"TECHNOLOGY STRATEGY AND INTERNATIONAL R & D OPERATIONS"

by

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Abstract

International R&D operations, though not yet a very common activity for the international firm, have been increasing over the last decade ? Why is it that international firms decide to accept the increased communication difficulties of geographically decentralised R&D operations, in order to create networks of laboratories. In this paper we discuss the three traditional explanations of closeness to cheap labour markets for engineers, closeness to markets, and closeness to sources of technology. But on the basis of twelve case studies of Large European and North-American firms, we conclude that none of the these explanations can completely explain the companies' behaviour. The underlying explanation seems to be more the learning process that is going on in R&D. We further explore the consequences of this learning objective on planning and control procedures, the networking of laboratories, and the communication between laboratories.

Technology Strategy and International R&D Operations

1. Introduction

Casual observation of the business press indicates that the Research and Development function, an activity which many companies tended to keep at home in the headquarters, has increasingly become subject to internationalisation. Let us not be mistaken, carrying out R&D on an international scale is still not a widespread activity. A survey carried out by three large business periodicals in the Federal Republic of Germany, Japan and the United States (Brockhoff et al, 1988) suggests that German companies carry out 85% of their R&D at home, the U.S.A. companies 91.8% and for the Japanese companies in the sample the percentage of domestic R&D is even 98.1%. Though one has to take these figures with the necessary grain of salt, because they are probably somewhat biased by the sample of responding companies, they indicate that international R&D is not very widespread. However, the trend is not to be mistaken. International research is on the increase. A recent survey of the National Science Foundation (1), arrives at the very similar percentage of 91.9% of domestic R&D spending for U.S. companies, and shows that R&D spending abroad by U.S.A. companies jumped by 33% in 1986 and 1987, while spending at home went up by only 6%. For Japan and Europe, the trends are less well documented, but the scarce indications available suggest similar trends to exist in these two regions.

Why is it that companies decide to increase the geographical decentralisation of their R&D ? How does this influence strategy formulation, and how is this international network of R&D operations managed ? These are the questions we have set ourselves to address in this paper. To provide partial answers, we will use the insights we obtained through case studies carried out in twelve large European and North-American companies.

2. The research basis

In twelve large multinationally operating companies data was gathered though interviewing of research managers and their subordinates. In some cases the users of the results of research and development work, such as product managers and/or production managers were interviewed too. The interviews ranged from several hours to several days. Though the basis for the intervies was a checklist of items to be discussed, in most interviews the questions and

answers were very open, and adapted to the specific technology and market presence of the company involved.(2)

The twelve companies do not form a sample which is representative for a specific industry. Four companies belong to the electronics industry, one to the food industry, two to the pharmaceutical industry, four to the chemicals industry and one to the automobile industry. Nine of them are European, and three are North American companies which have been established for a long time in Europe. All of them had a long time experience with carrying out Research and Development on an international scale. The number of laboratories ranged from two to seventeen. In each of the cases, the companies had several hundreds of people working in research and development. Each of the companies is considered to be successful to very successful by evaluations in the professional business press, and judging from the financial performance over the last five years. This does not guarantee however the quality and succes of their R&D performance. In fact in more than one company we were granted interviewing time, because managers were concerned about the performance of their international R&D performance, and they hoped to get a sort of benchmark evaluation by the interviewing process.

The activities of the laboratories ranged widely on a scale from fundamental research to very applied technical customer service. We however discarded from the analysis simple process engineering outlets. Even in the definition of what research and development are, we found an enormous variety. What was classified by one company (even in the same industry) as research, would probably be named applied development by another company. Consequently it does not seem very useful to provide here a table with the number of research and development laboratories according to their technical activities at this stage. Whenever necessary in the analysis we will make the distinction between development and research

3. Why internationalising R&D ?

The disadvantages of international R&D operations can be summarised in one concept : increased difficulties in communication. This in itself leads to difficulties in coordination, reduces the speed of the development and can decrease the productivity of the R&D process. Spreading out the resources in R&D makes the company also run the risk of ending up with laboratories which are below the critical mass. Thus there are more than enough reasons to refrain from internationalising R&D. What is than the positive element that companies make decide to accept these disadvantages and go ahead with the creation of laboratories abroad ?

Traditionally the management literature (Terpstra, 1977) would indicate three categories of reasons : increased access to cheap R&D labour, closeness to the market and the customers, and access to the best sources of technological developments. Each of these three reasons find some support in the traditional theories on the internationalisation of the firm.

The neo-classical economic theory would argue that companies intenationalise their operations (in particular their production organisations) to take advantages of cost differentials in different countries. A laboratory can be considered to be a production site of knowhow. Since the cost of a laboratory is to a large extent determined by the cost of the professional scientists and engineers, one would expect companies to move to countries where PhD holders come cheap. The countries one thinks of usually in this context as an example are India or the Philippines , and indeed a limited number of specialty chemicals and software development companies have set up development laboratories in the Indian subcontinent or in Manila. With a few exceptions this trigger for internationalisation of R&D is rather weak, and this because one has to be fairly confident that the cost differential will exist over a long time. Indeed the creation of an R&D laboratory does not happen overnight. To be able to prove itself the laboratory has to build up a base of know-how, and have the time to produce its first results. This generally requires 5 to 10 years, and few places on earth can pretend to have cost differentials for professional personnel which will extend over such a long period.

A more sophisticated form of this argument is used in the case of multinational companies with headquarters in small countries. Their demand for professionals sometimes exceeds the total supply of the country. It is said for example that Philips of the Netherlands requires per year more engineers than the Dutch universities produce. The same is true for Swedish companies (Hakanson and Zander, 1986). In this case companies would create laboratories in countries with an abundance of engineers, which happen to be India and the U.S.S.R.

The data available on international R&D does not confirm such a movement triggered by cost differentials or availability of engineers. On the contrary previous studies (Ronstadt, 1977; Behrman and Fischer, 1980, Hakanson and Zander, 1986; Harris,1986), and also my own case studies suggest that the huge majority of R&D investments abroad tend to be in the free market oriented, industrialised countries. Consequently, this argument based on cost advantages does not seem to explain a lot of the internationalisation activities. Having said this, the availability of engineers is often a secondary consideration in the choice of location of the laboratory site.

The second category of reasons have to do with the market. Multinational companies have to become more responsive to their markets, have to adapt products to the national markets, and can not always rely on global marketing and global products to be successful. The best way of doing this is by being present in this market and by working closely together with users and customers. This requires the local presence of at least a technical support laboratory. And since these technical support laboratory seem to have the almost unstoppable tendency to grow into local product development centers (Ronstadt,1977), one gets a proliferation of market oriented product development laboratories in the larger markets.

This explanation of the increasing geographical decentralisation of R&D happened to be supported by the international product life cycle theory, as it was proposed by Vernon (1966) and his students. Although they never meant it to be that way, fairly quickly this theory was used as a prescriptive theory of how product development should internationalise. In an extreme simplification of the theory people would argue that after the introduction of the product in the lead market, and once the product specifications would be more or less stabilised, export to less sophisticated markets would start. Gradually export would be displaced by local production. This local production would increase the extent of its technical activities, and require the development of some process engineering capabilities. This technical support would provide equally support to the market, and as Ronstadt(1977) indicates, would grow into a local development center. Some of these local development centers would develop strong development capabilities, and their output could become relevant for other countries. In that sense they could develop a global product development responsability.

The model is attractive due to its simplicity and its evolutionary approach. But several underlying assumptions do not hold, such as a clear hierarchy of markets, the inherent logic of the growth of the laboratory, etc. Even the original proposers of the international product life cycle concept indicate that the theory has several fallacies, and it can clearly not be the basic explanation of international R&D as it happens today (Vernon,1979).

The third approach is the one usually preferred by technologists. Laboratories abroad are created to tap local sources of scientific and technological development. Technology development is very parochial (Allen, 1977; Harris, 1987), and as a consequence one finds an uneven distribution of technology development across the world. Consequently one gets concentrated sources of technological development such as the Californian academic network for genetic engineering, or the tight network of automotive suppliers in Japan or central Western Europe. To get access to the output of these concentrated sources of technology,

one has to be physically close to them, and participate in the local network of technology production. There exists of course the normal diffusion process of technological know how via publications and technical sales people, but in many cases these traditional diffusion mechanisms are too slow, or break down. Especially in the case of research laboratories which are not located in Anglo-Saxon countries, the language barrier and differences in scientific traditions might reduce the potential for early access to some of the research results.

Transaction cost approaches to market structures (see for example (Teece, 1981) support this category of triggers for internationalisation. Given the difficulties to trade in technological knowhow, in particular the fact that one often needs to transfer people to transfer technological know-how, the internal mechanism of creating a laboratory abroad close to the source of know-how can be more efficient than a pure market transaction through a contract, i.e. buying technology. The problem with this theoretical underpinning is that it provides a reasonable partial logic for the reason why companies internationalise their R&D, but that it has practically nothing to contribute to answer the question of how these laboratories should be managed.

These three categories of reasons are often used to look at the trade-off between the advantages of internationalising R&D and the disadvantages of increasingly difficult communication and the loss of scale economies in R&D. None of them however could completely explain the reasons for internationalisation as they were provided to me in the case studies which I have available. If one checks the results of the interviews with these three categories, all of the twelve companies fall in each of the three categories and perhaps at the same time in none of them. Consequently this taxonomy in three groups does not seem to be very helpful.

One R&D manager of a European electronics firm phrased his answer this way :

> "The key element of success in development is to be able to rely on good skills. We are located in [a small city far from larger cities]. We were created here. But it will be obvious that it is nearly impossible to attract everyone who is needed for good development in one location. Certainly this is not an ideal location for it. It is a very rural area, which might have a special kind of attraction for those who do not like city life, but that is not sufficient to attract all engineers or scientist who are needed. Moreover, successful development requires a constant exchange of ideas, not only inside, but also outside the firm. In [this small city] there are virtually no other firms than us, who are active in similar fields. There is, except for a quite powerful university, no opportunity

for an extensive exchange of ideas."

A superficial analysis of this quote would lead us to think that lack of a qualified workforce had led this firm to expand its laboratories internationally. But the enthusiasm for the exchange of ideas, the urge to belong to a network of information exchange and discussion was much stronger than the need to have access to pools of engineers. The same desire to belong to such a network was expressed by several other managers. But let us not be mistaken. Although the word network was used by virtually all of the interviewed managers, their view of a network was not limited to a technical network of research institutions, laboratories, universities, etc. In the description of these networks suppliers, subcontractors, customers, users, government representatives and competitors were explicitly mentioned.

Why do companies want to belong to these networks? And here we come to the essence of what in our opinion drives internationalisation of the R&D function. The core concept in each of our discussions was 'learning'. A manager of another European electronics firm told us in a somewhat presumpteous way :

> "Each laboratory, as well as doing its own research, is a listening post strategically placed where information technology is making rapidly progress. Nothing happens in Silicon valley that I don't learn about in 24 hours."

Perhaps this research manager was fooling himself. But his intentions were clear. He wanted to learn as fast as possible. The network that is created by building up an international R&D operation should help the company to develop better early warning systems, shorter routes to commercialisation and stronger market orientation in product development. And that at the same time that the company has to rely to a far greater extent on and compete for external sources of technological and market knowledge.

4. Linking international R&D and Strategy : learning

Bartlett and Ghoshal (1989) propose that many worldwide industries have been transformed in the 1980s from traditional global, multinational or international forms toward a transnational form. Instead of demanding efficiency, or responsiveness, or learning as the key capabilities for success, these businesses now require participating firms to achieve all three strengths at the same time in order to remain competitive. One of the characteristics of the transnational firm is according to them the ability to manage multiple innovation processes, and to facilitate the learning process. They describe two traditional ways in which internationally operating

companies innovate : central innovations and local (country specific) innovation processes. Though both types of innovation still have their value in today's world, they argue convincingly that the transnational company has to combine these two types of innovation with what they call the locally leveraged and the globally linked innovations. Locally leveraged innovations permit the company to use the most creative resources and developments of its subsidiaries worldwide to benefit the whole company. Globally linked innovation processes combine through flexible links the efforts of multiple units to create synergies that significantly leverage the innovation process.

Research and development has of course traditionally a role to play in innovation. Its role is twofold : solving technical challenges which are part of the innovation processes, and contributing technology-based ideas to the concept definition, but also creating maintaining and expanding a knowledge base which will enable future innovations. Learning as part of the R&D process has recently been stressed by several scholars (Imai et al, 1985; Maidique and Zirger, 1985; Meyers and Wilemon, 1989, Imai and Baba, 1989). This learning aspect becomes even more dominant in the case of international R&D. If R&D's task would be limited to technical problem-solving the need to decentralise geographically R&D operations would probably be far less urgent. Access to problem solving capacity, namely the engineers, might still be a reason. But though this access sometimes is a secondary trigger for internationalisation, it is rarely dominant in the choice of number of foreign R&D sites and their location.

Learning in new product and process development is not limited to internationalisation, and internationalisation is not the conditio sine qua non of learning. But learning about different markets, different problem solving methods, different sources of technological progress, different cultures, different competitors, and rapid diffusion of that learning throughout the organisation is definitely enhanced by creating an international network of R&D laboratories. In other terms, apart from the result oriented problem-solving, the R&D group has to learn for the company, to enable the company to pursue transnational strategies in the future, and effective learning requires the R&D group to go international.

If we take this perspective of learning as the link which exists between the strategy of the transnational company and the internationalisation of R&D, what can we learn from the case studies ? Three aspects become dominant. First how can the planning and control process, which is traditionally the formal link between strategy and R&D contribute to the learning process. Secondly networking seems to be the dominant form of integrating the business perspective and the technological perspective. And thirdly, organisational learning requires diffusion of knowledge.

Effective diffusion of knowledge requires communication. The geographical dispersion forces companies to take a different perspective on their communication networks in R&D. Each of these three themes will be discussed in the following paragraphs.

5. The planning and control contribution to learning

Planning and control is a traditional topic of management of R&D and is one can find very documented overviews of planning procedures in Souder(1986). It is not our intention to look at the broad issue of planning, but to limit us to that what is specific in the internationalisation context.

Behrman and Fischer (1980) spent quite some attention to how planning and control is exercised in international R&D. Following a taxonomy of managerial styles proposed by DeBodinat (1975), they assign the managerial styles of the companies in their sample to four discrete points on a continuum from absolute centralisation of the decision -making to total freedom. As one could expect they find neither many successful examples of absolute freedom, nor of absolute centralisation, and the majority of the cases in their sample of 50 companies is characterised by either participative centralisation or supervised freedom. We find in some of our case studies a similar result (De Meyer and Mizushima, 1989). However the categorisation in discrete points on this continuum is somewhat artificial, and we have asserted that planning and control and managerial style of decision-making can move on the continuum over time, and depends on the technological characteristics of the specific foreign laboratory involved. The position on this continuum is dynamic rather than static, and not depending in the first place on the characteristics of the parent company, but rather on the characteristics of the individual laboratory. The parent company's culture plays a role here but rather in second order.

But the more interesting observation is that in each of the companies which did not consider themselves to be unsuccessful the planning and related activities had a strong learning component. Why do we say 'not unsuccessful' companies. Due to our research methodology we have no hard measure of success. However in two of the companies we studied, the planning procedure was changed shortly after our interviews. (There was no obvious causal link between our visits and the reorganisation, though in case research the interactionist aspect can never be gauged accurately). The mere fact that the company reorganised its procedure can be judged to be an indication of below average performance of the planning process before the reorganisation. There is of course no indication that companies which did not reorganise are performing well.

How did this learning component find its expression ? In many of our cases the managerial decision making on planning issues was closer to participative centralisation than to supervised freedom. There was however each time an enormous effort to involve local laboratory personnel and local laboratory management in the formulation of the objectives, and the means to reach those objectives. One company has a two-yearly planning cycle with internal scientific conferences which were used to determine research targets but also to exchange information between strategic planning, the business units and the scientists. In one of the specialty chemicals companies the research manager said:

> "Tied to the planning process are meetings of the heads of R&D centres once a year in [headquarters' location] for what may be called information meetings. These meetings do not bring all centres together at once. In fact there are three meetings each year for the heads of the Sourthern hemisphere, South East Asia and the rest of the world. These meetings are set up to exchange information about the latest field results and market developments around the world. Following these meetings there is a period of information digestion. During this period the [staff of the central R&D] are involved in extensive travelling to various centres and discuss issues brought up during the information meetings. The final planning meeting takes place two months after the information meetings."

These and other remarks at this company showed that the whole planning cycle was used more to educate each other and diffuse information than strictly planning only. A yearly budget cycle was even said to make no sense in this company, since development cycles were from five years upwards. But the educational value to the company of the planning process was very important. The same company also has a central data base for general access. All data generated by the different development centers are entered in the database in a uniform format. The database, which is accessible to all researchers and product managers is considered to be an excellent means of diffusion of information as well as control of the ongoing activities.

In one of the other companies, which was characterised by its own management to be an example of participative centralisation, the central research staff is responsible for the yearly formulation of defining and assigning R&D projects to the different centers. But since this central staff is very small compared to the total number of laboratories and professionals, they have to rely entirely on discussions with the operating units to get insight in technology, markets and process capabilities. The travel schedule of the staff of this central R&D body was very impressive, and clearly an indication of a lot of personal communications. The control procedures of this company,

mainly a set of standardised progress reports, were equally used as educational instruments and diffused very quickly and efficiently to well chosen targets in R&D and marketing. Again, the whole planning and control procedure had a strong educational element included.

In one of the companies a major tool of planning was what they called the V.I.P.'s or Very Important Projects. They were considered to be a centerpiece of the research efforts, since every laboratory was supposed to contribute to it. Such a project had of course a strong integrating influence, but it also was a way of exchanging ideas between different laboratories. Again we find planning as a learning tool! In the same company a number of advisory and strategy boards were involved in the planning process. Though the central R&D group was instrumental in initialising the board meetings and coordinated the whole process, laboratory managers were heavily committed throughout the process. A core element of the planning process was the communication and cooperation in the various meetings. The board meetings, in which researchers, representatives of the business units and distinguished outsiders participate, were considered to be unique opportunities for crossboundary contacts and familiarisation. Laboratory managers spend about 2.5 to 5 days per month in coordinating and planning meetings, which are organised at the different sites to "give the researchers the opportunity to meet regularly the members of the central R&D team". Planning and evaluation of ongoing projects were really used as an organisational learning experience for the company.

Striking was that in the two less successful companies that educational element of the planning process was lacking seriously. In one case the planning process was carried out by a Strategic R&D Planning group which only at the highest level interacted with the Strategic Business Planning Group. Perhaps that in the end the result of the planning exercise was a fair reflection of technological potential and market opportunities and that in that sense the process was satisfactory, but there was clearly no attempt to use the planning process as an exchange of ideas and a process of mutual education. In the second case the planning at toplevel was done by a board bringing together the technological and the business managers, but at lower level there was no other interaction than the one needed to perform short term problem solving. Even between different groups in R&D there was little interaction. Synergy between different R&D groups were decreed to be almost unexisting, and creating them was considered anyway a waste of time. The comment by a business manager of a small diversification project in this company was quite revealing : "only when we [the business managers and the technologists of different R&D sites] started educating each other about what we knew, we started making some progress".

To get the benefit from internationalisation of R&D in

the organisational learning process of the company it seems that the planning, control and eveluation process, independent of its positioning on the scale from absolute control to absolute freedom has to be transformed into a learning process. It is interesting to see that Meyers and Wilemon (1989) come to the conlusion on the basis of an exploratory survey on learning in new product development teams that the strongest inhibitors for learning have to do with establishing and maintaining clear project objectives. This is clearly an element of the planning process. De Geus (1988) gives a description of Shell's planning process and asserts that planning should be a learning process, and that one of the objectives for improving planning systems should be the acceleration of the learning process. Consequently common scenario building, common preparation of the strategy formulation, projects common to different laboratories can contribute to the better linking of R&D and strategy through improved learning. In the trade-off between planning efficiency and learning of the organisation, the choices should favour the learning side.

6. Networking as a core element of the organisation

Part of the learning and accelerating the learning is the rapid diffusion of data, information and knowledge. One aspect of this diffusion has to do with communication in an environment where the difficulties of communication are compounded by geographical distances. A second element is the networking. Let us look at this second element first.

In all of our case studies the concept of networks was raised at some point. They were considered to be the new and most appropriate way of organising the relations within an international R&D operation. Scholars of international business have also shown considerable interest in the concept in recent times. Hakanson and Zander(1986) put it in this way :"Increasingly Swedish firms are now moving towards an 'integrated network model', characterised by tight and complex controls and high subsidiary involvement in the formulation and implementation of strategies. In consequence ...heavy flows of technology, finance, flows and materials tie subsidiaries to each other and the parent." Bartlett and Ghoshal (1989) say that precisely the integrated network is the structural framework of the transnational company. And in the limited field of R&D as a learning process Meyers and Wilemon(1989) indicate that informal networks are by far the most efficient tool for intergroup learning. Imai and Baba (1989) propose that in the case of systemic innovations, a network organisation within the company and across the company's boundaries is a necessary condition for innovation success.

Thinking about networks in communication terms, one has to keep four elements in mind : the roles of the nodes, the density of the communication on the links, the ties to other networks, and the dynamics of node roles and link density.

Ghoshal and Bartlett(1989) and Noria and Ghoshal(1989) have attempted to provide a conceptual model to study the first three elements in the multinational company. Here we will limit ourselves to **what is important** in the international R&D concept.

The role of the nodes becomes in this context what the specific role is of the laboratory in the learning of the organisation. What is its mission or charter. The R&D manager of one of the electronics companies insisted very strongly on the fact that to have a successful contribution of the foreign laboratory to the firm, the laboratory needed a worldwide charter, i.e a worldwide responsability in the problem-solving and learning process. But charters must be dynamic and be adapted to changing characteristics of the information sources among which the foreign laboratory is implanted. In one of the cases where senior R&D management and its customers were less satisfied with today's performance, part of the lack of satisfaction could be explained by a lack of clear charter for each of the laboratories in the learning process. The case was interesting in the sense that it was one of the cases which was at length described in earlier studies on international R&D management, and the present situation could be compared with an account written in the middle of the seventies. First of all, when management was asked about the role of the different laboratories, management was at unease with the question, and fell back on some of the descriptions which had existed in the early seventies. They admitted however that these role descriptions were more history than reality. In one particular case the charter consisted among other things of using the process capabilities of a particular factory to develop worldwide product applications. Originally factory and laboratory were close to each other. But an incremental change in laboratory location and factory knowhow had gradually rendered the charter of the laboratory obsolete. However formally the charter had remained the same. To conclude, one can say that to contribute to the learning process of the company, the different laboratories must have a clearly and dynamically defined charter which is worldwide known and accepted.

The second characterisitic of the network is the local external network. This is the main mechanism through which the local laboratory can fulfill its role of local learning. The density and quality of the communication with local partners is a measure of the laboratory's effectiveness to tap in the local network. Imai and Baba (1989) stress what they call the selforganising character of these networks : ".., associated and emergent linkages among producers themselves, and between producers, marketers and consumers, contribute toward creating their own markets, while multiplying through self-organisation." Again the static pattern of the linkages is important but not sufficient. Linkages have to be dynamic and as they argue, generate their own development. Their approach is somewhat similar to

more recent (and controversial) biological theories that life forms are not irreducible entities, but synergistic, teeming conglomerates of bacteria, and that the border of a particular life form is not easy to determine, if at all. Evolution of an organism is then the banding together of groups of bacteria. The border of an organisation, and in particular the research organisation is equally difficult to draw. And the evolution of an organisation is perhaps the constant teeming up with other nucleus organisations.

The information and knowledge learned locally has to be diffused in the company. A self-organising local external network can only be effective if it is linked to a strong internal network. This is partially an issue of intra-company communication. But it is also related to how well the laboratory is embedded in the network inside the company, but outside R&D. In one company the senior management had taken two successful actions to strengthen the intercompany network. First they had chosen persons with a high visibility in the headquarters to act as laboratory directors or as senior researchers in the laboratory. These people had the explicit role of being the ambassadors of the laboratory at the headquarters and the other functions in the company. Secondly, realising there was a gap between decentralised laboratories and centralised marketing, some of the marketing functions were decentralised to the same locations as the laboratories. One sees here two complementary actions : a strengthening of the local intra-company network (decentralising marketing) and a strengthening of the international intra-company network (the ambassador role).

This ambassador role emerged in several of the case studies. Whatever the name, time and again it was an attempt to increase the visibility of the foreign laboratory in headquarters or in important subsidiaries, by using the personal credibility and visibility of the so-called ambassador to represent the laboratory. Other actions that were described to us on how to strengthen the intra-company network had to do with intra-company scientific conferences, tours of selected scientists and engineers through the different laboratories, projects cutting through the different laboratories, worldwide task forces, etc.

Apart from the local external and the intra-company networks, we were several times confronted with the existence and importance of the external international network. Ghoshal and Bartlett(1989) describe something similar. An analogy might help us to understand this. The European electrical grid is widely interconnected, and there are constant flows from of electricity from one country to another. To a country like Belgium for example it is of utmost importance to be connected to the French and the German grid, so that it can rely on both to avoid loss of tension or frequency. But what is also important is that in case that the line to France would go down and Germany has

no spare capacity to support the Belgian grid, that Germany is interconnected with France and can channel power from France through its own network to Belgium. The example is far removed from the organisations we study here, but the comparison can nevertheless help us to understand a characteristic of these organisations. The external local networks of the different laboratories are also connected among themselves, and a careful management of this international network external to the company can provide a boost to the effectiveness of the learning and diffusion process in the company. In the most extreme case the external network can be a more efficient diffusion mechanism than the internal communication network. This does not have necessarily to be the result of a breakdown of the internal networks. It simply can be that two laboratories work on very different projects, but work with a common technology provided by an outside supplier. The synergy between the two projects might be obscured by different perceptions about the two projects within the company, while the supplier might be able to provide some linkages between the engineers working with a similar technology in two different laboratories.

The link between subsidiaries of suppliers or customers is an obvious example. Users of micro-electronic components will find subsidiaries of the major suppliers such as NEC or Motorola in each of the countries where they have laboratories, and one can expect that communication between the sales subsidiaries of these suppliers exists. But there is usually also a fairly strong network between the academics with whom the company has contacts in the local R&D laboratories : they meet each other at the same professional and scientific conferences, read each others papers, and exchange eventually data on the research projects they might carry out for the same company, but in different countries. In one of the case studies the R&D management had consciously attempted to nurture these international links between academics by organising so-called private conferences to whom all the academics who worked for the company were invited to make presentations. The R&D management of this company told us explicitly that the main goal of these conferences was to create an invisible network of academics working for their company.

Dynamic management of nodes, local external links, intra-company links and external international links are all part of enhancing the diffusion process. The other element of that diffusion process is the communication

5. Communication

Communication in R&D is probably one of the most widely researched topics in R&D management, and the most consistent result out of all this research seems to be that personal

contacts are the best form of communication in R&D. The seminal work of Allen (1977) has demonstrated this amply, but it has been confirmed by many other studies in the U.S.A. and Europe. It does not seem necessary to add here a few more examples of general communication problems and solutions in R&D. The most interesting corner of this communication problem in an international context is the added difficulty of geographical distances. Indeed it makes that core element of communication in R&D, the informal personal contact, much more difficult.

Obvious solutions to overcome this had to do with the traditional methods of integration (common project teams, exchange of researchers, etc). In all but one of the companies we studied the travel budget ranged between 5 and 7% of the total R&D budget, and this was generally not considered to be too high. Though there were travel restrictions, they had more to do with the disruptive effect of excessive travel on the work at home (in the local network), than with the direct cost of it. However, everybody recognised the burden that international travel brought to scientists' time utilisation. Two types of action were considered to cope with this. First an emphasis on documentation of the work. Documenting research results is important in any situation, but the discipline required and the effort to disseminate the resulting reports appeared to be of an different order of magnitude than in a normal single site laboratory. Secondly, a lot of expectations were built up about the possibilities of electronic communication. Consequently all of the companies we studied were experimenting with more or less sophisticated forms of electronic communication. These experiments ranged from the first careful attempts to use electronic mail to full-fledged videoconferencing systems.

One of the main questions raised about these electronic communication systems was the question to what extent they could replace direct personal contacts. There did not seem to be high confidence that electronic communication, even in its most sophisticated form such as in videoconferencing, could be more than a temporary replacement to the direct face-to-face contact. "Videoconferencing, integrated CAD/CAM databases, electronic mail and intensive jet travel all contribute to lowering the communication barriers. All things considered, however, the most effective communications, especially in the beginning, is a handshake across a table to build mutual trust and confidence. Then and only then the electronics can be really effective," was the way the senior product development manager of the company, that had deployed the comparatively most sophisticated electronic communication systems in our sample, described it. In each of the companies that had built up some experience with electronic communication systems, we could sense the same idea as is expressed in this quote. Electronic communication can make a very valuable contribution on condition that a certain level of

confidence between partners exists already. --The 'handshake' is an important preceding condition for the effective use of electronic communication systems.--

That level of confidence can seemingly only be built through personal face-to-face contact. And it has a tendency to decay over time, even if there is intensive use of sophisticated electronic systems. One of the engineers having a considerable experience with videoconferencing summarised his own attitude by saying :"[Although it is a great system], I have two difficulties with it. I still cannot express emotions on a videoconferencing system. It seems so silly to become angry, to joke, to deviate from the subject and to talk about your family, to complain about your boss, all those things you need to do to get to know each other. And I am never sure that my colleagues at the other end are not taping me, to use my own words against me. I know it is silly, because I am not scared of taping at the phone, but videoconferencing meetings still create much more official commitments than a simple phone call." Thus even with the best electronic communication systems confidence between team members of a project team spread out over the globe seems to decay like nuclear radiation over time, even if they have real time contacts through electronic mail and billboards, computer conferences, videoconferencing systems and the telephone. Confidence between engineers has perhaps, like nuclear radiation,a half-life time. Thus regular face to face contact seems still necessary, to boost that confidence to a level high enough to have effective team work. We have called this decay of confidence and the regular face to face contacts needed to restore the confidence level to its initial level the halflife time effect of electronic communications in international R&D.

A second issue which was regularly raised in the context of international communication was the increase in problems about security. Though it seems to be a mere technical problem to protect databases and communication lines to intrusion by outsiders, in several companies, the risk of access by third parties inhibited a full commitment to computer communications in R&D. Consequently, some of the companies we studied were reluctant to use international computer networks for more than only routine results. More sensitive materials, especially discussions about the most recent technical developments, and which are so essential to the learning in the company were still kept out of the realm of electonic communication systems.

7. Conclusion

The thesis we have developed in this paper is that, though the classical theories on the internationalisation of the firm explain some of the reasons why companies develop international R&D operations, the underlying explanation can be summarised in the concept of learning. The contribution of international R&D to the technological strategy of the

firm is in the improvement of the company's learning about the long term evolution of markets, technologies, competitors and suppliers. If one accepts that point of view the effectiveness of the international R&D operations will be determined by the company's ability to manage that learning process. Linking the learning in R&D to the technological strategy happens in most cases through the planning, evaluation and control process, and we assert that our planning processes should be reviewed with this learning as an objective in mind. Planning should be a learning exercise, not about the planning process, but about the technological and market evolutions. Linking the learning to technological strategy requires also a extremely well organised diffusion of the knowledge throughout the firm. This diffusion can be stimulated by paying special attention to the communication, but also by seeing the R&D organisation as a network of laboratories which are connected with each other inside as well as outside the company.

Notes

(1) As reported in the 'International Herald Tribune', february 27, 1989, Exporting R&D Operations could Hurt U.S. Economy

(2) Two pedagogical case studies based on the research cases were published in de la Torre(1989)

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