status is determined by firm- and state-specific R&D tax discounts. Firms in the sample are eligible for both federal and state-level R&D tax incentives. As the former are determined through firm-level interactions with federal tax rules and the latter through the spatial distribution of a firms' inventors across states, the two channels can be decomposed (see Appendix B.3 of Bloom et al.

[7] We follow Bloom et al. (2013) and use a Newey-West estimator allowing for autocorrelation of lag 1 in the Tobin's Q, sales and R&D regressions and a negative binomial model for patents. Since they show that accounting for the potential endogeneity of the spillover variables does not change their results, we do not replicate this step.

(2013) for details). Additionally, we use an instrument for RJV participation proposed by Helland and Sovinsky (2019). In particular, the introduction of leniency programs in 1993 made RJV participation, ceteris paribus, easier; therefore we add a post-93 dummy as additional instrument for RJV participation. Finally, we follow Duso et al. (2014) and consider a firm's lagged stock of patents as a proxy for how efficiently it innovates and, thus, as a potentially important determinant of RJV participation. The full information maximum likelihood estimator, implemented in the endogenous treatment regression model, allows us to account for the endogeneity of the RJV dummy, both when we consider it as a separate variable and in interaction with the technological and product market R&D pools.[8]

4 Empirical Results

Market value

Table 2 reports the spillover effects of R&D on market value, i.e., on Tobin's Q. The first column replicates BSV's results: there is a positive and significant impact of technologically close companies' R&D on a firm's value and a negative and significant impact of the R&D of companies close in the product market space (the "business stealing" effect). The second column shows that the positive impact of technology spillovers is larger, while the negative effect of the product market spillovers is smaller, for RJV insiders than for outsiders. This is consistent with the view that RJV participation increases absorptive capacity in such a way to benefit more from the R&D of technology close firms. At the same time, participation helps to shelter from the R&D of product market competitors. Differences between the effects on insiders and outsiders, however, are not large.

[Insert table 2 about here]

The third column shows that the pool of product market spillovers of closely related partners has a lower negative effect on firm value than the pool of non-partners. Conversely, the pool of technology spillovers of partners is not significantly different from the pool of non-partners. In other words, the business stealing effect is mitigated through RJV participation, whereas the positive technology spillovers are not affected. Finally, the fourth and last column shows that all these results stay virtually the same when we run our full specification.

[8] For Tobin's Q, sales and R&D, we implement the *etregress* command in Stata and estimate clustered standard errors at the firm level, which account for heteroskedasticity and autocorrelation. For patents, we implement the endogenous selection approach by estimating the inverse Mills' ratio and including it as a regressor in the negative binomial model.

Note also that RJV participation by itself has a positive impact on a firm's value in column (3), but there is no significant impact in the specifications reported in column (2) and (4). This might indicate that the effect of RJV participation runs actually through the technology and product market spillovers. Finally, the selection equation for RJV participation entails reassuring results. Our proposed instruments are significant drivers of firm's decision to join a RJV in the expected way: Higher R&D state taxes significantly reduce participation, while the initial stock of patents as well as the introduction of the leniency program significantly increase RJV participation.

Citation-weighted patents

Table 3 reports the same specifications but now with patent citations as outcome variable. Similarly as above, column (1) replicates BSV, and shows that technology spillovers increase patenting, whereas product market spillovers do not affect it. Perhaps surprisingly, the effects of RJV participation are unclear. Column (2) shows that RJV insiders produce less patents as a result of the total pool of technology spillovers than RJV outsiders. However, as shown in the full specification in column (4), this may be due to the negative effects of the pool of technology spillovers of the RJV partners. In the full specification, RJV insiders produce, overall, more patents as a result of technology spillovers than RJV outsiders. There is also no direct impact of RJV participation on a firm's patent production.

[Insert table 3 about here]

Sales

Table 4 reports the same regressions with sales as outcome variable. As in BSV, we find a positive and significant impact of technologically close companies' R&D on firms' sales, whereas the effects of the R&D of close competitors are insignificant. The second column shows that the positive impact of the total technology spillovers is larger for RJV insiders than for outsiders. Thus, RJV participation not only increases firm value but also sales, possibly thanks to greater absorptive capacity. Finally, the differential effect of the pool of technology spillovers of the RJV partners has a positive and slightly significant effect on a firm's sales, but this effect vanishes in the full specification. There is also no direct impact of RJV participation on a firm's sales.

[Insert table 4 about here]

R&D

Finally, table 5 reports the same regressions with R&D expenses as outcome variable. As in BSV, column (1) reports a positive and significant impact of close competitors' R&D on a given firm's R&D expenses, thus making R&D activities complementary. Column (2) shows that the effects of the total pool of product market spillovers is stronger for R&D insiders than for the outsiders. As in BSV, the total technology spillovers do not significantly affect R&D. But, interestingly, the effects for both insiders and outsiders become significant, and larger for the insiders (column (2)). Similarly, the effect of the pool of product market spillovers of non-partners becomes significantly positive while the effect of the pool of closely related partners is even more positive (column (3)). Instead, the effect of the pool of technology spillovers of closely related partners is less positive. These results are consistent with the idea that research collaborators are able to cut wasteful duplication of R&D among technologically close companies, whereas this is not the case among product market competitors. All these results remain the same in the full specification (column (4)). Note further that RJV participation on itself has a robust and negative impact on R&D spending, which is in line with RJV participation helping to cut wasteful duplication.

[Insert table 5 about here]

5 Conclusion

In this paper, we assess to what extent firms' collaboration through RJVs constitutes a mechanism that alters the effect of technology as well as product market spillovers on several performance outcomes. We build on the framework proposed by Bloom et al. (2013) and allow a more flexible model with RJV participation. We analyze two ways through which RJVs might enhance or mitigate spillovers. First, the spillover effects may be different for RJV insiders or outsiders, e.g., because RJV participation increases a firm's absorptive capacity. Second, the R&D pool of RJV partners might have a differential impact on a firm if compared to the R&D of non-partners.

Our results confirm the important role of RJV collaboration as a mechanism to internalize spillovers. First, we find that collaboration in a RJV enhances absorptive capacity of its members in both the technology and product market spaces. Moreover, RJV participation also has the beneficial effect of reducing wasteful duplication of R&D expenditures. Perhaps a bit surprisingly, these effects on R&D are not reflected in the next step of the innovation process, i.e., patent activity. Nonetheless, RJV participation has a significant impact on market outcomes such as sales and to an even larger extent on a firm's value (Tobin's Q).

The industrial organization and innovation literatures have long recognized that firms' innovation cooperation within RJVs is one of the most important channels through which firms can appropriate the positive returns from R&D. By confirming this intuition, our analysis implements the perhaps most natural step to answer BSV's call to investigate how mechanisms of knowledge transfer might shape both technology and product market spillovers. This might be particularly useful as it can further help discussing and analyzing the impact of policies that are specifically implemented to support R&D.

References

Anton, M., F. Ederer, M. Gine, and M. C. Schmalz (2018). Innovation: The bright side of common ownership? *Available at SSRN 3099578*.

Bena, J. and K. Li (2014). Corporate innovations and mergers and acquisitions. *The Journal of Finance 69*(5), 1923–1960.

Bloom, N., M. Schankerman, and J. Van Reenen (2013). Identifying technology spillovers and product market rivalry. *Econometrica 81*(4), 1347–1393.

Branstetter, L. G. and M. Sakakibara (2002). When do research consortia work well and why? evidence from japanese panel data. *American Economic Review*, 143–159.

Cassiman, B. and R. Veugelers (2002). R&d cooperation and spillovers: some empirical evidence from belgium. *American Economic Review*, 1169–1184.

d'Aspremont, C. and A. Jacquemin (1988). Cooperative and noncooperative r & d in duopoly with spillovers. *The American Economic Review*, 1133–1137.

Duso, T., L.-H. Röller, and J. Seldeslachts (2014). Collusion through joint r&d: An empirical assessment. *Review of Economics and Statistics 96*(2), 349–370.

Gomes-Casseres, B., J. Hagedoorn, and A. B. Jaffe (2006). Do alliances promote knowledge flows? *Journal of Financial Economics 80*(1), 5–33.

Griliches, Z. (1981). Market value, r&d, and patents. *Economics letters 7*(2), 183–187.

Hall, B. H., J. Mairesse, and P. Mohnen (2010). Measuring the returns to r&d. In *Handbook of the Economics of Innovation*, Volume 2, pp. 1033–1082. Elsevier.

Helland, E. and M. Sovinsky (2019). Do research joint ventures serve a collusive function?

Kamien, M. I., E. Muller, and I. Zang (1992). Research joint ventures and r&d cartels. *The American Economic Review*, 1293–1306.

Kamien, M. I. and I. Zang (2000). Meet me halfway: research joint ventures and absorptive capacity. *International journal of industrial organization 18*(7), 995–1012.

Link, A. N. (1996). Research joint ventures: patterns from federal register filings. *Review of Industrial Organization 11*(5), 617–628.

Lucking, B., N. Bloom, and J. Van Reenen (2018). Have r&d spillovers changed? Technical report, National Bureau of Economic Research.

6 Tables

Table 1: Summary statistics

	Mean	P10	P50	P90	SD	Obs
Tobins Q	2.47	0.56	1.49	5.04	3.11	9944
Cite-weighted patents	114.05	0.00	3.00	169.00	584.46	9389
Sales	3337.50	45.00	533.00	7482.00	10420.37	9869
R&D	106.35	0.00	5.00	157.00	480.55	9944
$SPILLSIC_{it}^{tot}$	1291.84	10.66	362.70	3897.30	2101.11	9944
$SPILLTECH_{it}^{tot}$	4568.53	879.92	3625.99	9573.05	3705.03	9944
$SPILLSIC_{it}^{par}$	99.44	0.00	0.00	27.97	461.90	9944
$SPILLTECH_{it}^{par}$	339.73	0.00	0.00	632.60	1199.95	9944
Market value	4400.69	27.40	464.47	8760.28	17468.55	9944
R&D Stock	628.34	0.00	31.52	1000.92	2812.30	9944
Total assets	4500.08	37.59	422.16	8229.00	19632.10	9944
Employees	18.06	0.39	3.75	40.81	53.05	9790
Patent count	18.04	0.00	1.00	31.00	84.33	9944

Notes: Table reports means, 10^{th}, 50^{th} and 90^{th} percentiles, as well as the standard deviation. Monetary values are in million 1996 USD.

Table 2: Spillover effects on Tobin's Q

	(1)	(2)	(3)	(4)
$\ln SPILLTECH^{tot}_{it-1}$	0.381***		0.336***	
	(0.11)		(0.09)	
$Out_{it-1} \times \ln SPILLTECH^{tot}_{it-1}$		0.318***		0.323***
		(0.09)		(0.09)
$Ins_{it-1} \times \ln SPILLTECH^{tot}_{it-1}$		0.374***		0.412***
		(0.09)		(0.10)
$\ln SPILLSIC^{tot}_{it-1}$	-0.083***		-0.085***	
	(0.03)		(0.02)	
$Out_{it-1} \times \ln SPILLSIC^{tot}_{it-1}$		-0.089***		-0.087***
		(0.02)		(0.02)
$Ins_{it-1} \times \ln SPILLSIC^{tot}_{it-1}$		-0.047*		-0.066**
		(0.03)		(0.03)
$Ins_{it-1} \times \ln SPILLSIC^{par}_{it-1}$			-0.007	-0.030
			(0.02)	(0.02)
$Ins_{it-1} \times \ln SPILLTECH^{par}_{it-1}$			0.023***	0.018***
			(0.01)	(0.01)
Ins_{it-1}		-0.357	0.484***	-0.339
		(0.31)	(0.15)	(0.31)
RJV				
R&D tax firm		-0.417	-0.417	-0.412
		(0.29)	(0.29)	(0.29)
R&D tax state		-3.336***	-3.338***	-3.333***
		(0.27)	(0.27)	(0.27)
Initial patents		0.306***	0.308***	0.307***
		(0.01)	(0.01)	(0.01)
RJV leniency		0.460***	0.462***	0.460***
		(0.04)	(0.04)	(0.04)
Observations	9944	9944	9944	9944
Firm fixed effects	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓

Notes: Standard errors in parentheses are robust to heteroskedasticity. Column (1) is an exact replication of Bloom et al. (2013); column (2) controls for selection into RJVs and allows for differential slopes and constants between members and non-members; column (3) imposes common slopes for total spillovers, but allows for an additional effect from partner spillovers; column (4) allows all slopes to vary. All specifications contain fixed-effects at the firm and year levels.

Table 3: Spillover effects on patent citations

	(1)	(2)	(3)	(4)
$\ln SPILLTECH^{tot}_{it-1}$	0.468***		0.472***	
	(0.08)		(0.08)	
$Out_{it-1} \times \ln SPILLTECH^{tot}_{it-1}$		0.469***		0.468***
		(0.08)		(0.08)
$Ins_{it-1} \times \ln SPILLTECH^{tot}_{it-1}$		0.382**		0.529***
		(0.18)		(0.19)
$\ln SPILLSIC^{tot}_{it-1}$	0.056		0.052	
	(0.04)		(0.04)	
$Out_{it-1} \times \ln SPILLSIC^{tot}_{it-1}$		0.051		0.048
		(0.04)		(0.04)
$Ins_{it-1} \times \ln SPILLSIC^{tot}_{it-1}$		0.097		0.089
		(0.07)		(0.08)
$Ins_{it-1} \times \ln SPILLTECH^{par}_{it-1}$			-0.096	-0.113*
			(0.06)	(0.06)
$Ins_{it-1} \times \ln SPILLSIC^{par}_{it-1}$			0.035	0.026
			(0.02)	(0.03)
Ins_{it-1}		-1.289	-0.952	-1.731
		(1.83)	(0.89)	(1.78)
RJV				
R&D tax firm		0.0490	0.0490	0.0490
		(0.33)	(0.33)	(0.33)
R&D tax state		3.555***	3.555***	3.555***
		(0.27)	(0.27)	(0.27)
Initial patents		0.316***	0.316***	0.316***
		(0.01)	(0.01)	(0.01)
RJV leniency		0.392***	0.392***	0.392***
		(0.04)	(0.04)	(0.04)
Observations	9023	9023	9023	9023
Firm fixed effects	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓

Notes: Standard errors in parentheses are robust to heteroskedasticity. Column (1) is an exact replication of Bloom et al. (2013); column (2) controls for selection into RJVs and allows for differential slopes and constants between members and non-members; column (3) imposes common slopes for total spillovers, but allows for an additional effect from partner spillovers; column (4) allows all slopes to vary. All specifications contain fixed-effects at the firm and year levels.

Table 4: Spillover effects on sales

	(1)	(2)	(3)	(4)
$\ln SPILLTECH^{tot}_{it-1}$	0.191***		0.181***	
	(0.05)		(0.04)	
$Out_{it-1} \times \ln SPILLTECH^{tot}_{it-1}$		0.179***		0.178***
		(0.04)		(0.04)
$Ins_{it-1} \times \ln SPILLTECH^{tot}_{it-1}$		0.220***		0.213***
		(0.04)		(0.04)
$\ln SPILLSIC^{tot}_{it-1}$	-0.005		-0.007	
	(0.01)		(0.01)	
$Out_{it-1} \times \ln SPILLSIC^{tot}_{it-1}$		-0.006		-0.006
		(0.01)		(0.01)
$Ins_{it-1} \times \ln SPILLSIC^{tot}_{it-1}$		-0.009		-0.009
		(0.01)		(0.01)
$Ins_{it-1} \times \ln SPILLSIC^{par}_{it-1}$			0.011**	0.004
			(0.01)	(0.01)
$Ins_{it-1} \times \ln SPILLTECH^{par}_{it-1}$			-0.001	-0.000
			(0.00)	(0.00)
Ins_{it-1}		-0.233	0.049	-0.210
		(0.14)	(0.06)	(0.14)
RJV				
R&D tax firm		-0.381	-0.389	-0.381
		(0.32)	(0.32)	(0.32)
R&D tax state		-3.466***	-3.469***	-3.463***
		(0.28)	(0.28)	(0.28)
Initial patents		0.300***	0.301***	0.300***
		(0.01)	(0.01)	(0.01)
RJV leniency		0.420***	0.421***	0.420***
		(0.04)	(0.04)	(0.04)
Observations	9935	9935	9935	9935
Firm fixed effects	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓

Notes: Standard errors in parentheses are robust to heteroskedasticity. Column (1) is an exact replication of Bloom et al. (2013); column (2) controls for selection into RJVs and allows for differential slopes and constants between members and non-members; column (3) imposes common slopes for total spillovers, but allows for an additional effect from partner spillovers; column (4) allows all slopes to vary. All specifications contain fixed-effects at the firm and year levels.

Table 5: Spillover effects on R&D

	(1)	(2)	(3)	(4)
$\ln SPILLTECH^{tot}_{it-1}$	0.100		0.118**	
	(0.08)		(0.06)	
$Out_{it-1} \times \ln SPILLTECH^{tot}_{it-1}$		0.102*		0.108*
		(0.06)		(0.06)
$Ins_{it-1} \times \ln SPILLTECH^{tot}_{it-1}$		0.112*		0.141**
		(0.06)		(0.07)
$\ln SPILLSIC^{tot}_{it-1}$	0.083**		0.078***	
	(0.03)		(0.03)	
$Out_{it-1} \times \ln SPILLSIC^{tot}_{it-1}$		0.070**		0.071***
		(0.03)		(0.03)
$Ins_{it-1} \times \ln SPILLSIC^{tot}_{it-1}$		0.125***		0.102***
		(0.03)		(0.03)
$Ins_{it-1} \times \ln SPILLSIC^{par}_{it-1}$			-0.024**	-0.032***
			(0.01)	(0.01)
$Ins_{it-1} \times \ln SPILLTECH^{par}_{it-1}$			0.027***	0.020***
			(0.00)	(0.01)
Ins_{it-1}		-0.837***	-0.221**	-0.694***
		(0.25)	(0.10)	(0.26)
RJV				
R&D tax firm		0.983***	0.957***	0.961***
		(0.28)	(0.28)	(0.28)
R&D tax state		-4.931***	-4.921***	-4.928***
		(0.25)	(0.25)	(0.25)
Initial patents		0.284***	0.284***	0.284***
		(0.01)	(0.01)	(0.01)
RJV leniency		0.398***	0.398***	0.399***
		(0.04)	(0.04)	(0.04)
Observations	8579	8579	8579	8579
Firm fixed effects	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓

Notes: Standard errors in parentheses are robust to heteroskedasticity. Column (1) is an exact replication of Bloom et al. (2013); column (2) controls for selection into RJVs and allows for differential slopes and constants between members and non-members; column (3) imposes common slopes for total spillovers, but allows for an additional effect from partner spillovers; column (4) allows all slopes to vary. All specifications contain fixed-effects at the firm and year levels.