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Ralph Siebert

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Wissenschaftszentrum Berlin für Sozialforschung gGmbH,
Reichpietschufer 50, 10785 Berlin, Tel. (030) 2 54 91 - 0

ABSTRACT

The Impact of Research Joint Ventures on Firm Performance:
An Empirical Assessment[*]

Research and Development Joint Ventures are based on cooperative agreements where firms share the costs and results of a particular research project. While theoretical analysis of research joint ventures on profits, R&D intensity, output and prices is more developed in the existing literature, few empirical investigations exist. This paper gives a first insight into the impact of research joint ventures on firms' profit margins. In addition, it investigates the degree to which different firm variables influence participation in research joint ventures (RJVs). For this purpose, 314 US research joint ventures registered from 1985 to 1992 are considered in the study. 2,923 unique cooperating firms and 13,186 noncooperating firms represent the basic sample. A descriptive comparison of cooperating and noncooperating firms finds that cooperating firms achieve a lower profit margin. In addition to this, larger firms are more likely to form RJV's on average. Regression analyses show that two offsetting effects influence the profit margin and that the R&D investments of cooperating firms have a higher impact on profits. Beyond that, the firm size has a positive and significant influence on RJV participation.

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ZUSAMMENFASSUNG

Die Auswirkung von Forschungs-Joint Ventures auf den Unternehmenserfolg: Eine empirische Beurteilung

Forschungs-Joint Ventures beruhen auf Kooperationsvereinbarungen, bei denen mehrere Unternehmen übereinkommen, Kosten und Nutzen eines bestimmten Forschungsprojekts zu teilen. Während zahlreiche theoretische Untersuchungen über Forschungs-Joint Ventures und deren Auswirkungen auf die Gewinne, die F&E-Intensität, den Output und die Preise vorliegen, mangelt es an einschlägigen empirischen Analysen. In dieser empirische Untersuchung, die sich auf nordamerikanische Daten stützt, wird analysiert, welche Faktoren Unternehmen veranlassen sich an Forschungs-Joint Ventures zu beteiligen und wie sich dies auf ihre Umsatzrentabilität auswirkt. Einbezogen werden 314 nordamerikanische Forschungs-Joint Ventures, die in der Zeit von 1985 bis 1992 ihre Kooperation angemeldet haben. 2923 unterschiedliche kooperierende Unternehmen und 13186 nichtkooperierende Unternehmen stellen die Grundgesamtheit der Auswahl dar. Ein deskriptiver Vergleich der beiden Unternehmensgruppen zeigt, daß kooperierende Unternehmen eine niedrigere Umsatzrentabilität erzielen. Im Durchschnitt nehmen eher große Unternehmen an einem Forschungs-Joint Venture teil. Regresssionsanalysen zeigen, daß zwei gegeneinander wirkende Effekte die Umsatzrentabilität beeinflussen. Die F&E-Investitionen der kooperierenden Unternehmen besitzen einen größeren Einfluß auf die Profite. Darüber hinaus übt die Unternehmensgröße einen positiven und signifikanten Einfluß auf die Teilnahme an Forschungs-Joint Ventures aus.

I. Introduction

More than forty years ago, John Kenneth Galbraith recognized that the era of cheap innovation was over, and that "because development is costly, it follows that it can be carried out only by a firm that has the resources associated with considerable size" (Galbraith (1952), p. 91f.) Furthermore, it has been asserted that even large firms do not have adequate resources to undertake unilateral development of some new technologies. As a consequence, firms often engage in joint developments. In practice we find an increasing number of coordinated R&D activities, even amongst potential competitors. Microelectronics and Computer Technology Corporation, a cooperation of 20 firms, was formed in January 1985 to develop advanced computer architecture. Another example is Kaleida Labs, Inc., a consortium of Kaleida, Apple and IBM, formed in May 1993 for the development of new multimedia software technologies. These consortia are examples of how investment problems have been overcome by the formation of research joint ventures.

In the literature, a research joint venture has been defined (very restrictively) as: "A (research) joint venture occurs when two or more firms join together to form a third, often with a particular (research) project in mind" (Schmalensee & Willig (1992), p. 437). The National Cooperative Research Act of 1984 (Department of Justice, Public Law, 98-462) defines a “joint research and development venture” as any group of activities, including attempting to make, making or performing a contract, by two or more persons for the purpose of-

(A) theortical 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..,

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

(E) any combination of the above.

We use this definition of a joint research and development venture (RJV) in the further setting, because we allow for an broader definition and because the *National Cooperative Research Act of 1985* is the source for the empirical part of this paper.

The incentive for private firms to invest in research and development (R&D) depends on various market factors. Firms invest in research and development in order to obtain the know-how to produce new products or to produce existing products more cheaply. While basic research is directed towards obtaining new fundamental knowledge, applied research is associated with product and process innovations. Product innovations create new goods and services while process innovations reduce the cost of producing existing products. This paper focuses on applied research, with emphasis on process innovations.

The advantages of forming a research joint venture can be summarized as follows. Firstly, costly research projects can be realized in a research joint venture, because the expenditures can be distributed among many firms **(cost-sharing effect).** Secondly, firms have the possibility of internalizing the externalities associated with R&D investment so that the incentive for investment can increase. Thirdly, the investment risk that exists because of uncertainty in demand can be reduced through RJVs. Fourthly, economies of scale as well as economies of scope in the R&D process can be exploited fully. Finally, research joint ventures take place because of synergy effects, as each firm contributes distinct capabilities and know-how to a research joint venture.

RJVs can therefore have positive effects on welfare. Cooperative R&D can eliminate wasteful duplication (compare, e.g., Grossman & Shapiro (1986)). Furthermore forming an RJV may increase the effective R&D investment since spillovers are exploited. Moreover, research joint ventures distribute R&D results more widely compared to individually performed R&D. Consumer surplus is increased as products are produced at lower costs by a larger number of firms. On the other hand there are also negative effects of RJVs on social welfare. Research joint ventures may lead to cartel-like behaviour in the product market. Finally, there could be dynamic market power effects. If a subset of firms form an RJV, more participating firms might gain additional market power. As a consequence, competition in the final product market might be reduced. Moreover, an RJV could be used to drive non-participating firms out of the market.

A descriptive comparison of cooperating and noncooperating firms finds that cooperating firms achieve a lower profit margin. In addition to this, larger firms are more likely to form RJVs on average. Regression analyses show that two offsetting effects influence the profit margin and that the R&D investments of cooperating firms have a higher impact on profits. Beyond that, the firm size has a positive and significant influence on RJV participation.

This paper is organized as follows. Section II reviews some of the models available in the literature, and Section III introduces the data and presents some descriptive statistics. Section IV presents two regression analyses and a Logit-estimation, and finally, Section V concludes.

II. The Theory of Research Joint Ventures

In this section four models of RJVs are presented. Each model describes the impact of R&D cooperation on R&D intensity, output, prices, profits and consumer surplus. D'Aspremont and Jacquemin (1988, 1990) present an analysis of cooperative and noncooperative research and development, related to a two-stage duopoly game with symmetric firms, taking into account technological spillovers. Cooperation in the research and development stage results in higher R&D intensity, a higher output level and higher profits than in a noncooperative case, provided that spillover parameters exceed a certain level. The models from Henriques (1990), DeBondt-Veugelers (1991),

Suzumura (1992) and Amir (1995) are based on the D'Aspremont and Jacquemin-Model.

Kamien, Muller and Zang (1992) extend the D'Aspremont and Jacquemin-Model to *n* symmetric firms that produce one product (substitute) each, and possess a general convex R&D cost function. The demand functions are symmetric and linear. The basic result of this paper is the favorable assessment of traditional RJV (RJV cartel) in a competition policy sense. In Cournot competition, it yields the highest level of R&D investment, the highest profits and the lowest prices for the whole spillover range. Models as De Bondt and Wu (1994), Kamien and Zang (1993) and Stenbacka and Tombak (1995) are related to the model of Kamien, Muller and Zang (1992).

The model of Röller, Tombak and Siebert (1996) assumes an ex ante asymmetric distribution of firms. It is shown that large firms (low marginal costs) have a greater incentive for investing in R&D than small firms. Moreover, large firms may have an incentive to exclude small firms from participating in an RJV because they would gain market power. This suggests that larger firms tend to form RJVs among themselves, excluding smaller firms.

The analysis of Amir (1995) considers the standard two-stage R&D model with nonstrongly decresing R&D returns. In this setting, firms' R&D decisions are always of a bang-bang nature. Cooperation does not always lead to a higher propensity for R&D. It yields higher total profits when demand is high, and higher social welfare when R&D costs are low enough.

The empirical analysis below focuses on two central questions: What is the impact of RJV formation on firm performance and which firm characteristics have a significant influence on RJV participation? In adressing these questions, the following two hypotheses are taken from the theoretical models discussed above. The first hypothesis concerns the impact on profits.

1) *"Firms' profits are higher if they take part in an RJV, than if the R&D activities are done in a noncooperative way."*

As discussed in Röller, Tombak and Siebert (1996), large firms might have little incentive for integrating small firms into an RJV, in order to increase their market power.[1] Hence, firm size could possibly be a significant variable, having a positive influence on the probability of RJV participation, leading to the following hypotheses.

2) *"Firm size exerts a positive influence on RJV participation."*

[1] This phenomenon is termed "over-exclusivity".

III. The Data and Descriptive Analysis

The basic data consists of two parts. The first part provides information about the research joint venture itself, while the second part carries data on the participating firms. The RJV data are taken from the *Federal Register*, an official American gazette. The performance of RJVs is thereby limited to the US. Nevertheless, multinational or foreign firms are not prevented from joining an US research joint venture. As per the National Cooperative Research Act of 1984, it is recommended that RJVs announce their research area and their participants in the *Federal Register* with the assistance of the Department of Justice and the Federal Trade Commission. The second type of data is obtained from Moody's Global Company Data which provides company-level information on some 17,785 international firms.

We therefore have firm-specific data on companies that are not participating in a research joint venture as well as those that are participating in a research joint venture. Tables 1 and 2 provide general frequencies of firms RJV participation.

Table 1: Frequencies of entire sample

Object	**Frequency**
Number of RJVs	314
Number of firms with RJV participation	4,599
Number of unique firms with RJV participation	2,923
Number of unique firms without RJV participation	13,186

Table 2: Frequencies of the sample used in the regression analysis

Object	**Frequency**
Number of firms with RJV participation	155
Number of unique firms with RJV participation	39
Number of unique firms without RJV participation	77

As shown in Table 1, 314 research joint ventures are included. Only RJVs registered prior to 1992 are considered, since the effects on the success of firms are likely to last for at least a two-year period.[2] The number of unique firms participating in RJVs is 2,923. The total number of cooperating firms in the data set is 4,599, registered from 1985-1992. Thus, firms participate in more than one research joint venture. On average, firms in the entire sample are participating in 1.5 RJVs. The average size of an RJV is 11 participants. The highest frequency is in the category of 10-15 participants. 13,186 unique firms do not participate in a research joint venture.

The frequencies of firms' RJV participation used in the regression analysis is given in Table 2. The number of unique firms with RJV participation is 39, the number without RJV participation is 78. On average, firms are participating in four Research Joint Ventures in this sample.

We now present some descriptive statistics in order to (gain some first impressions on the data and to) motivate our econometric analysis below. We devide the last sample into two subsamples: firms that are participating in an RJV, and firms that are not participating. Table 3 gives a general overview of both subsamples. We compare these subsamples by using three different criteria. The first criterion refers to the average profit margins.

Table 3 shows the profit margin of firms without RJV participation is 10.196% on average. Firms with RJV participation just have a 8.124% profit margin on average. This result gives the impression that RJV participation is not very attractive. One explanation might be that only a small fraction of the cooperating firms have high profit margins, while the majority possesses an extraordinarily low profit margin. This explanation, however, is not convincing from a theoretical perspective, since no reason is provided as to why some cooperating firms should have a much higher profit margin than other cooperating firms. The average number of participants is 11 firms per RJV. This high number is the reason to reject the explanation because more firms would benefit from the innovations, and this in turn would increase the profit margin of cooperating firms. Another possible explanation is that we have a reverse causality problem: RJV participation might lead to lower profit margins, though RJV participation is not necessarily the reason for a lower profit margin. Hence, we could find that RJVs are actually very attractive.

[2] Hereby, a long-term effect on profits is taken into account for the technologies that were once created by the firms.

Table 3: General overview of both subsamples

Variable	Mean	Minimum	Maximum
Subsample of noncooperating firms			
PROFIT MARGIN	10.196	0.702	29.629
EMPLOYMENT	7,834.66	63	67,000
Total R&D Expenses (in US $)	61,954,000.55	500,000.00	946,000,000.00
R&D as a percentage of total revenues	9.0	0.227	62.903
Investments as a percentage of total revenues	11.15	0.176	65.083
Total assets as a percentage of total revenues	125.593	30.926	985.595
Total revenues	1,366,272,000.73	11,000,000	15,748,000,000
Subsample of cooperating firms			
PROFIT MARGIN	8.124	1.007	25.342
EMPLOYMENT	28085.87	927.00	171500.00
Total R&D Expenses (in US $)	266,153,000.85	3,000,000.00	1,767,000,000.00
R&D as a percentage of total revenues	6.733	1.523	19.264
Investments as a percentage of total revenues	6.545	0.739	36.766
Total assets as a percentage of total revenues	101.839	62.539	209.205
Total revenues	5,702,076,000.92	120,000,000	28,786,000,000

To investigate this further, it is useful to present a comparison of R&D expenditures as a percentage of total revenues, since R&D might contribute to the different profit margins as well. Table 3 shows the mean R&D expenditures as a percentage of total revenues for both groups. It is clear that R&D intensity for cooperating firms is lower than that of noncooperating firms. The smaller R&D intensity for RJV participants might be due to the cost-sharing effect. Each firm that joints an RJV invests only a fraction of the total R&D investment that is required for the RJV. The cost-sharing effect hereby lowers the R&D investment of each cooperating firm. Since only the R&D expenditures as a percentage of total revenues is considered in this comparison firms **total** R&D expenditures on an average should also be compared. Table 3 reports total R&D expenditures. It can be seen that cooperating firms spend with $266.15 million - much more than those of noncooperating firms ($61.95 million). By comparing the total R&D expenditures, we get a different picture than by comparing the R&D percentage. The R&D intensity is higher if the firms do not join an RJV. Cooperating firms are larger on average, possess a larger amount of total revenue and spend a larger total amount in R&D. In a relative sense, cooperating firms spend smaller amounts on R&D, than noncooperating firms.

Moreover, the above results are robust if one does the comparison at the industry level (see Table 4). After classifying the firms by major industries, we do not find any evidence that RJV firms have higher profit margins. The profit margins of cooperating firms in each major industry are lower than those of noncooperating firms. Thus, we can definitely exclude the assumption that in some industries cooperating firms will have a higher profit margin while in the majority of industries cooperating firms will have a lower profit margin. As a consequence, the profit margin for the total number of cooperating firms is lower. Turning to total R&D expenditures and R&D percentages, we get the same results as before. The row "all Industries" gives the means for all firms in the corresponding group.

Thus, RJV participation seems to be associated with smaller profit margins, even at the industry level. As mentioned above this does not imply that RJV participation is not profitable, since RJV participation is influenced by many more factors and thereby might be attractive to firms. A more detailed analysis is required that includes more variables for explaining the profit margin. A firm acts in an environment that is influenced by many variables. Because single effects are not revealed in the comparison of the means, it is much too general and prevents conclusions about any single variable. In the following section, we attempt to explain profit margins as a function of several other relevant variables.

Table 4: Comparison at the industry level

	Mean for firms without RJV participation					Mean for firms with RJV participation				
Industries	**firms**	**PROFM**	**EMPLOYM**	**total R&D in th. US $**	**R&D**	**firms**	**PROFM**	**EMPLOYM**	**total R&D in th. US $**	**R&D**
Agriculture, Forestry, and Fishing	-	-	-	-	-	-	-	-	-	-
Mining	3	8.596	5,931.67	35,000.00	7.166	4	4.801	12,519.75	293,500.00	2.713
Construction	-	-	-	-	-	-	-	-	-	-
Manufacturing	52	10.092	9,268.12	80,076.92	8.998	31	8.224	32,011.29	290,419.35	6.896
Transportation and Public Utilities	3	9.621	496.67	2,666.67	7.116	1	6.820	5,772.00	46,000.00	1.833
Wholesale Trade	7	14.032	1,761.43	9,214.29	11.788	1	11.007	4,520.00	124,000.00	8.534
Retail Trade	1	1.508	4,383.00	51,000.00	4.727	-	-	-	-	-
Finance, Insurance, and Real Estate	5	6.055	11,315.00	57,600.00	4.228	-	-	-	-	-
Services	6	12.610	4,792.00	15,000.00	11.861	2	12.440	21,314.00	16,500.00	13.791
Public Administration	-	-	-	-	-	-	-	-	-	-
Nonclassifiable Establishments	-	-	-	-	-	-	-	-	-	-
all Industries	**77**	**10.196**	**7,834.66**	**61,954.55**	**9.0**	**39**	**8.124**	**28,085.87**	**266,153.85**	**6.733**

IV. Econometric Analysis

In this section we investigate the impact of RJV participation on firm performance. As mentioned above, the data are based on the National Cooperative Research Act of 1984, which recommends that participants in RJVs file with the *Federal Register*. Concerning the question of sample selection it is possible that smaller firms are not represented to the same extent as large firms. There are two reasons for this. First, firms are not required to file under the National Cooperative Research Act. Since smaller firms are less likely to be the subject of an anti-trust investigation, it appears reasonable to argue that smaller firms are less likely to file and thus underrepresented in our sample. Secondly, smaller firms are often not reported in our Moody's company database. Therefore our data might be overemphasizing larger firms. This, however, is less of a problem when comparing the two data sets (cooperating and noncooperating firms) since both sets are subject to the same defficiency.

To investigate the impact of RJVs on profit margin, we specify a variable parameter model in order to show different influences of the R&D intensity on profit margin for cooperating and noncooperating firms. Thus, we consider the case in which the slope parameter for R&D percentage may differ between the two groups. In our model, the profit margin (PROFM) is assumed to be endogeneous. The equation to be estimated is as follows:

$$PROFM_i = \beta_1 + \beta_2 EMP_i + \beta_3 INV_i + \beta_4 (1 - DUMMY_i) R\&D_i + \beta_5 (DUMMY_i) R\&D_i + \beta_6 ASSETS_i + e_i \quad (4.1)$$

where i refers to the firm. The definition of the variables used in the model are given in Table 5.

Table 5: Variable Definitions

Endogeneous Variables:

PROFM	Profit margin of 1994 (Net income/total revenues)
DUMMY (f. Logistic-estimation)	Dummy-variable for participation in an RJV

Exogeneous Variables:

EMP	Numbers of employees in a firm (in 1994)
INV	Investment (fixed assets, from 1994) as a percentage of total revenues (1994)
R&D	R&D expenditures (from 1990) as a percentage of total revenues (from 1990)
ASSETS	Total assets (1994) as a percentage of total revenues (1994)
TOTREV	Total revenues (1994)
DUMMY	Dummy-variable for the participation in an RJV

The profit margin (PROFM) of the firms refers to the year 1994 and is restricted to be within -50% and 50%.[3] The dummy-variable (DUMMY) takes on the value 0 if the firm does not participate in an RJV, and the value 1 if the firm is participating in an RJV. The number of employees (EMP) per firms during the year 1994 is used as a proxy for firm's size. Investments (INV), research and development expenditures (R&D) and the total assets (ASSETS) are expressed as percentages of total revenues (compare the variable definitions in Table 5). [4] R&D expenditures (as a percentage of total revenues from 1990) are available for 1990 and assumed constant over time. [5] Therefore, the R&D is valid for research projects started between 1985 and 1992.[6]

The ordinary least squares estimates of equation (4.1) are shown in Table 6[7]. The model is significant with an F-value of 7.465, and an adjusted R-square of 0.22.

Concerning the parameter estimates, the number of employees, the investment and the R&D for cooperating and noncooperating firms are all significant. Interestingly, the parameter estimations for the noncooperating as well as for the cooperating firms suggest a high return for R&D on profit margin. The R&D of noncooperating firms ((1-DUMMY)*R&D) has an elasticity of 0.20, whereas the R&D of cooperating firms (DUMMY*R&D) has an elasticity of 0.33. This means that an 10% increase in R&D will increase the profit margin of the noncooperating firms by 2.0% whereby the profit margin of the cooperating firms will increase by 3.3%. Thus, the R&D of cooperating firms have a larger effect on the profit margin than the R&D of noncooperating firms. The parameter estimation for employment (EMP) indicates a negative influence on profit margin with an elasticity of -0.1. This means that an increase in the number of employees by some 10% decreases the profit margin by 1%. The investment (INV) also has a positive influence on the profit margin with an elasticity of 0.09. A 10% increase in investments raises the profit margin by 0.9%.

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3 Firms that have a lower profit margin than -50% result from a negative net income. Firms with negative net income are often those, which are Development Laboratories and do not produce any Outputs. Firms with a higher profit margin than 50% often are Investment Firms and Banks. The restriction ensures the investigation of those kind of firms where the developed Technology is able to have an impact on Output and profits.

4 Hereafter, referred to as investments, R&D and total assets.

5 A dynamic consideration of R&D expenses was not feasible due to data constraints.

6 If the fact is taken into account that cooperating firms in this sample are taking part in 4 RJVs on average, the assumption that R&D expenses for cooperating firms are constant over time seems reasonable. The main task is to distinguish between cooperating and noncooperating firms. If firms are participating four times on average, it appears that average R&D investments between the two groups of firms should differ.

7 Normality of the residuals, homoscedasticity, no multicollinearity problems and no autocorrelation have been tested and confirmed the assumptions for an ordinary least square method. If the data set is ordered by a certain criterion, problems of autocorrelation can have an effect on cross-sectional data.

Table 6: OLS estimates of equation (4.1) and (4.2)

OLS estimates of equation (4.1)			
Variable	Parameter	Standard Error	Prob>|T|
INTERCEPT	6.762435	1.135014	0.0001
EMP	-0.000067	0.000023	0.0052
INV	0.088119	0.046312	0.0597
R&D (1-DUMMY)	0.202365	0.068489	0.0038
R&D (DUMMY)	0.330470	0.140161	0.0202
ASSETS	0.007785	0.005984	0.1960
N=116 F-Value 7.465 Adj R-square=0.2194			
OLS estimates of equation (4.2)			
Variable	Parameter	Standard Error	Prob>|T|
INTERCEPT (1-DUMMY)	7.055330	1.19312	0.0001
INTERCEPT (DUMMY)	5.493880	1.93738	0.0055
EMP	-0.000061	0.000024	0.0131
INV	0.089583	0.04642	0.0562
R&D (1-DUMMY)	0.186732	0.07127	0.0100
R&D (DUMMY)	0.445353	0.19973	0.0278
ASSETS	0.007557	0.006	0.2106
N=116 F-Value 7.609 Adj R-square=0.217			

Causality problems between the endogeneous variable (profit margin) and the other variables result in bias estimates. R&D, the most ambiguous of the variables is less of a problem because of the time-lag: profit margin is for 1994 and R&D are for 1990.

IV.1 Fixed Effects

Next, we respecify equation (4.1) by allowing for group-specific fixed effects. We will allow for the possibility that in addition to a difference in the R&D-slope parameter, the intercept changes as well. The equation to be estimated is as follows:

$$PROFM_i = \beta_1(1 - DUMMY_i) + \beta_2(DUMMY_i) + \beta_3 EMP_i + \beta_4 INV_i + \beta_5(1 - DUMMY_i)R\&D_i + \beta_6(DUMMY_i)R\&D_i + \beta_7 ASSETS_i + e_i \quad (4.2)$$

The results are given in Table 6.

The estimated impact of employment, investment and total asset are very robust. The R&D of noncooperating firms stay at the elasticity level of 0.19, whereas the elasticity of R&D for cooperating firms increases to 0.45. Thus, the R&D of cooperating firms still has a larger effect on the profit margin than the R&D of noncooperating firms. The intercept parameter for the noncooperating firms takes on a higher value than the intercept for cooperating firms. This parallel shift in the intercept indicates that cooperating firms achieve a lower profit margin. The difference in the intercept estimate turns out not to be significant.

The question then arises, why noncooperating firms get a higher profit margin, although both regression analyses indicate that R&D of cooperating firms is more effective. An explanation can be found by realizing that there are two opposing effects at work. The first one is the so-called **cost-sharing** effect. Since each firm invests only a fraction of the whole R&D investments undertaken by the RJV, it allows firms to share the R&D expense, without sacrificing R&D output. Given that the effective R&D is higher than the R&D invested by each cooperating firm, one would expect that the effect of R&D on profits is larger.

Cost-sharing is possible because the spillover parameter in an RJV is higher (usually assumed at one) than if firms do not form an RJV. Our estimates in Table 6 indicate that the spillover parameter under no RJV is quite small on average, since the R&D intensity is only two times higher and the average number of RJV members is about 11.

The second effect on profitability is **firm-size**. It can be seen in Table 6 that firm size has a negative impact on profitability. Since cooperating firms are larger on average this would explain the descriptive finding of lower profits.

To compare the offsetting cost-sharing and firm-size effect quantitavely we evaluate their impact at the sample mean. Using the estimates in Table 6 we get a size-effect of

$$\hat{\beta}_2 \frac{\left(\overline{EMP}_{RJV} - \overline{EMP}_{NRJV}\right)}{\overline{EMP}_{RJV}} = -0.0721. \tag{4.3}$$

As we can see from equation (4.3), the comparison between cooperating and noncooperating firms results in a firm-size effect of -0.0721. This means that the firm-size effect lowers the profit margins of cooperating firms by 7.21% on average.

Similarly, the cost-sharing effect can be calculated as,

$$\frac{\hat{\beta}_6\left(\overline{R\&D}_{RJV}\right) - \hat{\beta}_5\left(\overline{R\&D}_{NRJV}\right)}{\overline{R\&D}_{RJV}} = 0.0626. \tag{4.4}$$

Equation (4.4) says that cooperating firms get a 6.26% higher profit due to cost sharing.

Adding up both effects we get the total effect that determines profit margin for cooperating firms. The total effect takes on a value of -0.095: cooperating firms get a 1% lower profit margin on average when both effects are incorporated. This result is consistent with the result from the descriptive analysis.

The impact of research joint venture participation cannot be explained by a comparison of the average profit margins (as in the descriptive analysis). **The cost-sharing and the firm-size effect on profit margin are neglected**. The regression analyses can reveal both effects and the total effect is consistent with the results from the descriptive analysis. Cooperating firms pursue a more efficient R&D that has a higher impact on firm's success (cost-sharing), but because of the higher counter-effect (firm-size effect) it may seem that an RJV is unattractive.

IV.2 A Logit Estimation

We now investigate the determinants of RJV participation. For this purpose we use a Logit-estimation which attempts to identify variables that exert a significant influence on the probability of research joint venture participation. Each firm is coded dichotomously: a firm is coded with a one if it participated in an RJV and 0 otherwise. The dependent variable (the conditional probability $PR(DUMMY_i = 1/X_i)$ is considered, whereby X describes the matrix of exogeneous variables. The following equation is to be estimated:

$$PR(DUMMY_i = 1/X_i) = \beta_1 + \beta_2 EMP_i + \beta_3 INV_i + \beta_4 R\&D_i + \beta_5 ASSETS_i + \beta_6 PROFM_i + e_i \tag{4.5}$$

$i=1.....T$ represent the firms.

Because the observations occur just once, the maximum-likelihood method is applied for estimating the parameter *ß*.

Table 7 reports the results for the Logit model.[8]

Table 7: Logit estimates of equation (4.5)

Variable	Parameter	Standard Error	Pr>Chi-Square
INTERCEPT	-0.9590	0.6951	0.1677
EMP	0.000059	0.000017	0.0006
INV	-0.0117	0.0230	0.6097
R&D	-0.0122	0.0383	0.7506
ASSETS	-0.00540	0.00565	0.3397
PROFM	0.0272	0.0423	0.5195
N=116 Score-Test: 19.920 , p=0.001		2 LOG L: 25.408 , p=0.0001	

The score statistics is used to measure the influence of a combination of exogeneous variables on the endogeneous variable. Accordingly, our model is significant at a level of 0.001. The parameter estimate is significant only for employment. The signs of the parameter estimates indicate the direction of the change. Therefore, the employment number has a positive influence on the probability of research joint venture participation. This statement is compatible with the above statement that large firms participate more often in RJVs. This concludes the verification of the second hypothesis that firm's size exerts a positive influence on RJV participation.

All the other variables do not have a significant influence on the probability of research joint venture participation. Also very interesting is the insignificance of the profit margin on the decision to cooperate. This result ensures the unambiguous causal relationship - which we assumed - that cooperation influences the profit margin, but not vice versa.

[8] The results of a Probit-estimation are very similar to the results for a Logit-estimation.

V. Conclusion

This paper presents an empirical analysis of RJVs and tests two hypotheses. The analysis of the first hypothesis is compounded by several effects. From the descriptive analysis we get the result that the mean of the profit margins is 2.07% below the profit margins of noncooperating firms, and still lower when the firms are classified by major division industries. Yet, as the regression analyses show, R&D have a greater impact on profit margin when firms are cooperating. One factor that influences the profit margin of cooperating firms in a positive way, is the **cost-sharing** effect. R&D investment levels of cooperating firms are lower than those of noncooperating firms, although the R&D output remains the same as if the R&D efforts would have be done separately. Therefore, the R&D investments of cooperating firms receive a higher influence on profit margin. The **firm-size** effect influences the profit margin of cooperating firms in a negative way. Because the firm-size effect is larger than the cost-sharing effect, the profit margin of cooperating firms is influenced by an aggegated negative effect of 1%.

As a result, RJVs may increase social welfare because they raise the efficiency of R&D investments. The increased efficiency of R&D investments makes an RJV attractive from the firms point of view and represents an incentive for firms to join a cooperation. However, a descriptive analysis of profit margins can fail to reveal the positive impact of RJVs because of the firm-size effect, which lowers the profit margin for cooperating firms.

The second hypothesis is confirmed by the Logit-analysis: firm size has a positive and significant effect on the probability of RJV participation. The descriptive analysis shows that cooperating firms are larger on the average. In addition to this, it is mostly large firms that join research joint ventures. In summary, large firms have a greater incentive for joining a research joint venture, *at least among themselves.*

In a two-stage game, four different scenarios are possible that distinguish between cooperation and noncooperation in the R&D stage and the product market. Fershtman and Gandal (1993) analyzed a scenario that assumes no cooperation in R&D and cooperation in the product market with respect to a *semicollusion*. The incorporation of further strategic variables, in addition to those considered under the aspect of collusion, shows that firms do not necessarily benefit from forming a collusion in the product market.

In particular, firms can over-invest in strategic variables other than those in which they are colluding. One question still open in this study is whether cooperating firms destroy the advantages (additional profits) gained in the R&D stage by individual firm over-investment (for example, in advertisement). This fact may destroy the overall profits of cooperating firms. An over-investment in the product market may reach such a level that firms are better-off not colluding in the R&D stage, because they may yield lower profits than by not colluding. Further tasks include a more dynamic investigation of R&D expenditures and profits as well as the creation of two (more) homogeneous groups of firms (cooperating and noncooperating) for arranging a more unambiguous comparison.

As a consequence, the amounts expressed as percentage could be substituted by total amounts (e.g the profit margin could be substituted by net income), which makes a comparison between both groups more easy because it avoids decreasing profit margins in firms'size and makes it possible to measure direct effects on profits for both groups.

There are still unanswered questions remaining that warrant further analysis in the area of research joint ventures.

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