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External versus internal acquisition of new technology

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Nr.298

External Versus Internal Acquisition of New Technology

Michael Hermes

November 1992

External Versus Internal Acquisition of New Technology

1. Introduction

The development of new technologies and their application in new products or processes are essential in today's competitive environment. Companies must make a strategic decision concerning which new technologies they want to incorporate in their products/processes. Furthermore, they must decide how to acquire these new technologies. In-house research and development (R&D) is just one possible source of new technology. Another alternative would be to obtain a license, or to acquire a company that has special expertise in the field of interest. "New", in this context, means new to the company. If, for example, a license is available, the technology cannot be new to the world, and perhaps is not even new to the industry. Taking the perspective of the company in the decision making process suggests defining "new" also in respect to the company. The choice between different sources of new technology has a strong impact on the future competitive position of the company. To have a supplier develop a new technology rather than developing it through one's own R&D efforts very probably lessens the necessary financial commitment (Teece 1976, p. 19), but at the same time deprives the company of an opportunity to get acquainted with a new field of know-how, thus possibly weakening the future technological position of the company in this field (Capon, Glazer 1987; Link et al. 1983; Pisano 1991).

Over the last 10 to 20 years, there has been a strong trend towards multi-technology products and processes. Hence, even major companies have only a small chance to master all technologies incorporated in their products. Because of this, a growing tendency can be observed towards utilizing external expertise (Baranson 1978, p.xi; Sen, Rubenstein 1989). Another important reason for externalization of R&D tasks is the reduction of development time (Albach et al. 1991, Baranson 1978, Gold 1987, Mansfield 1988). The use of supplier expertise in the development process is reported to be an important means of accelerating product development (Clark, Fujimoto 1989). Some authors, however, doubt this effect of external acquisition of technology (McDonough III, Barczak 1991).

There is a large amount of literature which discusses the various means of technology acquisition (e.g. for R&D cooperations: Betz 1991, Brockhoff 1992 a, Dobberstein 1992; Rotering 1990; Sinha, Cusumano 1991 and others), but only a few authors consider the different means of technology acquisition as options in a decision-making process (e.g. Krubasik 1988; Roberts, Berry 1985; Schneider, Zieringer 1991). The existing papers treat this decision on a purely conceptual basis and generally offer no or only episodic empirical support of their hypotheses.

This paper aims to deal with the following question:

In which situations do companies use which source for acquiring new technology?

Later it will be helpful to split this broad question into a number of sub-questions. As a by-product, it will be possible to shed some light on an empirical justification of the different decision supporting concepts raised in the literature. Keeping in mind the limitations of the empirical approach used here, managerial implications will be drawn.

2. Conceptual background

There are a large number of alternatives for the acquisition of new technology. In this paper we will restrict ourselves to the following options:

- Internal R&D
- R&D carried out by Suppliers
- Licensing
- Purchase of Patents
- Acquisition of Companies
- Contract Research by Universities/Research Institutes
- Contract Research by Engineering Companies
- Research-Joint-Ventures/Cooperative Research

Cutler (1991) gives a somewhat more comprehensive list. He specifies the *hiring of specialists* as another means of external acquisition of technology. In our view this is part of internal R&D. One might also add *imitation of innovations* to this list. Again we consider this a mode of internal R&D. Also *literature* as external source of technological know-how has been discussed. But literature can replace the other sources only to a small extent. The *user* as a potential source of innovation was studied extensively by von Hippel (1988). We assume that the user will be only in rare cases the main source of a new technology. In addition, for practical reasons the number of sources studied in our project had to be limited. Therefore the user was not taken into account.

Typically not all alternatives will be available in all projects. But only in rare cases will there be just one possible way. During some interviews with industry managers a problem in this context arose. Are the options specified above true alternatives? That is, can they really replace each other? Interviews carried out during pre-testing of a questionnaire indicated that often several of these sources are used simultaneously in one project. Furthermore it was stated that several of the "alternatives" listed above are not independent sources, such that they would not require inputs from other sources (Dosi 1988). To give an example: simply for the purpose of defining a project task so that it can be carried out effectively and efficiently by a research institute, one needs a significant amount of detailed in-house know-how in this field, and, perhaps even more important, to really benefit from the results of contract research, significant specialized in-house competence is necessary to support the technology transfer process. These facts cast some doubt on an approach that treats these different sources as true alternatives. Radnor (1991) chooses an approach to the make versus buy decision that uses a continuous scale from 100% make to 100% buy. Another way to address this problem will be discussed later.

The decision among alternative sources of new technology will depend on the project situation. The impact that characteristics of the different sources have on the choice will depend on the project situation (Link et al. 1983). The properties of the project situation may be divided into three groups: properties of the market situation, properties of the technology, and properties of the company's relation to the technology.

First of all, the market situation might have an impact on the decision. Roberts and Berry (1985) consider the familiarity of the company with the market as an important variable in this context. A company unfamiliar with the requirements of the market it wishes to penetrate with a new technology might seek partners to reduce the risk of missing market requirements. Another variable which might be considered is the market distance of the development project in question. If a new technology is expected to result in a marketable product only in the

long term, a company might well be less eager to internalize the development of this new technology. Also, high time pressure is expected to have an influence on the choice of the source of new technology, favoring external sources (Roberts, Berry 1985). Teece (1986) argues that the possibility to build market entry barriers will result in a tendency to internalize.

Secondly, properties of the new technology itself will be important. Questions to be considered: Does thorough mastering of the new technology provide a competitive advantage in the market the company is interested in? Is it difficult to imitate the new technology (e.g. via reverse engineering)? Will patent rights survive in this area - in other words, are they difficult to circumvent? Is the relevant knowledge in this area to a large extent tacit? If all these questions are answered in the positive, then it is possible to build up a long term technological leadership resulting in competitive advantages. In this case, companies will seek to keep the know-how appropriate, and that in many cases means internalization of the development. Some of the issues raised here are incorporated in the concept of appropriability put forward by Teece (1985)(see also van Hippel 1982). The technological risk connected with the development of the new technology is also widely seen as an important criterion for the choice of the appropriate source (Capon, Glazer 1987; Krubasik 1988; Pearson 1990, Utterback et al. 1991).

Finally, the position of the company with regard to the new technology will influence the choice among different sources. If the company has a weak technological position compared to possible external suppliers, if the new technology is not a core technology, if only small technological familiarities exist, and, furthermore, if not all R&D resources are available in-house, then there will be a strong tendency to acquire the new technology externally. If the new technology plays a major role in the long term strategy of the company, appropriation of the new technology will be attempted, which in most cases means internalization.

The concepts published in literature attempt to recommend strategies according to situational factors. Roberts and Berry (1985) propose the familiarity matrix (figure I). Strategies are recommended on the basis of familiarity with technology and market. Going from the base/base field to the New-Unfamiliar/New-Unfamiliar field, the degree of internalization and of corporate involvement decreases. According to the specific weaknesses in the different fields - either on the market or on the technology side - specific strategies are proposed. In the case of new and unfamiliar technology for a base market, for example, "new style" joint ventures are advised. These "new style" joint ventures are characterized by the alliance between a large company with the necessary marketing skills and a small company with high technological expertise (see also Hlavacek et al. 1977).

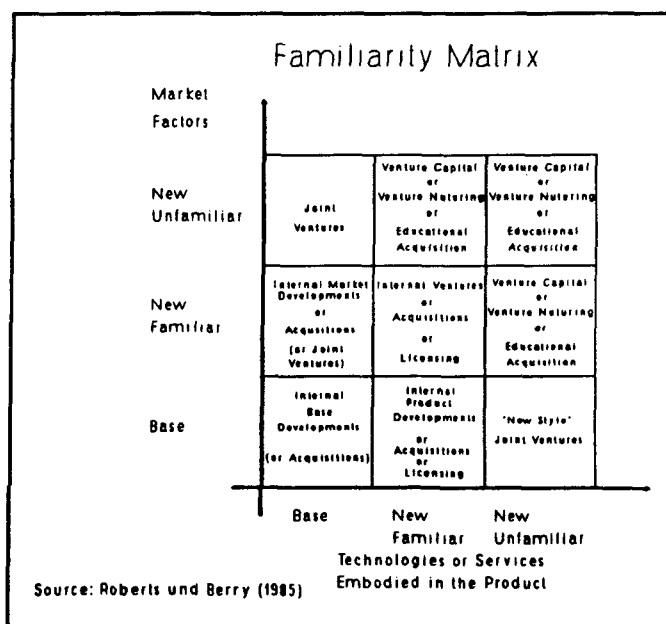


Figure I

Krubasik (1988) uses development risk and opportunity cost as crucial factors (figure II). Development risk entails market risks as well as technological risks. It seems plausible that risk is negatively correlated with

familiarity (Utterback et al. 1991), therefore this approach combines the two factors of Roberts and Berry into one. The other factor - opportunity cost - might be viewed as an implicit measure of time pressure. The recommendations to use external sources of technology such as acquisition or joint ventures occur in the region with rather high time pressure. An important part of a crash program - recommended for a situation with low risk and high time pressure - is the external sourcing of parts and components rather than developing these components in-house. Time pressure (or, in other words, urgency) is also part of the concept of Pearson (1990). Pearson's concept suggests, furthermore, uncertainty of means and ends as criteria for the choice of the appropriate development strategy. This concept and other concepts, including approaches based on transaction cost theory, are presented in Brockhoff (1992 a; 1992 b).

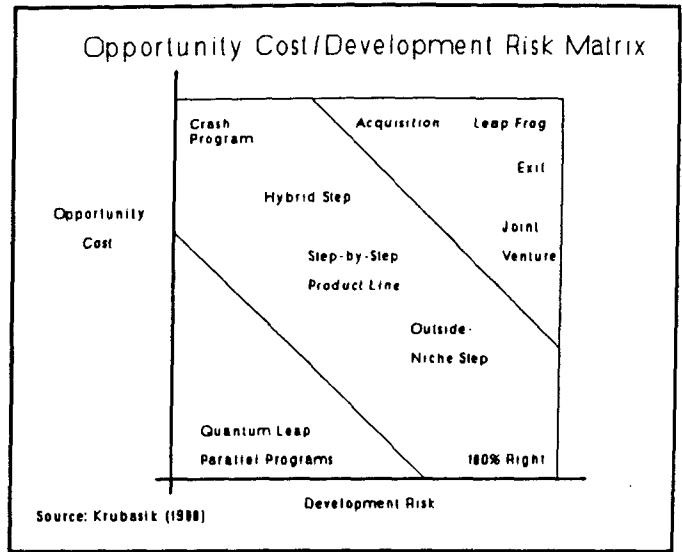


Figure II

As a consequence of the issues raised in the above paragraph, the research question raised in the beginning will be divided into the following three sub-questions.

- Can the different sources be regarded as alternatives?
- What are the main factors describing the project situation?
- Are there differences in situation factors between different sources?

3. Empirical Results

In order to get some empirical insight into the questions under discussion a survey was carried out. The questions and results discussed here are part of a broader approach. A questionnaire was sent to 194 companies in West Germany. So far 81 questionnaires were returned. The questionnaire asks for a description of two "successful" projects leading to new technology. One of the projects should mainly be carried out by internal R&D, the other should be carried out using mainly external sources. Mainly internal or external means that more than 50% of the project costs are spent internally or externally, respectively. The 81 responses contain descriptions of 72 "internal" and 70 "external" projects. One limitation of this approach shall be mentioned. By asking for successful projects we aimed at something like "best practice". But to really distinguish what made these projects successful a different approach would have been necessary. Either the success of technology acquisitions would have to be measured by a number of variables on a continuous

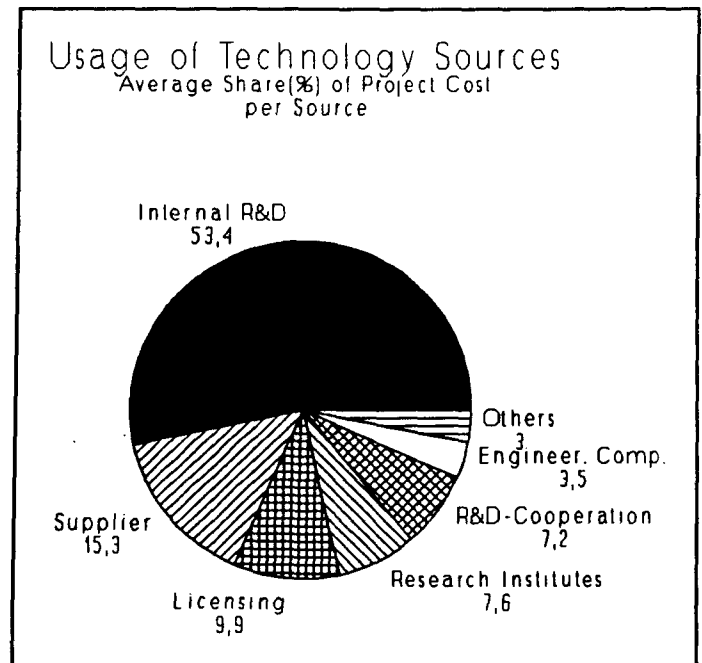


Figure III

scale (Hauschildt 1992), or one could compare successes and failures (see e.g. Cooper 1983), thus measuring success on a dichotomous scale. Especially in trying to derive managerial implications one has to keep this limitation in mind.

Can the different sources be regarded as alternatives?

Figure III shows the average distribution of costs among the different sources. All averages presented in this paper are unweighted. On average about 50% of the costs are spent internally. However, in more than 80% of the projects sources of technology are used simultaneously (figure IV). Use of 4 sources of technology occurs nearly as often as the use of only 1 source. Figure V shows this same effect again, e.g. suppliers contribute to about 50% of the projects, though only 15% of the costs are spent on them (figure III). So, when suppliers are used, they receive only 30% of the total project costs. This raises the question of whether there are projects one can justly classify as "supplier projects". Furthermore, it is interesting that in well above some 90% of the projects internal R&D is involved. External acquisition of knowledge seems to be based upon a significant amount of in-house competence (Radnor 1991). An interesting question in this context concerns the characteristics of the in-house competence necessary to make efficient and effective use of external sources of technology (Dosi 1988; Sen, Rubenstein 1989).

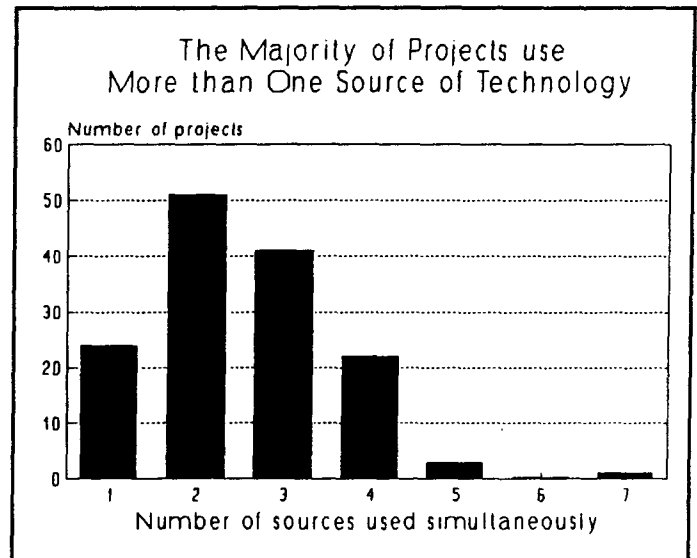


Figure IV

The data presented so far merely illustrates the problem of whether it makes sense to treat the possible sources of technology as alternatives. This question is studied by performing a cluster analysis. If clearly separated clusters appear, each one dominated by one source, and if the clusters have a low internal variance and are well distinguished from one another, then it seems justified to treat the sources as alternatives. The cluster analysis was carried out using the share of cost spent on the different possible technology sources as cluster variables. The squared euclidean distance was used as a distance measure and the clustering was performed using the Ward algorithm.

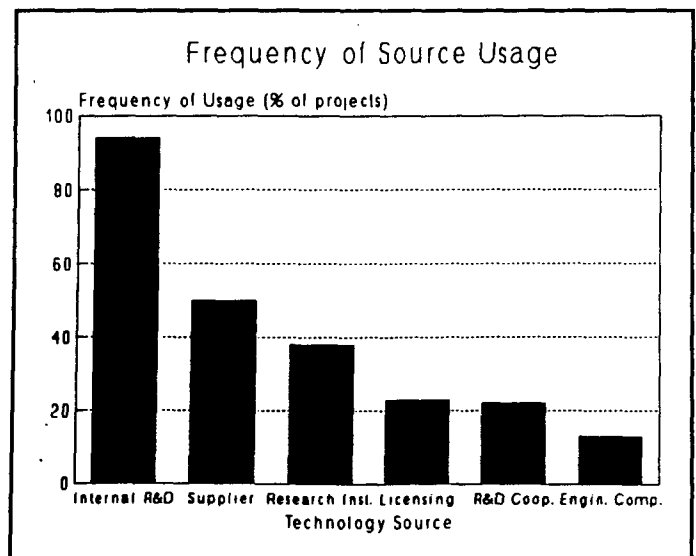


Figure V

We chose a solution with 7 clusters. The appropriate number of clusters is determined keeping the topic of this analysis in mind. Reducing the number of clusters would lead to a mixture of different sources which are separated in the solution with 7 clusters. Increasing the number of clusters would result in a split of the internal cluster into two. A necessary condition for a cluster solution is that the clusters are internally homogeneous and externally heterogeneous. This is the

case. The resulting clusters are rather homogeneous (in all clusters, less than 1/3 of F-values are greater than 1; only 17% of the total variance occurs inside the clusters). The clusters are well distinguished from one another (every cluster is significantly different from all the other clusters on at least one variable). Figure VI shows the result; 6 out of 7 clusters are clearly dominated by one source of technology. The 7th cluster represents a mixture of the other sources. We assume that due to the small number of cases that these sources occur combined in one single group. In all clusters external sources are supported by some internal R&D. The main result of this cluster analysis is that there is a well-founded justification for treating the different sources of new technologies as alternatives, always keeping in mind that only rarely can "pure" cases be found.

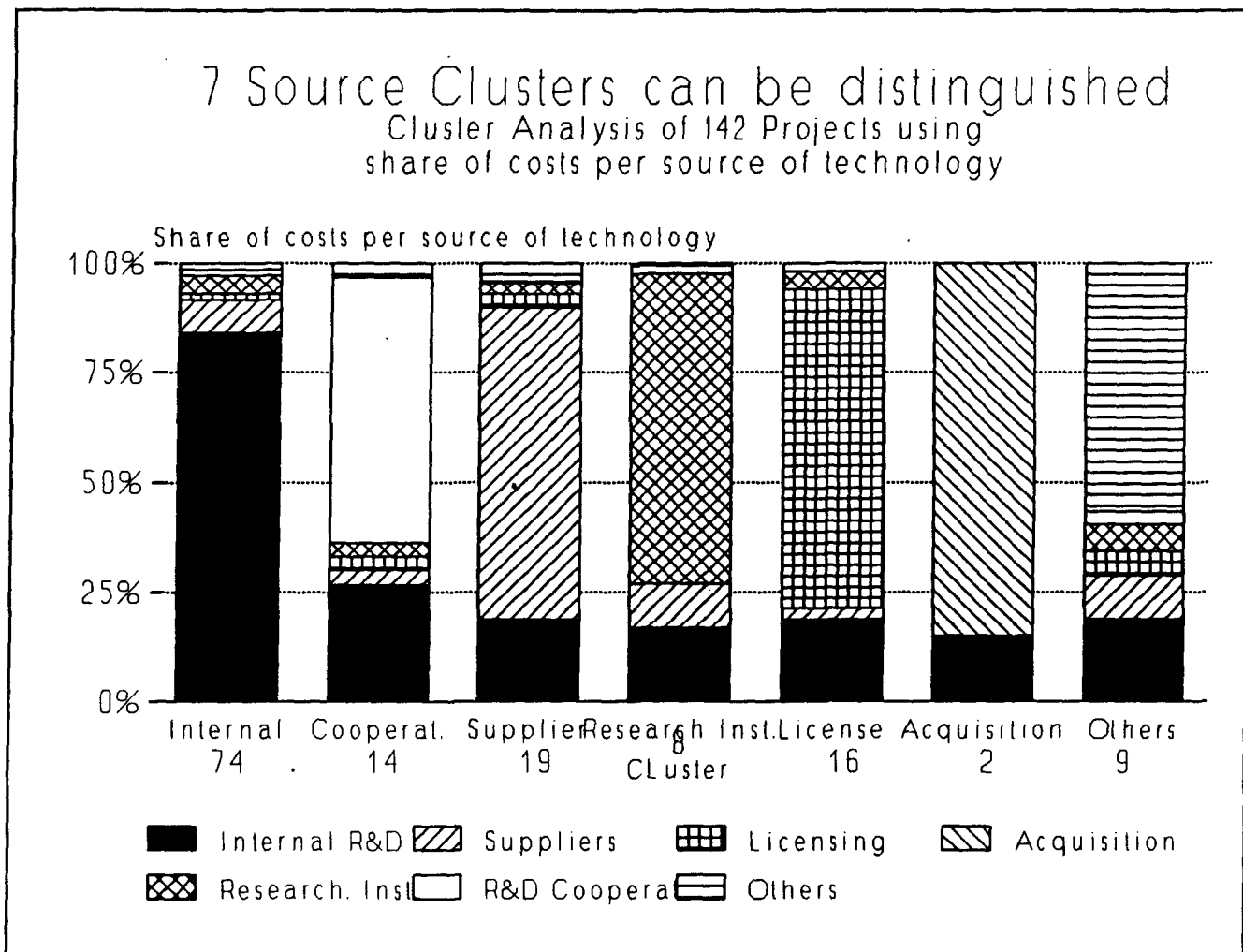


Figure VI

What are the main factors describing the project situation?

The questionnaire is comprised of 21 variables describing the project situation. Variance analysis shows that the source clusters differ significantly in a number of these variables. In order to reduce the number of items to be considered to a reasonable amount, a factor analysis was carried out. The factor analysis covers the 14 variables for which this procedure seems appropriate (MSA-values above 0.55). Except for one, the variables excluded from the analysis show no significant differences between the source clusters. Therefore, they are not relevant in this context. Through principal component analysis and using the Kaiser-criterion to determine the appropriate number of factors, 5 factors could be extracted. A KMO-value of 0.66 and an explained variance of 66% show that it is reasonable to conduct this factor analysis. A varimax rotation was used to facilitate the interpretation. The resulting factors offer quite natural interpretations and show considerable face validity. The

following five factors could be extracted (factor loadings in brackets):

Factor 1: Competitive relevance of the technology

- Difficult to imitate (.80)
- Difficult to communicate (.59)
- High market entry barriers (.59)
- Thorough mastering of the technology leads to competitive advantage (.65)

Factor 2: Relative technological position

- Similar to in-house technologies (.76)
- Required R&D resources fully available in-house (.82)
- External suppliers have weaker technological position (.73)
- Core technology (.47)

Factor 3: Market-Know-How

- Familiar Market (.92)
- Company already on the market (.91)

Factor 4: Strategic Relevance

- Technology plays a major role in long term strategy (.74)
- High investment (.77)

Factor 5: Market distance

- High technological risk (.73)
- Marketable application only in the long run (.80)

Factor 1 incorporates variables that ensure the competitive relevance of the technology. First of all the technology has to offer the opportunity to gain a competitive advantage. But this advantage must be defensible to be of long term importance. A technology that is difficult to imitate and the know-how of which is not easily communicable may be defended at least as a trade secret. The existence of high market entry barriers reinforces these advantages. Altogether this description shows similarities to the concept of non-tradeable assets (Winter 1987).

Factor 2 describes the technological position of the company towards the new technology. Similarity to in-house technologies probably offers the opportunity to estimate risks and chances of the new technology on the basis of experiences in closely related technical fields. Similarity might even signify that technical solutions can to some extent be transferred. Similarity of technologies also implies a similarity of necessary R&D-resources, thus increasing the chance of having all required resources in-house. The firm's own technical starting position must be set in relation to the starting position of external suppliers. Similarity to in-house technologies, availability of R&D resources and strong relative starting position will obviously recommend the new technology as a future core technology.

Factor 3 states the extent of market know-how. If the market for the new technology is similar to the markets the company is working in and, moreover, if the company is already present on the market, then it will most

likely posses significant market know-how.

Factor 4 characterizes the strategic relevance of the new technology for the company. If a technology plays a major role in the long term strategy of a company, the company probably must and will be well prepared to invest heavily in the new technology.

Factor 5 describes the market distance of the new technology. If a marketable application of the technology can only be expected in the long run, then the project is more likely to be a research rather than a development project. One would generally expect that the technical risk connected with research is higher than that of development (Utterback et al. 1991). In a far-reaching interpretation, one might think of this factor as negatively correlated to time pressure, assuming that research projects are typically less costly and less correlated to other company activities like manufacturing or marketing than development activities are (Utterback et al. 1991). Development activities will typically have clear time schedules and a higher degree of intercorrelation with other company functions, which consequently produces pressure to make input necessary for other company functions available in time.

Are there differences in situation factors between different sources?

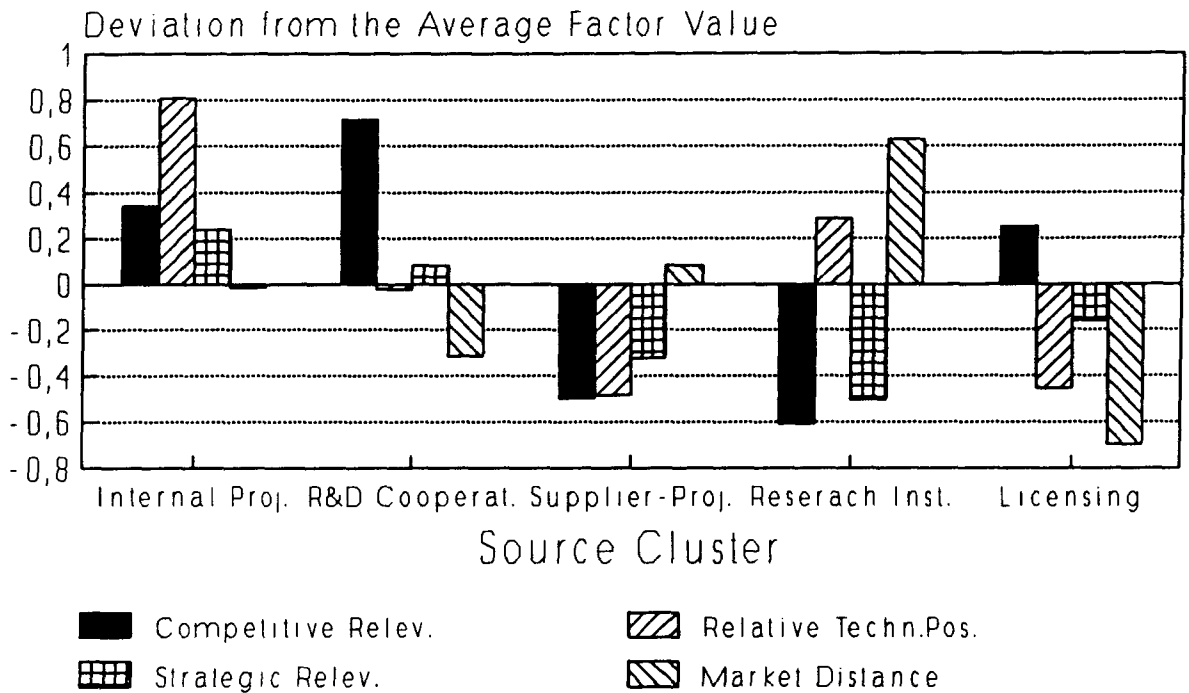
This question will be addressed through a variance analysis. The variance analysis examines whether or not there are significant differences in one variable depending on the value of another variable. Here it will be tested whether the situation factors show significant differences depending on their source cluster membership. If the variance analysis indicates significant differences, this does not imply that there are significant differences between all pairs of source cluster or even between any of the pairs.

The variance analysis shows significant differences on 4 of the 5 factors on a 5% level. Factor 3 - market know-how - is not significantly different between the source clusters. The deviations of the factor values from sample means are shown in figure VII for 5 of the 7 clusters. The acquisition cluster is not shown because it contains only two projects. The mixed cluster is not shown because its structure does not allow a clear interpretation of the results.

New technologies that are developed by **internal R&D** have a competitive as well as a strategic relevance above the average. The market distance has average values. The most outstanding feature in this cluster is a relative technological position that is markedly above average. This picture is very plausible. A technology that offers sustainable competitive advantages and is part of the strategic focus of the company is attractive. If, in addition, the company has a strong technological position, the obvious solution is to develop the new technology through internal R&D.

New technologies that are developed by **R&D cooperations** show only an average relative technological position and strategic relevance. Market distance is below average, but most outstanding is the high competitive relevance of the technology. Again there is a plausible interpretation of these values. The technology is highly attractive in terms of competitive relevance, and fits the company strategy though it is not a key project. The technological position is only average, which means that there are companies which are better. To increase the chance of being a successful player in this interesting field, the company needs external support. Assuming that the company is willing to improve its technological position in the long run, seeking support from suppliers or through licensing might not be the first choice. This is because by cooperating, the company might achieve better access to complementary know-how and stimulate the in-house learning process.

The Source Clusters differ significantly on the Situation Factors



Deviation per Factor
at 5% significant

Figure VII

New technologies that are acquired through **licensing** show a competitive relevance above and a strategic relevance slightly below average. But it is striking that the company's own technological position is far below average and the technology is very close to the market. The technology is nice to have due to its competitive relevance, but having only a low strategic fit it is not appropriate for internal R&D. Moreover, the poor relative technological position would probably make this a risky and also time-consuming and costly undertaking. Being close to the market, time overruns would most likely result in opportunity costs. Licensing makes the technology and thus the competitive advantages available without too much internal involvement. Moreover licensing will probably do this at low risk and in timely fashion.

New technologies that are acquired through **suppliers** show average market distance. But it is remarkable that the technologies have low competitive and strategic relevance and that the company's technological position is weak. Obviously the company is not good at the technology and it doesn't care to be good, as the technology lies outside the strategic focus. The picture is clear, there is no reason to develop such a technology internally. We can assume that it is required as a complementary technology for an intended product, the market success of which is determined by features not related to this technology. It seems reasonable to let a supplier develop such a technology. For the supplier this technology might well be more attractive, because he is operating within a different market.

New technologies that are developed using **research institutes** have a low competitive relevance, and play only a subordinate role in the company strategy, although the relative technological position of the company is above average. The projects will typically not lead to marketable products in the short term. Such characteristics are expected in the case of more research-oriented projects, where technological potentials are difficult to judge at an early state. The rather good technological position of the company shows that the new technology is not completely outside the range of technologies usually used in the company. Because future potential might surface the project is pursued, but without much strategic commitment.

Coming back to the concepts published in literature, we will first look at the familiarity matrix of Roberts and Berry (1985). Technical familiarity is closely related to the relative technological position in factor 2. The importance of this factor was supported by the data. To compare our results with the recommendations of Roberts and Berry, the strategies proposed in the familiarity matrix must be projected onto the technological familiarity axis. A comparison of their suggestions with the results obtained here can naturally only be made for those technology sources that occur in both studies. R&D cooperations in this paper are comparable with the new style joint ventures of Roberts and Berry. The joint venture ("old style") of Roberts and Berry serves mainly marketing and distribution needs and hence is not a means of technology acquisition. In the base segment the authors suggest internal development. This fits well to the findings of this study. In the intermediate field internal development or licensing are suggested. In the field with the lowest technological familiarity they advise "new style" joint ventures, or R&D cooperations in our terminology. The results of our survey would suggest a different order for the last two fields. Our data show that the in-house competence is around average in the case of cooperations and below average for licensing. This may be due to the differences between R&D cooperations and the "new style" joint ventures of Roberts and Berry. The latter represent only part of the cases called "cooperations". The questionnaire does not allow determination of the relative size of the cooperating partners. The second factor in Roberts and Berry, familiarity with the market, can be compared with the market know-how factor in our study. This factor turns out to be of no importance for the decision on the source of new technology. This seems to be in contrast to the recommendations of Roberts and Berry. But one has to keep in mind that their study has a somewhat different focus than this one. They look for entry strategies. An entry strategy does not only ask for the source of new technology but also for the best way to market the technology. For the second part of their topic the market familiarity is probably highly relevant (Capon, Glazer 1987).

The topic of appropriability put forward by Teece (1986) is connected with the competitive relevance factor. This factor turned out to be highly relevant in the choice between different sources of new technology.

The opportunity cost/development risk matrix of Krubasik is more difficult to evaluate. Opportunity costs have an aspect of time pressure. Time pressure in our study did not show a significant effect on the choice of the source of new technology. But here lies one major caveat of the way of treating the data. The results might only indicate that there is no individual source of new technology that, on average, is significantly faster in providing new technology. On a project level, time may well be a very important criterion for choosing the source of technology. The questionnaire also asked for the weight that several criteria had for the source-decision. The data show that on the average, time was the most important criterion. So it seems that the question of which source is able to provide new technology with the least delay can only be answered on the project level. The development risk axis of Krubasik combines technological as well as market risks. Market risks turned out to be of no significant importance for the choice of the source of new technology. Technologi-

cal risk is part of the market distance factor which does not clearly favor internal or external sources of new technology. Therefore the development risk does not allow the making of general recommendations concerning the source of new technology. It should be stressed again that this by no means implies that development risk is not an important criterion for the choice of the appropriate technology source.

4. Summary and Outlook

We have aimed to address this question: In which situations do companies use which sources for acquiring new technologies? Seven distinctly different source clusters were found, all of them but one clearly dominated by one source. The project situation can be described by five factors. Four factors show significant differences in the different clusters. Plausible interpretations can be given for the differences between the clusters, which are generally in line with findings in the literature.

This study indicates that the approach chosen in successful technology acquisitions can be interpreted on the basis of a clear strategic concept. This concept might also prove useful for practical managerial purposes. The variable distinguishing most strongly between internal R&D and the external sources is the relative technological position (Dosi 1988; Meyer, Roberts 1988; Utterback et al. 1991). If this position is strong, the technology should probably be developed in internal R&D. Only when the new technology is of very small competitive relevance might contract research be preferable. If the technological position is very weak, either licensing or research carried out by suppliers is advisable, depending on the competitive relevance. In this case technologies with a high competitive relevance should preferably be licensed. If the technological position is average and the competitive relevance is high, then R&D cooperations might be preferred. Although these propositions seem plausible, one should keep in mind that the empirical data do not allow us to assume that acting contrary to this concept leads to failure. This question needs to be studied in more detail in future research.

Thus far the source clusters have been taken as given, and situational differences were looked for. The obvious next step is to use the characteristics of the project situation as predictors for the appropriate source of technology. Furthermore, for reasons mentioned above a success measure should be introduced. If it is possible to construct discriminant functions such that a large majority of projects could be classified correctly, then a decision-supporting concept could be proposed based on empirical evidence. In this survey the number of projects in the different external source clusters is rather small, therefore it is probably difficult to thoroughly test the predictive value of such a concept. It seems very worthwhile to further extend the approach taken in this study.

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