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Abstract: Though there is a body of theoretical literature on research joint venture (RJV) participation facilitating collusion, empirical tests are rare. Even more so, there are few empirical tests on the general theme of collusion. This note tries to fill this gap by assuming a correspondence between the stability of research joint ventures and collusion. By using data from the US National Cooperation Research Act, we show that large RJVs in concentrated industries are more stable and hence more suspect to collusion.

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1. Introduction

Although joint R&D activities among firms are encouraged everywhere today, the same old suspicion still lingers: does cooperation in R&D facilitate product market collusion? Given that so many firms participate in research joint ventures (RJVs), it is important to get a clearer view on this issue. On a more general level, empirical studies testing the theoretical predictions of collusion are relatively rare because of problems of selection bias and a lack of adequate data (Levinstein and Suslow, 2006). This paper constructs and applies an indirect test of collusion through RJVs.

We build upon the conjecture that RJVs may facilitate product market collusion.[1] A necessary condition for RJVs to be used as collusive devices seems their *stability*. Cabral (2000, p1041), for example, states that "Firms may delay innovation [and stay in the RJV] with the sole purpose of maintaining a sufficiently credible punishment for cheating on the price agreement".[2] Indeed, RJVs make collusion in the product market easier, but only when participants are effectively able to use the RJV as a coordination or punishment device. When a firm is observed to leave the RJV, it is likely that the intended collusion was not sustainable or that the RJV was started for reasons unrelated to collusion. Similarly, the stability of collusive agreements is negatively affected by a firm's entry (Vasconcelos, 2004). Therefore, when a firm enters an RJV after its initial formation, it is less likely that this RJV (still) serves collusion.

Suspicion of collusion is especially relevant for *large-scale cooperations between firms operating in the same industry*. In a general context, Stigler (1950) realized that firms outside the collusive agreement have incentives to freeride, which makes relatively smaller agreements

[1] RJVs may induce collusion through creating common assets – and therefore common interests – among participating firms and provide therefore a credible punishment mechanism (Cabral, 2000; Martin, 1995). This idea is reminiscent of Bernheim and Whinston's (1990) theory of multi-market contact: firms that interact in more than one market are able to sustain collusion more easily. RJVs may further induce collusion when being used as a vehicle for the transmission of information to signal cooperative behavior (Cooper and Ross, 2007).

[2] Martin (1995, p. 734) makes a similar argument: "The threat to break up an R&D joint venture can form part of a fallback strategy that will sustain tacit collusion on product markets." Catilina and Feinberg (2006) model RJV participation and collusion decisions as a coalition formation game. They find that when both decisions are taken simultaneously, the stability of the RJV and product market collusion are one-to-one related.

unstable. Therefore, it is hypothesized that more RJV participants increase the stability of the RJV. Noticeably, large RJVs *in high concentration industries* are of concern. Both higher rewards of colluding and easier detection of defection make these industries more interesting for collusion (Ordover and Baumol, 1988; Levinstein and Suslow, 2006). This leads us to test if the stability of the RJV, and hence, as supposed, the incidence of collusion, is significantly affected by industry concentration when the RJV is relatively large.

To be fair, large research collaborations may serve their purpose, i.e. induce more research and learning. These learning dynamics lead firms to exit (Reuer and Zollo, 2005) and new firms to enter in the expectation to learn in this RJV. Therefore, we set as a necessary condition for a large RJV to be research-active (as opposed to facilitating collusion) its *non-stability*. Non-profit entities, such as universities and governmental research bodies, do not compete with firms in the product market. It seems therefore clear that their presence has a positive impact on (expectations of) learning (Sinha and Cusumano, 1991), but a negligible impact on collusive effects. We thus propose a second test to see whether large RJVs with non-profit members are less prone to be stable, and thus more likely to be research-active.

The collaborations we investigate are set up under the US National Cooperative Research Act (NCRA). By granting certain antitrust exemptions, the NCRA stimulates firms operating in the same industry to cooperate in R&D on a large scale. The aim of the NCRA is to provide a solution to perceived competitive threats to U.S. high-tech industries, and has been a great success (see e.g. Vonortas, 1997). But, given their large scale and that members are competitors, there may be particular suspicion of firms using the NCRA-RJVs as vehicles for product market collusion, which makes them of particular interest for our study.

We build a simple econometric framework to determine which factors explain an RJV's stability. Controlling for the heterogeneity due to size differences through size dummies, we investigate in a probit regression whether large RJVs' stability is affected in a different way by their product market's HHI and the presence of non-profit members. We control for other characteristics – including industry and year of formation dummies – that we expect to influence the probability of stability.

The results indicate that RJVs are more stable in highly concentrated industries, but only when the RJVs are relatively large; the suspicion of collusion may therefore be justified. We also find some support for a negative impact of non-profit entities on the stability of the larger RJV. Given our results, it is desirable to go into more detail about which of these NCRA-RJVs can be identified as vehicles for collusion. Goeree and Helland (2007) also provide some recent (indirect) empirical support for the hypothesis that RJVs facilitate collusion. Analyzing NCRA-RJVs in the telecom industries, their paper exploits the variation in RJV formation generated by a more stringent U.S. antitrust stance towards collusion. If product market collusion is not a motivation to form an RJV, they argue, the propensity to enter into an RJV should not be affected by this change. By finding a lower RJV-participation after the policy, the authors conclude, as our study does through a different test using information on all sectors, that the NCRA-RJVs are suspect of being used for collusion.

The structure of the paper is as follows. The next section discusses data and modeling issues. Section 3 discusses the main findings. Finally, in section 4, we conclude.

2. Data and Modeling Issues

Our main data set consists of information on the 785 formed NCRA-RJVs over the period 1985-1999. Among the RJVs formed under the NCRA, slightly more than two-thirds (548) did not experience the entry or exit of any firm in any year of existence after their initial formation. We therefore define the main variable of interest to be a dummy (STABLE) that takes on the value of one if the RJV did not experience any in-and-out movement during its lifespan, and zero otherwise. By doing this, we implicitly consider the entire RJV's life as a single observational point. This is not crucial for the issue we want to study. Indeed, time does not play an important role in the analysis, as we are interested in questioning why *no changes* occurred during the sample period.[3]

We then matched the RJV data with the Compustat North America database containing information on about 22,000 public U.S. firms (1986-1999). Each NCRA-RJV is linked to an industry by using the assigned RJV's SIC2 code and the year as matching keys. For each industry (defined at the SIC2 level) and for each year, we calculate a measure of concentration (HHI), as well as medians and standard deviations for several other indicators, such as number of employees and R&D intensity. Given that we collapse the RJV's life into one observation, we average the according industry characteristics over the number of periods for which the RJV is observed. While table 1 gives a short description of the main variables, in table 2 we report preliminary statistics for some relevant characteristics in the two sub-samples of stable vs. unstable RJVs. The central point of this note is to connect an RJV's behavior to its product market's concentration. Stable RJVs are found in slightly less concentrated industries; the HHI equals 0.07 in the stable sub-sample vs. 0.08 in the non-stable sub-sample (see table 2). A second factor of interest is how an RJV's stability is linked to the number of non-profit members. Stable RJVs are found to include fewer non-profit entities (NON_Profit equals 0.33 vs. 0.75). We further control for relevant industry variables, as well as for the number of links an RJV has with other RJVs (for a detailed discussion of these variables, see Duso et al., 2007).

The most eye-catching difference between stable and non-stable RVs, however, is the fact that stable RJVs are almost three times smaller than unstable ones in terms of participating for-

[3] Time might play a role in the sense that different RJVs are observed for a different number of time periods in the sample. We therefore control in the regressions for this issue by means of year-of-formation dummies.

profit firms in the year of RJV-formation (SIZE: 6.4 vs. 16.4 respectively).[4] This is of course a statistical artifact since initially larger RJVs have, all else being equal, a higher probability of experiencing the exit of one of its members; we therefore have a closer look at the frequency of stable RJVs in relation to their size in table 3. Although the frequency of stable RJVs decreases almost steadily with the number of for-profit members, a sizeable proportion of medium-sized and large RJVs is stable. Hence, to assess the drivers of stability, we need to control for the heterogeneity due to size differences. For this purpose, in our statistical analysis we partition the RJVs into three size classes: *small* (up to three initial for-profit members), *medium* (4 to 9 initial for-profit members), and *large* (more than 10 initial for-profit members).[5]

We now propose a simple econometric framework to determine which factors explain an RJV's stability. We first control for the heterogeneity due to size differences through dummies for size classes (s_j). Second, we account for the fact that an RJV's size might affect in a different way how product market's and RJV's characteristics influence its stability. Indeed, we argue that research cooperations might be used as a coordination device to collude in the product market, and that this problem may be more relevant when the RJV is large and embedded in a more concentrated industry. Second, we contend that learning might create dynamics in RJVs, where this is more likely to happen in large RJVs with more non-profit organizations participating. Hence, we model a size-dependent impact of product market concentration (HHI) as well as the number of non-profit members (NON_PROFIT) on an RJV's stability. Finally, we control for other characteristics (X) – including industry and year of formation dummies – that we expect to

[4] We focus on initial size to explain whether an RJV is stable along its lifetime in order to avoid endogeneity problems. Furthermore, initial size seems a more natural choice than, for example, the average number of firms participating in the RJV over its existence since it allows us to predict an RJV's behavior just by looking at its initial composition. For a full analysis of RJV dynamics, see Duso et al. (2007).

[5] While it is clear that RJVs with up to 3 members are qualitatively different from the others in terms of dynamics, the definition of medium-sized RJVs is subjective. We chose to define as large RJV the top 20% of the size distribution. However, we tried with other classifications --including more size classes-- and the qualitative results were not affected.

influence the probability of stability. The probit regression to explain why RJV *i* in size class *j* is stable, is therefore the following

$$STABLE_i = \sum_{j|j\neq SMALL} \alpha_j s_{ij} + \sum_{\mathrm{j}} \beta_{\mathrm{j}} s_{ij} HHI_i + \sum_{j} \gamma_{\mathrm{j}} \mathrm{s_{ij}} \mathrm{NON\_PROFIT_i} + \delta\, \mathrm{X}_i + \varepsilon_i, \qquad (1)$$

where ε_i is a i.i.d. error term.

3. Results

Table 4 reports the results of the Probit estimation of equation (1). As expected, the probability of being stable decreases with the size groups: Medium and large RJVs have respectively 48% and 79% lower probability of being stable than small RJVs.

Large RJVs may be used as a vehicle for collusion in the product market, and stability of these large collaborations is a necessary condition for this to be true. Consistent with this idea, we estimate a strongly positive and statistically significant effect of the industry's concentration on the probability of being stable, and this *only for large RJVs*; a 10% increase in the HHI induces a 27% higher probability of a large RJV being stable. Interestingly, this effect is not significant for medium and small RJVs, which provides further evidence for our claim that especially large RJVs may be potentially used as a vehicle for collusion. Second, the presence of non-profit entities significantly decreases the probability of being stable, yet again only for large RJVs; a 10% increase in the log of the number of non-profit insiders decreases the probability of being stable by almost one percent. This suggests that large RJVs with non-profit organizations are effectively used for the main purpose of the NCRA. Firms cooperate in R&D and learn, which leads firms to exit and new firms to enter in the expectation to also learn.

Other industry characteristics also matter for stability, yet their effects do not depend on the size.[6] First, industry size asymmetries appear to increase stability. Second, the probability of being stable significantly decreases by 63% in the high-tech software industries, suggesting a more active learning in these potentially high-spillover industries. Finally, our model is performing well in predicting RJVs' behavior; it correctly classifies more than 83% of the observations and, most interestingly for this study, over 90% of the stable RJVs.

4. Conclusions

By using data from the U.S. National Cooperation Research Act, it is shown that large RJVs in concentrated industries are more stable and hence more suspect to collude. Large RJVs in which many non-profit organizations participate, on the other hand, have a lower propensity to be stable and are expected to mainly exist for research purposes. On a more methodological level, ours may be seen as an alternative test for collusive behavior through RVJ participation, which does not suffer from the typical problems of direct tests.

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[6] We tested whether the coefficients were size dependent. Given that it was not the case, we estimated an average effect, which allows a more efficient estimation.

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Table 1. Description of the Variables Used in the Regressions

Variable	Description
STABLE	Dummy equal to one if the RJV did not experience the entry or exit of any firm in any year after its formation
SIZE	Number of for profit participants in the RJV in its formation year.
NON_PROFIT	Number of non-profit participants in the RJV in its formation year.
HHI	Herfindahl index in a SIC2 industry based on sales, averaged over the RJV lifespan.
FIRM_SIZE	Median of employees at the SIC2 industry level (in thousand), averaged over the RJV lifespan.
FIRM_SIZE_sd	Standard deviation of employees at the SIC2 industry level (in thousand), averaged over the RJV lifespan.
R&D INTENSITY	Median R&D intensity (R&D expenditures/sales), averaged over the RJV lifespan.
HightechM	Dummy=1 if the industry is high-tech manufacturing industry according to the AeA[7] (SIC4: 3571, 3572, 3577, 3651, 3663, 3669, 3671, 3672, 3678, 3679, 3821, 3823, 3825, 3826, 3829, 3827, 3861, 3812, 3844, 3845)
HightechC	Dummy=1 if the industry was high-tech communications industry according to the AeA (SIC4 codes: 4812, 4813, 4822, 4841, 4899)
HightechS	Dummy=1 if the industry was high-tech software industry according to the AeA (SIC4 codes: 7371, 7372, 7373, 7375, 7376, 7379)
LINKS	Number of links (i.e. average number of other RJVs where insiders in RJV i are present in time t), averaged over the RJV lifespan.

Table 2. Preliminary Statistics – Variables used in the Regressions

	Stable				Unstable			
	Mean	**St.Dev.**	**Min**	**Max**	**Mean**	**St.Dev.**	**Min**	**Max**
SIZE	6.42	13.37	1	159	16.4	23.75	1	180
NON_PROFIT	0.33	1.47	0	18	0.75	4.51	0	52
LINKS	27.21	25.28	1	123	30.30	29.53	1	122
HHI	0.07	0.06	0.01	0.79	0.08	0.07	0.01	0.72
FIRM_SIZE	0.83	0.82	0.01	5.93	0.96	1.15	0.02	5.35
FIRM_SIZE_sd	2.80	0.89	0.46	4.54	2.52	0.97	-1.67	4.50
R&D intensity	0.07	0.07	0	0.31	0.07	0.08	0	0.31
hightechM	0.16	0.37	0	1	0.07	0.25	0	1
hightechC	0.17	0.37	0	1	0.07	0.26	0	1
hightechS	0.05	0.22	0	1	0.14	0.35	0	1
Obs		548				237		

[7] The high-tech industries have been identified according to the American Electronics Association (AeA) classification (http://www.aeanet.org/Publications/IDMK_definition.asp).

Table 3. RJVs' Size Distribution and Stability

Number of initial for-profit insiders (SIZE)	Stable	Unstable	Size Classes
1	24 96.00 %	1 4.00 %	**Small RJVs (342)**
2	207 97.18 %	6 2.82 %	
3	89 85.58 %	15 14.42 %	
4	46 65.71 %	24 34.29 %	**Medium RJVs (282)**
5	35 45.45 %	42 54.55 %	
6	33 71.74 %	13 28.26 %	
7	14 45.16 %	17 54.84 %	
8	20 58.82 %	14 41.18 %	
9	13 54.17 %	11 45.83 %	
10 or more	67 41.61 %	94 58.39 %	**Large RJVS (161)**
Total	548 69.81 %	237 30.19 %	785

Table 4. Probit Regression: The probability of Stability

	Coefficient	Marginal Effect	Std.Error	
SIZE MEDIUM	-1.479	-0.477	0.282	***
SIZE LARGE	-2.545	-0.790	0.341	***
HHI * SMALL	-1.685	-0.482	1.866	
HHI * MEDIUM	2.463	0.704	1.892	
HHI * LARGE	9.611	2.749	3.499	***
NON_PROFIT*SMALL	0.050	0.014	0.300	
NON_PROFIT*MEDIUM	-0.011	-0.003	0.216	
NON_PROFIT *LARGE	-0.296	-0.085	0.153	*
ENTRY_SIC2	4.168	1.192	4.399	
EXIT_SIC2	-19.789	-5.660	13.188	
FIRM_SIZE	-0.215	-0.061	0.266	
FIRM_SIZE_sd	0.472	0.135	0.240	**
R&D-INTENSITY	-0.212	-0.061	3.483	
hightechM	-0.115	-0.034	0.249	
hightechC	0.024	0.007	0.356	
hightechS	-1.699	-0.602	0.521	***
LINKS	-0.030	-0.009	0.061	
# Obs		783		
Wald-Chi2		336.45		
Prob		0.0000		
pseudo-loglikelihood		-269.20		
pseudo-R2		0.44		
Sensitivity		90.68%		
Specificity		66.95%		
Correctly classified		83.52%		

All size variables are transformed into logs. We control for industry dummies and for the RJV's year of formation. The reported standard errors are computed using the robust/sandwich estimator. Significance at the 1%, 5%, 10% is represented by ***, **, and * respectively