The Management of Innovation in International Corporations as a Dynamic Process of Organizational Learning

Models on Organizational Structures, consisting of Research and Development units

Martin U Großmann
Industrieseminar der Universität Mannheim
University of Mannheim, Schloss
D-68131 Mannheim
Federal Republic of Germany
Tel: +49 621 292-5527
Fax: +49 621 292-5259
E-mail: marox@mailrum.uni-mannheim.de

Abstract

Scholarly research has long identified innovations as one important reason for internationalizing corporate businesses. This statement is represented analytically by cause-effect-relations at the beginning of the project. Innovations, i.e. the underlying technologies, have a crucial impact on industries and their development over time. The dynamic relationship between technologies and their industries will be explained on the basis of technology and industry life cycles.

Subsequently, it is pointed out that one important precondition for generating innovations successfully is the organizational structure by which research and development (R&D)

units are linked together. Basically, three organizational models which are examined can be distinguished: an international network model, a centralized, and an internationally decentralized model. According to these models, the process of organizational learning on knowledge, relevant for innovations, takes place in different ways. To generate successful innovations, R&D personnel has to learn diligently and quickly from both: the new technological developments and from new or changing market needs. Proposals could be made to facilitate organizational learning in the field of R&D. Then, the organizational models are allocated to the quadrants of a technology portfolio. One axis symbolizes the attractiveness of the technology which basically illustrates the technology life cycle. This may offer a theoretical explanation of the need for adjusting organizational R&D models and the organizational learning process according to the dynamics of technologies.

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INNOVATIONS AS THE RAISON D'ÊTRE FOR INTERNATIONAL CORPORATIONS

In most industries, expenditure in research and development (R&D) has increased significantly over the last few decades. Nowadays, national markets are too small to warrant high R&D costs and this is further complicated by the shortening of product life cycles. Thus, national corporations try to derive further profit in foreign markets with their innovations.

For that purpose, direct investments abroad are necessary to enable companies to grow step by step into the international environment. Since other national and international corporations are involved in foreign markets, the competition increases.

Under competitive market conditions, the ability to innovate is becoming the prime source of success (Bartlett 1989). This leads to a strong pressure on the innovation process which causes additional R&D expenditure. These reinforcing cause-effect relationships are illustrated in figure 1 by a positive feedback loop.

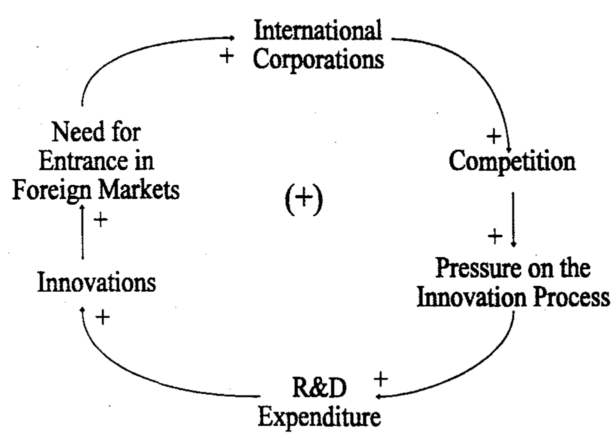

Figure 1: Cause-Effect Relationships creating International Corporations

IMPACT OF NEW TECHNOLOGIES UPON INDUSTRY LIFE CYCLES

The changing character of industries can be represented by an industry life cycle (ILC) constructed in a similar way to the product life cycle used to describe the market evolution of products (Bonoma and Kosnik 1990). The stage in which the ILC exists could be interpreted as the accumulated stages of all products comprised by one industry. Moving through the ILC, the following stages can basically be distinguished: introduction, growth, maturity, saturation, and decline.

The market of new industries is typically a low-growth market. If the products contribute to the customer's utility successfully they will move into the growth phase in which sales, i.e. the market volume increases.

The growth slows down in the maturity stage. The gradient of the market volume curve becomes zero later on in the saturation phase when no additional turnover can be realized. After this peak has been reached the market volume may decline.

Industries and their products accordingly are the result of combining different technologies[1] (Servatius 1985). A technology life cycle (TLC) also exists (Ford and Ryan 1981) (see figure 2):

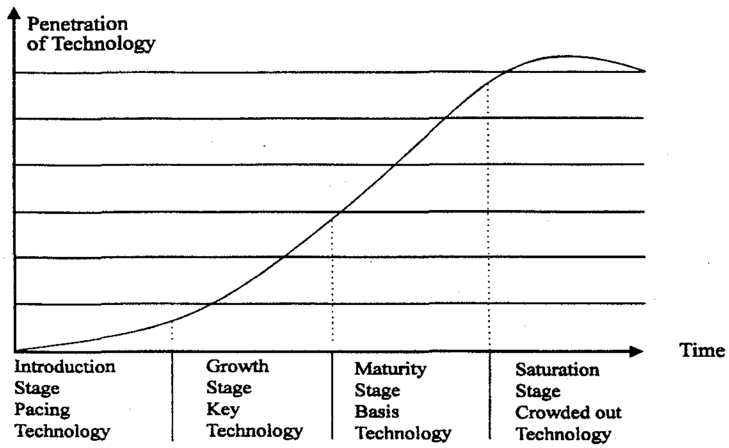

Figure 2: Technology Life Cycle[2]

Emerging technologies as a result of basic research involve a high degree of risk.[3] But, their potential extent of influencing competition either by increasing product or process performance or by modifying cost-structures is high (Servatius 1985). They are called pacing technologies and they may replace the subsequent key technologies.

Key technologies are allocated to the growth phase of the TLC. The technological risk is reduced because of a growing number of fields to which they could be applied. Their key function is related to the significant advantage which the user has in current competition.

Following on, in the mature stage, and especially in the saturation stage, advantages in R&D are difficult to achieve. The risk inherent to these technologies is low and they serve as basic technologies for most competitors. Therefore, their competitive impact is weak and they will possibly be substituted in the near future.

The likely impact of technological developments upon industries can be described as follows (compare figure 3):

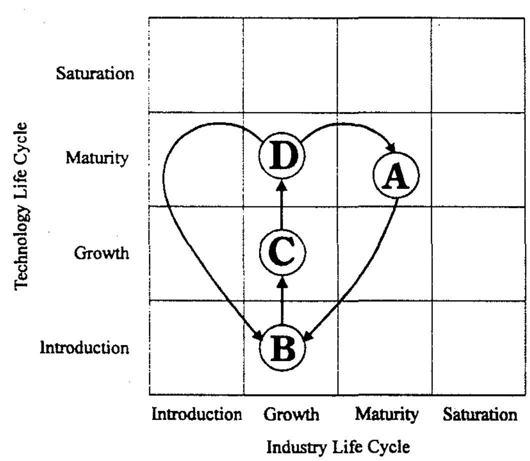

Figure 3: Impact of Technologies upon Industries

In a mature industry which may be based primarily upon mature technologies,[4] the market shares are relatively stable and technological evolution is slow (point A). If pacing technologies emerge it is likely that the industry moves back into the growth stage (point B). To cause the industry to return to the growth phase, the new technology should be of sufficient competitive impact. This is the case if the market value of existing products increases by implementing the new technology or if new products are brought out.

Because of the fast technology diffusion caused by profit incentives the technology moves into the growth phase (point C). Since many new market entrants appear, market shares become highly volatile. As the technology matures (point D), other competitive factors, e. g. price, service network, and quality, regain importance (Ketteringham and White 1984).

As growth rates decline, the industry may return to its original mature state and stabilize (back to point A). The original leaders in the mature industry at the beginning of the process may regain a strong market position and the market entrants during the growth phase of the technology will either abandon their business or may be acquired. However, it is likely that further new technological developments offer opportunities that will sustain the industry's growth rate (back to point B).

This development process could be possible for the future of the chemical industry. In particular, the pharmaceutical sector could be shifted into the growth stage by biotechnology, especially by genetic engineering. This emerging technology enables new drugs and diagnostic products to be manufactured. It also facilitates production processes in the chemical industry.

ORGANIZATIONAL STRUCTURES CONSISTING OF R&D UNITS AS LEARNING ORGANIZATIONS

To generate innovations successfully, the organizational structure in which R&D units[5] are linked is one crucial factor.[6] Basically, three organizational models can be distinguished: an international network model, a centralized, and an internationally decentralized model.

Generally, the objective of any organizational structure in the field of R&D is to support the innovation process effectively and efficiently.[7] Moreover, it should allow R&D results to be exploited as rapidly as necessary related to the best competitor on a global scale.

In the following examinations, the author tries to prove the hypothesis, that the above mentioned R&D models can be allocated to specific stages of the TLC and by moving through the TLC, the organizational model should be modified accordingly.

INTERNATIONAL NETWORK MODEL

Typically, research on new technologies causes high growth rates in scientific knowledge. Technological discoveries take place in short periods which either make the former scientific knowledge rapidly obsolete or they expand on previous research. Moreover, in such fields of pacing or key technologies, the outcomes of research often fill gaps in fairly unknown fields.

Nowadays, the growth of knowledge at the beginning of TLCs takes place in many research institutes distributed worldwide.[8] Hence, if a corporation decides on research for a specific pacing or key technology,[9] it should establish R&D units abroad close to successful institutes. Co-operating with such institutes in selected research areas, the company is able to participate in the growth of scientific knowledge by learning from external research. This co-operation may also allow a stable supply of research professionals for the firm' s laboratories.

Subsequently, with the corporation's own research endeavours the company could obtain a leading position in the corresponding fields. Innovations at the beginning of TLCs are primarily caused by technological breakthroughs and not by market needs (Zahn 1986).[10] Therefore, an R&D-

structure should be very sensible for the high dynamics in scientific knowledge inherent in the corporation's environment.

An International Network Model (INM) may be the most suitable for research on emerging and early growing technologies, i.e. for pacing and early key technologies. The following figure offers an INM in the technological field of genetic engineering from the view of a German corporation.

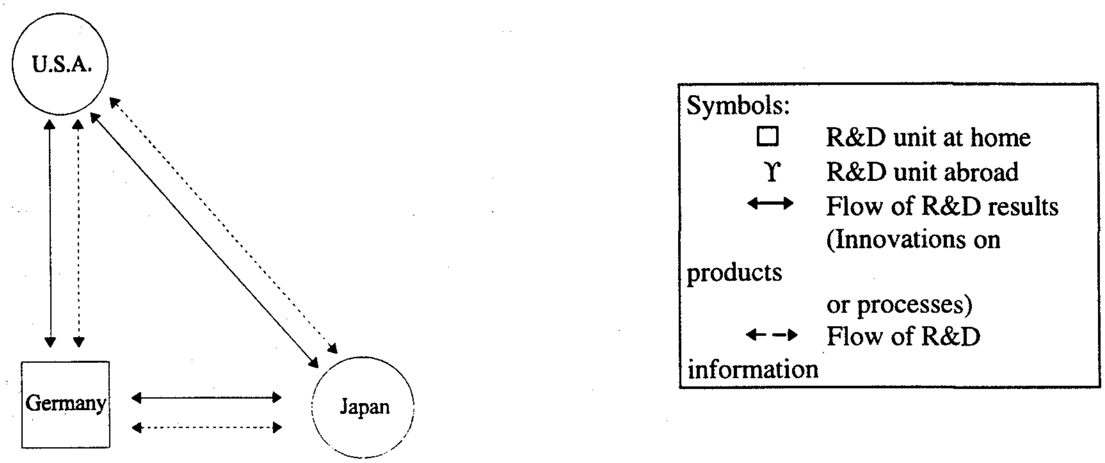

Figure 4: International Network Model

Research and especially development in genetics is executed on a worldwide leading level in the United States[11] and more and more so in Japan. German international corporations should therefore erect R&D-laboratories overseas. The main task of the central R&D unit in Germany concerning the network co-ordination is to monitor the R&D portfolio of the foreign units to ensure their conformity with the overall corporate strategy. To keep the decision process in R&D units abroad flexible enough to permit the rapid exploitation of new knowledge, line responsibility for the units should rest with local subsidiary management.

Foreign units have to be closely linked by a communication network to guarantee a rapid transfer of knowledge within the corporation. By intensive exchange of R&D information and results between all units the lerning process of the participants is easier and quicker (Senge 1990). See figure 4 which shows the communication network between headquaters and abroad and vice versa. Additionally, linkages exist between foreign units. In such learning organizations, the learning units, i.e. R&D laboratories, are close to the "source of scientific knowledge" and consequently the innovation development time becomes shorter.

The R&D network as a "centre of technology" is responsible for developing **one** technological field and this may be relevant to different business units of a corporation. In this sense, the research of every network unit should be based on a holistic perspective

For example, genetic engineering can be applied in the chemical industry, particularly in pharmaceutical, agricultural, and environment-protecting areas. German chemical gigants are more or less involved in most of these areas, which are usually internally organized by divisions. The R&D units of these divisions which are involved in genetic research should be linked by an INM, since it is likely that technological breakthroughs in one section are of high value for the others. Subsequently, the other business units can utilize new research findings in their production processes worldwide.

In addition, political and legal restrictions, such as the German law on genetic engineering, which were until recently very tough, could be overcome by INMs.

The degree of integrating R&D laboratories into an international network and herewith the speed and success of the organizational learning process could be enhanced by personal interaction between researchers of different countries: by regular meetings and training activities, by mutual exchange of research personnel, and by joint research projects. However, a high degree of international co-ordination is necessary and therefore it is limited by it's co-ordination costs.

CENTRALIZED MODEL

Using the flexibility and innovative power of globally distributed laboratories causes high additional expenditure in comparison with a centralization of R&D activities in the home country. Moreover, centralising R&D resources reduces costs by economies of scale since assets are commonly usable and by economies of scope since interdisciplinary interaction at one location is possible.

Up to a specific size of the R&D centre, internal communication is simpler and therefore cheaper than in an INM. Last and least, centralization leads to a relatively culturally homogeneous R&D personnel. But, the management of intercultural teams does not seem to pose too many problems since the scientific culture usually dominates local culture (Servatius 1987, de Meyer and Mitzushima 1989).

The problem of deciding between an INM and a centralized model is in fact a trade-off between costs. For example if an INM is favoured, additional R&D organizations including facilities and their co-ordination have to be paid for. Opportunity costs by the loss of economies of scale, economies of scope, and critical mass in the R&D centre are incurred. In the case of centralization, opportunity costs arise due to untransferred scientific information from abroad.

The cost of lost opportunity is low if the international growth rate in scientific knowledge is low. This is the case at the end of TLCs for technologies in the late maturity and saturation stage. There, the maximum of the technological performance will already have been exploited.

An international co-operation which has a leading position in technological fields at the end of the TLCs is more or less independent of foreign research experiences. The diffusion of scientific knowledge through conferences, publications, and patents on the specific field of technology appears to be quick enough. The organizational learning process is predominantly related to the specific areas examined above in which advantages of centralization could be reached.

In conclusion, the centralized model, illustrated in figure 5 is most suitable for technologies placed in the late mature and saturation stage, i.e. for late basis and crowded out technologies.

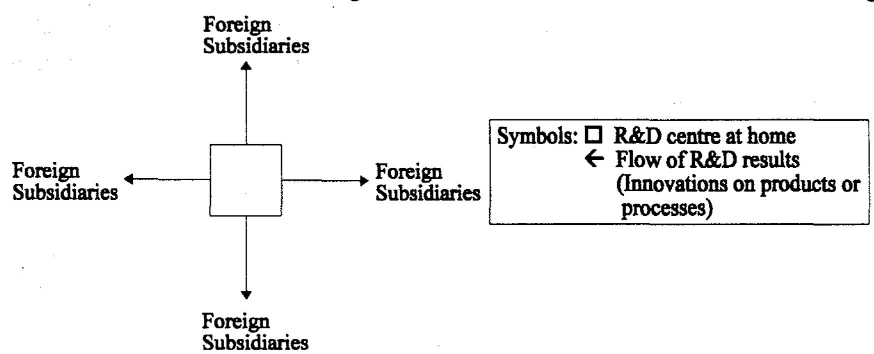

Figure 5: The Centralized Model

Within a completely centralized model, all R&D activities are executed at one location. The R&D results can be exploited by foreign subsidiaries without problems, if worldwide homogeneous consumer preferences exist.

But, if consumer preferences differ broadly, the central innovation process might not reach the market needs abroad, since new opportunities are only realised in the home market. Thus, organizational learning in the R&D centre is limited to the market of the home country.

To make the central process of organizational learning more effective, communication linkages between headquarters and overseas subsidiaries should be built up. The linkages help headquarters' R&D personnel not only to understand country-level needs, but also to give subsidiary managers access to central R&D, to influence decisions related to product specification (Bartlett 1989).

Another proposal to increase the effectiveness of the organizational learning process could be by using a kind of "market mechanism" within the R&D centre.

For that purpose, the central research laboratories should be divided into two groups. The first is responsible for projects which are important for the company's long-term strategic position and are possibly applicable across different product divisions. Such laboratories have to be funded directly by the corporate board.

However, the second group dealing with R&D projects which are highly relevant to particular product divisions should finance their projects by these business units. The laboratories write proposal about R&D projects they would like to undertake and the divisions suggest a set of R&D projects they would like to sponsor.

The resulting negotiations are very similar to those in the market and the participants learn from each other's preferences. The supply on R&D interests of the laboratories come together with the demand on R&D projects strongly influenced by the product division's needs.

An intensive competition for projects and budgets under laboratories accelerates organizational learning with the result that the subsequent R&D projects are closely linked to the foreign market needs.

Learning processes are also necessary between central R&D and the production departments. Within R&D, production expertise must be implemented to facilitate manufacturing of the innovation once the design is completed. The learning process should be forced by personnel flows.

When ever possible, the company should identify the engineers in the production areas who will head the production task for an innovation currently under development and makes them a member of the research team in the early development process. With such a flow of personnel, difficulties and therefore delays in the manufacturing department can be minimized by injecting production knowledge into the R&D process. In this sense, the learning process takes place a priori which creates less expenditure in the R&D and in the production areas than by learning a posteriori, after problems have emerged.

INTERNATIONALLY DECENTRALIZED MODEL

The internationally decentralized model (IDM) has an intermediate structure which is placed between an INM and a centralized model. The IDM tries to join the models mentioned above. Now, the corresponding learning processes take place in one organization. In figure 6 an IDM is illustrated.

The R&D centre at home keeps a co-ordinating function in all technological fields in which the firm has a leading position. The R&D units abroad are usually part of foreign subsidiaries which hold high market shares. There are hardly any linkages between the foreign units.

It is easier to adjust R&D projects to foreign market needs in an IDM than in a centralized model. New market knowledge relevant to innovations constantly arise in a competitive environment (Giersch 1984). In the subsidiaries' R&D unit, this knowledge can immediately be used either to modify central R&D results or to create „market pull" innovations.

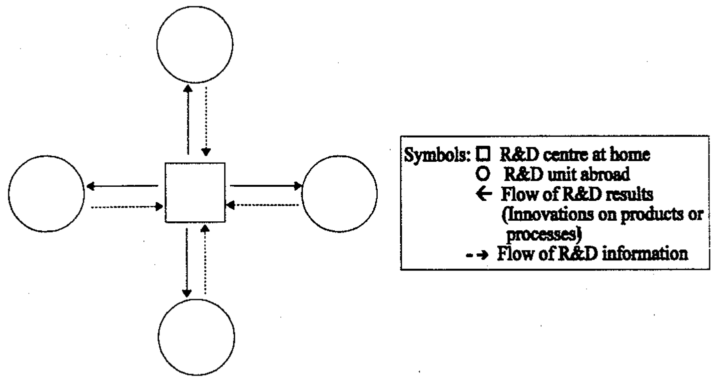

Figure 6: Internationally Decentralized Model

The necessity for adjustment may be important in most markets from the late growth phase onwards. From there on it becomes more and more important to satisfy customers' specific needs to maintain a competitive edge. But, the R&D centralization is recommendet for the late maturity stage onwards since dominating advantages of centralization emerge.

Consequently, the IDM could be an intermediate organization for technologies in the late growth to the early maturity stage.

CONCLUSION

The models described above can be placed into the quadrants of a technology portfolio. The technology fields in which a corporation may work should be evaluated corresponding to both axes of the portfolio illustrated in figure 7. Subsequently, the organizational model to support R&D most effectively and efficiently can be chosen.

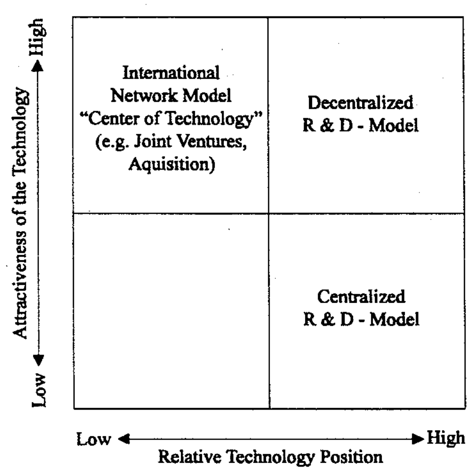

Figure 7: Technology portfolio

The "Attractiveness of the Technology" basically illustrates the TLC. Technologies from the introduction to the early maturity stage can be seen as highly attractive.[12] The "Relative Technology Position" is determined by assessing the firm's current position in a given technology related to the best competitor.[13]

In conclusion, the structure of international R&D organizations have to be adjusted on the dynamics of TLCs. Reconsidering the R&D model should be institutionalized by using technology portfolios.

Notes

1 Technologies usually imply a practical application of science or engineering knowledge (Ketteringham and White 1984).

2 The inception point of the curve is placed at that time at which the technology starts to have a market value (Ford and Ryan 1981, especially for stages before that point).

3 The risk of a technology can be measured by assessing the degree of uncertainty related to both the R&D outcome and it's potential yield (Ketteringham and White 1984).

4 The stage of an industry need not be identical to all the stages of the technologies incorporated. Their relevance for the development of an industry as a whole may differ strongly.

5 Theoretically, a R&D unit (or R&D laboratory) has to incorporate a minimum of personnel and equipment called 'critical mass' to be able to work efficiently. There is considerable variation in the estimations of critical mass dependent on the type of the technological field to which R&D has to be performed. For example, in the pharmaceutical section, estimates vary between 100 and 200 professionals (de Meyer and Mizushima 1989, Gerpott 1990).

6 Other factors are for example: the equipment, the personnel, and the controlling of R&D activities.

7 Generally, the performance of an R&D organization can be measured by two criteria: 1. the efficiency, which is the ratio of the output to input and 2. the effectiveness, which is the relationship between output and the objective (Anthony et al. 1991).

8 These institutes are mainly involved in basic and applied research. They are usually located at Universities, in venture firms or in corporations of current or potential competitors. In contrast to this, during the 1960s the leading R&D institutes on microelectronics were only in Boston and Palo Alto (de Meyer and Mizushima 1989).

9 The decision on such technologies could be based upon technology-portfolio-analysis with the objective to gain a sustainable competitive advantage in the corresponding scientific area (Harris et al. 1984).

10 With technological breakthroughs, for example in genetic engineering, new pharmaceutical products are conceivable against currently uncurable diseases.

11 For example in Boston and Cambridge / Massachusetts and in different Californian locations.

12 It can be evaluated on the basis of the following criteria: the potential extent of influencing competition (see page 2), the breadth and depth of the field in which the technology could be applied, and the technology acceptance.

13 Criteria used to determine this axis could be the previous R&D results, as demonstrated by patents, the financial and personnel strength, and the quality of the equipment.

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