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INDUSTRIAL NETWORKS

MAKE, BUY OR COOPERATE DECISIONS WITH RESPECT TO RESEARCH AND DEVELOPMENT IN INTERNATIONAL BUSINESS NETWORKS

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I. INTRODUCTION

Research and Development (R&D) is one of the most important business activities of the next decade (Porter, 1990). Commercialization of technological know how is essential for survival of firms (Teece, 1987). Organizational forms of R&D are one of the main competitive advantages of firms. The importance of cooperative agreements and networks as an alternative for in-house R&D is increasing (E.C., 1991; OTA, 1990). Collaborative agreements are of strategic importance for a firm (Håkansson, 1990). The number of international cooperative agreements has increased. For example, more than 30% of cooperative agreements in biotechnology are between companies from different parts of the world (Hagedoorn & Schakenraad, 1990). Table 1 shows the increasing importance of cooperative agreements in biotechnology.

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Table 1. Number of Cooperative Agreements in Biotechnology Industry Worldwide

<i>Period</i>	<i>Number</i>
before 1974	11
1975-1979	92
1980-1984	392
1984-1989	718

Source: Hagendoorn, J. & Schakenraad., "Alliances and Partnerships in Biotechnology and Information Technologies," MERIT, June 1990, p. 14.

In this article alternative organizational forms of R&D projects are analyzed. A framework is proposed which shows how organizational forms, governance structures and explanatory variables are related. By evaluating the existing economic and organization theories, two testable hypotheses have been derived. These hypotheses will be tested at the *industry level* with data concerning R&D projects of U.S. biotechnology firms. This article concludes with suggestions for further research.

II. RESEARCH QUESTION

In practice enterprises can choose different organizational forms for the acquisition and exploitation of technological know how. For instance, technological know how can be acquired through internal R&D, the acquisition of innovative enterprises, joint ventures, joint R&D, or by contract research and licensing. The exploitation of technological know how can be organized by internal exploitation, creation of innovative enterprises, joint ventures and licensing (Granstrand & Sjölander 1990). *Our research question is "How can the organizational form of a R&D project that a firm prefers be explained by environmental and managerial variables?"* For analytical purposes, we shall characterize organizational forms of R&D projects as one of the alternative governance structures: 'make,' 'cooperate' and 'buy' or 'sell' (Williamson & Ouchi, 1981).

The above mentioned research question has been split into three steps:

1. linking organizational forms and governance structures
2. explaining governance structures by explanatory factors
3. operationalization of explanatory factors by empirical variables

Figure 1 illustrates the three steps which comprise the research question and the explanation of organizational forms. Organizational forms of R&D are

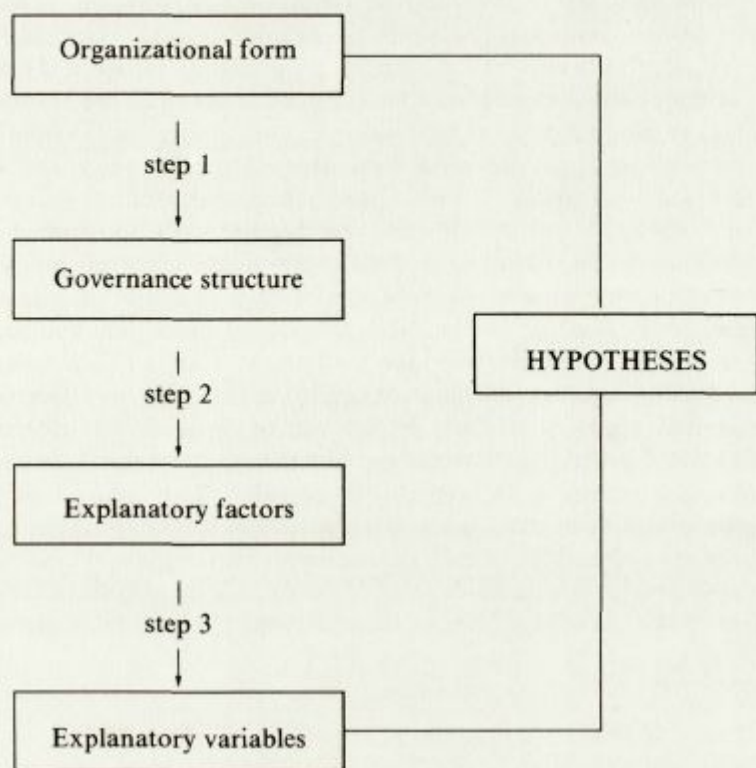


Figure 1. Steps Involved in Investigating the Research Question

analyzed in an indirect way and attempts are made to explain the underlying governance structures of those organizational forms.

III. ORGANIZATIONAL FORMS AND GOVERNANCE STRUCTURES

Organizational forms of R&D projects can be classified along several lines. As a start the *degree of organizational interconnectedness* can be evaluated. The degree to which primary and supporting activities in the 'value chain' (Porter, 1986) are implemented in cooperation with a partner is considered (Coopers & Lybrand Dijker van Dien, 1990). Contractor and Lorange (1988) mention the *degree of mutual dependence* of related firms as a point of reference. The typology by Harrigan (1988) of organizational forms as joint

ventures organizes these forms along *four key dimensions: form, focus, (degree of) autonomy and duration*. The basic classification of organizational forms into 'intrafirm,' 'open market' and 'interfirm' transactions by Root (1988) are taken as the point of departure. The question is whether the transfer of technological knowledge takes place within the organizational boundaries of a firm, between aggregates of firms at the market place, or between firms which cooperate with each other. In this setting, the corresponding governance structures 'make,' 'buy' (or 'sell') and 'cooperate' are distinguished. The organizational forms of internal R&D, the acquisition of innovative enterprises, as well as internal exploitation and creation of innovative enterprises can be classified as a 'make' option. Joint R&D, joint exploitation and joint ventures are each examples of the 'cooperate' option. Licensing and contract research represent the 'buy' (or 'sell') option. It has been ascertained that organizational forms of R&D projects can be classified into governance structures. In Figure 2, the connection between organizational forms and governance structures is illustrated. We consider R&D as a functional management activity in which assets such as human capital, physical capital and equipment are used for transforming inputs into outputs, which can be: (1) technological knowledge in the form of documents, blueprints or training, (2) rights to use knowledge (patents, licenses) and (3) knowledge embodied

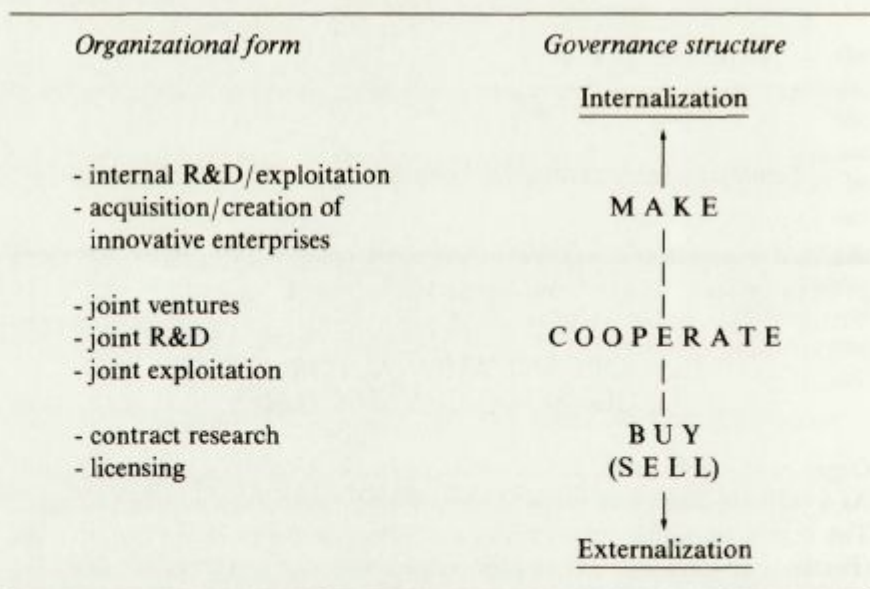


Figure 2. Organizational Forms and Governance Structures
(Step 1 Research Question)

in capital equipment and (intermediate) goods. Organizational forms can be distinguished to the extent to which transfer of technological know how is supported by a transfer of assets. Consistent with Robinson (1988), organizational forms of R&D are distinguished by the degree to which transactions in technological know how are coupled with transfer of cash, assets, financial and management control. The more R&D is internalized, the more control a firm has over the assets necessary for R&D.

IV. THEORETICAL BACKGROUND

The second step of the research question is linking governance structures with explanatory factors. Several approaches at the *industry* and *firm level* can be used to analyze governance structures of R&D. These include the evolutionary approach of Nelson & Winter (1982), resource dependence approach (Pfeffer & Salancik, 1978), transaction costs approach (Williamson & Ouchi, 1981), agency approach (Eisenhardt, 1989, Jensen, 1983, Jensen & Meckling, 1976, Levinthal, 1988), appropriability approach (Teece, 1987), network approach (Håkansson, 1989, 1990, Jarillo, 1988), 'nexus of treaties approach' (Aoki & Williamson, 1990) and contingency approach (Lawrence & Lorsch, 1969, Rothwell & Whiston, 1990).

The key explanatory factors in these approaches can be summarized as 'uncertainty' and 'dependence' (Aldrich, 1979; Fahey & Narayanan, 1986; Lawrence & Dyer, 1983). The behavior of a firm is directed to realizing a reduction of uncertainty and dependence. In a similar way, the degree of internalization of R&D (dependent variable) can be linked with the explanatory factors (independent variables) 'uncertainty' and 'dependence.' In accordance with the transaction cost, agency and contingency approaches it is assumed that uncertainty of transactions in technological know how stimulates internalization of R&D. Corresponding with the resource dependence approach of Pfeffer and Salancik (1978) the second assumption is that R&D will be more internalized if a firm is more dependent on buyers of the output (technological know how) or sellers of inputs necessary to perform R&D. *It is concluded that the degree of internalization of R&D is positively related to (1) the degree of uncertainty of transactions in technological know how and (2) the degree of dependence of a firm on buyers and sellers.* As was mentioned earlier, the third step of the research question is to operationalize the explanatory factors 'uncertainty' and 'dependence.' Put differently: "What empirically observable variables can explain organizational forms of R&D projects?"

Explanatory Factor 1: 'Uncertainty'

With respect to this issue, Kamien & Schwartz (1982) discern three forms of uncertainty: total costs of a R&D project ('technological uncertainty'), the

possibility that a competing technology will be introduced ('market uncertainty') and how much profits a new technology will contribute ('financial uncertainty'). However, uncertainty can be analyzed at a more fundamental level, namely at the level of management of R&D projects. Among other things, the costs which are necessary to coordinate R&D are a manifestation of the explanatory factor 'uncertainty.' In the agency approach, a more narrow definition, specifically the costs of structuring, controlling and bonding contracts, the so called 'agency costs,' are used. The interesting point is that in the agency approach the choice among several alternative contract forms can be explained by the explanatory factor 'uncertainty.' As Eisenhardt (1989) points out the length of an agency relationship is positively related to behavior and negatively related to outcome based contracts. The longer an agency relationship exists, the more control a firm wants to exert over activities performed by agents who act on behalf of the firm. So, based on the agency approach, the degree of internalization of activities is positively related to 'uncertainty,' which in turn corresponds to the duration of activities. The first testable hypothesis is formulated as:

Hypothesis I

A firm will be more inclined to internalize R&D as the development time of a project (or part of a project in consideration) increases.

Explanatory Factor 2: 'Dependence'

A second explanatory factor is 'dependence.' Pfeffer & Salancik (1978) distinguish two forms of dependence: 'sales' and 'purchase dependence,' together indicated as 'transactions dependence.' According to these authors, the degree of dependence will increase if a firm buys a greater share of its inputs from a supplier or sells a greater share of its output to one seller. The inclination to internalize activities is explained by a need to reduce several forms of dependence. Håkansson (1989, p. 73) links the propensity of firms to cooperate with the so called 'resource structure,' the degree of control a company exerts over the resources: input goods, financial capital, personnel, technology and marketing. He approximates the degree of dependence on buyers by the *market share* of a firm. Empirical testing on *industry level* confirms the propensity to cooperate is negatively related to market share. Pisano (1990) proposes a useful indicator of the degree of dependence, namely the (inverse of the) number of companies with capabilities in the same application area (N), which we will define briefly as 'companies with similar capabilities.' We use this indicator as well. We assume that the degree of internalization of R&D will increase when dependence rises as a result of a lowering of the number of companies with similar capabilities (N). Therefore, the second hypothesis is:

Hypothesis II

A firm will be more inclined to internalize R&D as the number of companies with similar capabilities (N) decreases.

V. EMPIRICAL TESTING**A. Introduction**

Hypotheses I and II are tested with data concerning biotechnology firms in the United States. In this industry, appropriate organizational forms of R&D projects are of primary importance due to rapid developments (Orsenigo, 1989; Pisano, 1990; Shan, 1990).

B. Data

A Dutch commercial bank (Rabobank Nederland), which specializes in (high risk) investments in biotechnology provided the data. The data pertains to a cross-section of 158 current projects in 1990 of nine U.S. biotechnology companies. The main activities of these companies are concentrated in the pharmaceutical industry. These companies all (1) have experience with R&D and (2) make use of appropriate distribution channels. For each project the stage of development, number of competing companies with capabilities in the same application area (N) and (eventual) type of financial agreement (organizational form) with possible partners is known.

The following stages are discerned: (1) the R&D stage, (2) stage I, (3) stage II, (4) stage III of clinical trials and (5) approval. In the R&D stage projects are started. In stages I, II and III the clinical safety of a drug is tested, followed by large scale testing with patients. Eventually in the approval stage a drug is registered. All organizational forms of the cross-section concern the exploitation of R&D: profit sharing and joint ventures ('cooperate' option), royalty, royalty/production agreements and production rights agreements ('sell' option). Other organizational forms such as distribution agreements were left out of consideration, because these forms concern the functional management activity 'marketing' only.

C. Testing

For analytical purposes the dependent variable 'organizational form' was categorized into one of the three governance structures 'make,' 'cooperate' and 'sell.' As an indicator of the duration (DEVT) of a project the stage of a project is used. The earlier the stage of a project, the longer the project will take. So in order of *decreasing* duration (DEVT) (1) the R&D stage, (2) stage I, (3)

stage II, (4) stage III of clinical trials and (5) the approval stage are discerned. As mentioned before, the number of competitors is used as a proxy for the number of companies with capabilities in the same application area (N).

In Tables 2 and 3 below the frequency of governance structures are taken on the one hand (dependent variable) and on the other hand the stage of development (Table 2) and number of competitors (Table 3) as explanatory variables.

Table 2 shows that there is greater inclination to prefer the 'make' rather than 'cooperate' or 'sell' option in the earlier stage of a project. An X^2 -test indicates there is a significant difference between the shares of the several types of governance structures in several stages of projects. As we have put forward, the earlier the stage of development, the longer a project will take. So internalization of R&D and duration (DEVT) of a project can be associated positively. In Table 3 an increase in the number of competitors (N) is linked with an inclination to prefer the 'sell' option rather than the 'cooperate' or 'make' option. An X^2 -test confirms that the preferred types of governance structures differ significantly when the number of competitors (N) increases. Our empirical testing with data from U.S. biotechnology firms shows that hypotheses I and II can be supported with data from current projects of biotechnology firms. Of course, before generalizing these results, further testing is needed.

Analysis of organizational forms at the *firm level* can be a useful extension of the analysis. We take one of the firms in the above mentioned sample, the U.S. firm Genetics Institute (G.I.), as an example. G.I. develops products for curing heart, vessel, blood diseases, and cancer. G.I. is a fast growing research intensive firm with 520 employees. During the period 1985-1989 total revenues grew annually by 30% to approximately \$43 million in 1989 (Paine Webber, 1990). It appears that international agreements with foreign firms are of strategic importance for the exploitation of technological know how. Three-quarters of the number of new products of G.I. are commercialized by international agreements with European and Japanese firms (Rabobank, 1990). Products in stage III of clinical trials or the approval stage have a relatively short development time. It was observed that for the commercialization of those products, license or license/production agreements are preferred. Whereas one product at the development stage, characterized by a relatively long development time, is developed by a joint venture with another foreign company. At *firm level* internalization of exploitation of R&D and the development time of a new product are associated positively. A next step, analysis of the evolution of organizational forms at *project level*, is an interesting field for future research.

Table 2. Stage of R&D Project and Governance Structure

stage	Governance Structure			total
	'make'	'cooperate'	'sell'	
(1)	25	5	4	34
(2)	11	6	11	28
(3)	7	0	8	15
(4)	5	0	12	17
(5)	1	1	10	12
total	49	12	45	106

Note: $X^2 = 33,04$ (12 degrees of freedom); $p < 0,001$.

Source: Rabobank Nederland, 1990.

Table 3. Number of Competitors and Governance Structure

number	Governance Structure			total
	'make'	'cooperate'	'sell'	
0	36	9	23	68
1	7	2	10	19
2	9	1	8	18
3-6	7	0	16	23
total	59	12	57	128

Note: $X^2 = 23,98$ (6 degrees of freedom); $p < 0,001$.

Source: Rabobank Nederland, 1990.

VI. SUMMARY AND CONCLUSIONS

This paper has tried to explain organizational forms of R&D projects. Organizational forms, governance structures and explanatory variables have been linked. It is hypothesized that the inclination of firms to internalize R&D is positively associated with the length of the development time (DEVT) and negatively associated with the number of firms with capabilities in the same application area (N).

Several issues deserve closer attention. *First*, as noted by Lawrence & Lorsch (1969), the integration between the functional management activities of R&D, production and marketing deserve special attention. This will be a managerial challenge. *Second*, the dynamics of organizational forms at *industry*, *firm* and *project level* is an interesting field of research in the future (Killing, 1985, Moenaert et al., 1990). In our view the time element of the explanatory factor 'dependence' should be taken into consideration. *Third*, further analysis of the characteristics of networks for diffusion of technological knowledge at the *industry* and *firm level* in an international competitive environment is an

interesting field of future research. As Håkansson (1990) notes the appropriate organizational form for commercialization of R&D in international business networks is a managerial issue of strategic importance.

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