

**"THE INTERNAL TECHNOLOGICAL RENEWAL
OF A BUSINESS UNIT WITH A MATURE
TECHNOLOGY"**

by

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N° 90/15/TM

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Printed at INSEAD,
Fontainebleau, France

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January 1990
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Abstract

The technological and strategic renewal of a business is one of the major challenges facing European and American companies. De-maturing the technology of a business unit is possible, but it is a daunting task. Many forces of resistance against the internalisation of a new core technology exist. On the basis of 18 in-depth case studies the authors have designed a framework to analyse the issues of internal technological renewal, and have determined a set of variables and relationships which determine the optimal organisational structure for the internalisation of a new technology. They propose a three stage model of perception, uncertainty reduction and internalisation.

key-words : de-maturity, technology renewal, technology management, technology organisation, technology absorption

1. Introduction

The difficulties which business units can encounter in the process of the replacement of an established mature core technology by a new, emerging technology have been described extensively in the literature (Abernathy et al, 1983). Doz(1989) calls the technological and strategic renewal of the business today's 'most taxing problem for major European and America corporations'. Cooper and Schendel (1976) studied some 15 years ago 22 companies which faced the replacement of their core technology by a new technology and they concluded that often the new technologies were introduced by outsiders to the industry. Established companies tended to take a defensive position and invested in the often unproductive further development of the existing technology. Indeed, given the performance limitations of the new technology, it was perceived by established companies to be below standard, and consequently neglected as a serious contender for the existing technology. Only several years after the introduction of the new technology, it reached the same performance level of the previous technology. By that time the momentum gained in terms of development by the new entrants, proved to be a quasi insurmountable barrier for the established companies in the industries. A successful counterreaction against the newcomers became very difficult. Often quoted examples of this pattern are what happened to the Swiss watch industry in the beginning of the seventies, or the replacement of vacuum tube technology by semiconductors in the fifties and the early sixties. But similar patterns are described for other industries (Roussel, 1984; Foster, 1986).

From a macro-economic point of view the simultaneous replacement of technologies and companies does not have to be an undesirable mechanism. In some cases it might be actually healthy for the society, since it entails a redistribution of power and economic wealth. But from the company's point of view it seems to be quite unsatisfactory that the introduction and development of a new core technology would lead in a large number of cases to the decline of the company or a business unit. Cooper and Schendel's results, interesting as they were, raised immediately the question whether the company or business unit can overcome the resistance against the replacement of the old core technology by the new one, i.e. organise its internal technological renewal as we will call it here. Is it possible to replace a mature technology by a new one, or to technologically 'de-mature' the business unit as Abernathy et al (1983) described it ? And if internal technological renewal is possible, what is than the optimal organisational structure to enable this ?

To explore these questions and in order to propose a framework to analyse and manage the process of internal technological renewal we have carried out a series of 18 in-

depth case studies. This paper reports on our findings. After a short review of the relevant literature, and a description of our methodology, we will propose the framework that we derived from the case research.

2. Internal technological renewal

Is technological maturity the unavoidable end of the evolution of a business unit? The answer is obviously no. Non-systematic observation of successful companies such as I.B.M. in computers, Parker in writing tools, or more recently Canon in camera technology indicate that companies and business units can successfully and repeatedly replace or complement one core technology by another. "Based on observations in various industries, there is a growing school of thought that this process of maturity can be reversed, and that an industry can 'de-mature'. The change can be either market or technology driven or both.... This forces producers to develop new product design concepts, possibly new technologies, and start a new cycle of product innovations," commented Dowdy and Nikolchev (1986). Companies can overcome what has been called the "Productivity dilemma" (Abernathy, 1978), the "Not-Invented-Here" syndrome (Allen, 1977) or can switch from one technological S-curve to another (Foster, 1986).

If we assert that internal technological renewal is possible, what do we mean by technological maturity? Clark (1983) defines a mature industry to be one "in which uncertainty about technology and product performance, and about appropriate process design, has been reduced to such an extent that the details can be codified". Abernathy et al (1983) define a mature industry to be one where "an earlier uncertainty has been replaced by a stability in core concepts, a stability that permits process technology to be embodied in capital equipment, or in engineering personnel and purchased in the market place". In both cases (technological) maturity is defined at the level of the industry. We are not convinced that this level of analysis is always meaningful from a management point of view. In the same industry one can find very different technological approaches. An example would be the medical imaging industry where simple X-rays, tomography, nuclear magnetic resonance, ultrasound and other technologies co-exist. While some of these technologies, and some of the companies or business units exploiting these technologies can be very mature, the industry itself does not seem to have reached maturity. Without going into a profound debate about this, we thought it more appropriate for our study to concentrate on business units with a mature technology. The focus of our research is on business units in which the technological uncertainty about product performance, product and process design is stabilised in core concepts, to the extent that details are codified and can probably be purchased in the market place. Internal technological renewal is the introduction of one or

more new core technologies that reduces this stability in a stepwise way.

From our definition it follows that the stability reduction can be in product as well as process technology. Internal technological renewal triggered by new product technology is illustrated by the classical examples of the Swiss watch industry, the replacement of the vacuum tube by the transistor, or the replacement of traditional cameras by electronic still pictures. Utterback and Kim (1985) gave several examples of processes such as continuous casting, or the float glass process which triggered important renewal in process and product technology. CAD-CAM in the clothes manufacturing industry, genetic engineering in pharmaceuticals, or automatic teller machines in banking are other examples of process technologies which triggered a process of internal technological renewal.

3. What makes internal technological renewal so difficult ?

Several factors make the managerial process of internal technological renewal a difficult one. Many of these factors have to do with variations on the Not-Invented-Here syndrome. In the initial stage of the development of a technology its performance often compares badly with the old technology, and the defenders of the old technology have no difficulties in emphasizing the shortcomings of the newcomers. Moreover the impact of technology as such is often underestimated by the old guard. In case of technological maturity the competition is often based on marketing, sales, service after sales or financial constructions, and the codifiable technology plays under these circumstances only a minor role. A new technology can become a very important competitive asset, but this is often not recognised by the management of the technologically mature business unit. This tends to be reinforced by the fact that new technologies make their first appearance at the moment that the old technology provides the biggest cash flows, i.e. at the height of its success (Becker and Speltz, 1983). The very economic success of the old technology increases the almost religious belief in the old technology's competitive capabilities and, as Cooper and Schendel (1976) observed, the mature business units keep on investing in the marginal improvement of the old technology.

Moreover, by its very nature the new technology will render obsolete the existing capital equipment, labour skills, materials and components, management expertise and organisational capabilities (Abernathy et al, 1983). In the short and medium term the introduction of the new technology will decrease the profitability, eventually the growth potential of the business unit, in particular when the financial and technological risks are high as in the case of newly emerging technologies (Williams, 1983). Lack of expertise, decreased profitability, low initial performance

of the new technology are reasons enough to reject the new technology.

Related to this N.I.H. syndrome is the observation that the business unit tends to react from its perceived strengths against the new competition. The strengths of a technologically mature business unit lay often in its production efficiency, process capabilities, cost reduction programmes, and efficient procedures (Abernathy et al, 1983). These strengths are not very hospitable for the introduction of a new technology and the decrease in technological stability this entails. Often these business units see evolution more as an increase in efficiency, rather than a regression towards more organic, flexible structures (Soukup and Cooper, 1983).

The existing power structure is another element of resistance. Managers and engineers often build their own careers with the old technology and run the risk to lose their power base with the new technology (Galbraith and Kazanjian, 1983; Kotter and Schlesinger, 1979). And even if management is prepared to give up its relatively comfortable position based on the old technology, their lack of expertise with the new technology renders their judgment erroneous (Gold, 1983). And a lot of sound judgment is needed. Rare is indeed the case where the replacement technology is an obvious exercise. In many cases several alternatives are available. The replacement of chemically coated paper by plain paper technologies in reprography was perhaps obvious, but the type of technology to be used was not clear, and several options were available. And if it is easy to predict that electronically formed pictures will replace some of the chemical photographic techniques, it is far less easy to see which segments of the market will be affected by it in the medium term, and how this replacement will change the volume of the market, or delivery of the product and the service.

Internal technological renewal is possible. The sources of resistance against it are multiple. How does the business unit proceed to improve its capability to internalise and exploit the new technology ?

4. The research project

Internal technological renewal is part of a larger effort which consists of several activities. It requires technological forecasting, technology assessment, the proper internal technological renewal, and an appropriate timing of market introduction and exploitation of the new technology in changing markets. Though we realise the importance of the other activities we decided to focus on only one of them, the introduction of the new technology in the organisation.

Our central research assumption was that a business

unit which is confronted with a new technology has a range of organisational options to internalise the new technology. We assumed that among these options there would be an optimal organisational structure, contingent on a number of variables which characterise the business unit and the technology. In this sense we positioned ourselves in the mainstream neo-contingency school.

On the basis of earlier observations (De Meyer and Van Dierdonck, 1984), we started with a typology of six categories of organisational structures :

1. Internal development either by the existing development department, or with a temporary or permanent task force, or with some form of an internal venture team.
2. Contract research, in which the development of the new technology is subcontracted to a specialised research company, and where the receiving business unit has to define the specifications and to create the appropriate structure to understand and absorb the information provided by the research company; as Cohen and Levinthal (1989) point out, this often requires some internal research to create the 'absorptive' capacity.
3. (Loose) collaborative agreements or partnerships, where several companies decide to collaborate to develop and analyse the technology. Often these partnerships are not very explicitly defined, as in collaboration with suppliers, customers, or even the government, and responsibilities and respective commitments and expectations remain unclear. Other typical examples are discussion forums and development efforts sponsored by the government, or by professional organisations.
4. Joint ventures or the creation of a temporary or permanent new entity by two or more independent partners, in order to develop and exploit the new technology.
5. Acquisition of a company, which has the knowhow about the new technology.
6. Purchasing of technology, or a contractual agreement with a third party, which has the technology, in order to transfer codified knowhow about the technology under the form of a licensing arrangement, and for which no immediate internal development is required.

This typology is neither exhaustive, nor complex enough to describe all organisational structures which we observed. As we found out during the case studies, most of the efforts of internal technological renewal were a mix of different

approaches. But this categorisation proved to be useful in two ways. First of all each of the categories is positioned differently on the spectrum from high control over the development (internal development for example) to low control (purchasing of technology). Secondly each of the categories scores differently on the spectrum from high formalisation (joint ventures or technology purchasing) to low formalisation (internal development through internal venture teams), or to put it differently on the classic spectrum from organic to mechanistic organisations (Burns and Stalker, 1961). Consequently the typology was used to select the case studies for the research project. To increase the heterogeneity of the cases, they were selected in such a way that their dominant organisational structures represented each of the categories we have described.

In order to develop a contingency model, contingency variables were needed. De Meyer and Van Dierdonck (1984) used a variation on Perrow's (1973) characteristics of tasks (analysability and variability), and completed this with the degree of exposure the company had with the technology. Roberts and Berry (1985) take two factors into account : degree of novelty and/or degree of familiarity with both technology and market. This familiarity is very similar to the degree of exposure in the previous reference. Boisot (1986) uses two characteristics of knowledge : the degree of diffusion and the degree of codification. And he correlates them with the return on external and internal technology transactions. From the beginning it was felt that this set of variables was too limited. But this literature analysis helped us to include at least these types of variables in the interviews.

Though we started with the central assumption that the optimal organisational structure for internalisation was contingent on a number of variables, among them the characteristics of technology mentioned above, the research project was designed as an exploratory study, precisely to identify the variables that play a role in determining the optimal form of organisational structure for internal technological renewal. Therefore we choose in-depth case studies as the research method. Eighteen case studies were carried out. Heterogeneity in the type of case studies was pursued actively. The cases come from different industries, concern different technologies (table 1), and business units of very different size (from small companies where business unit and company coincide to business units of multinational companies). We attempted to have three case studies for each of the categories of organisational forms described. Since in many cases a mix of different organisational forms was pursued, the case studies were classified on the basis of the dominant organisational structure. The dominant organisational form was defined as that structure that required relatively speaking the highest resource commitment.

Both successful and unsuccessful cases were studied. The word success has to be used with extreme caution. A case was defined to be successful if the technological renewal had taken place. In other words it is technological success, not necessarily commercial or economical success.

insert table 1 about here

Each case study required on the average 30 hours of interviews, as well as extensive desk research. Non-structured interviews were conducted with R&D, production, marketing, financial and general managers. Several of the case studies were followed over a period of more than two years. Regular reviews of the case studies helped us to derive the framework described below. (1)

To provide the reader with an idea of the type of cases we studied we will briefly summarise some of the cases :

Case A, B and C : internalisation of Computer aided design and computer aided manufacturing in the clothing industry. By the beginning of the eighties the Belgian clothing industry was in a very bad shape due to the competition of low labour cost countries in the traditional segment of ready made clothes. Net return for the industry had gone from 7.2% in 1968 to -11.9% in 1981. CAD-CAM was perceived to be an appropriate technology for the clothing industry in order to automatically generate patterns, grade the patterns, determine the cut planning and perform the automatic cutting. Three types of cases in different companies were studied : purchasing of technology from established suppliers such as Gerber, Electra and others; contract research for the development of a proprietary CAD-CAM system, and cooperative joint ventures between smaller garment producers in order to commonly exploit one CAD-CAM system. In the last case a very innovative form of a cooperative corporation was created with the financial support and guidance of a government-sponsored industry federation.

case D : a large producer of construction materials and bricks was confronted with a stagnating market and wanted to use its cash flow to create a new venture in neo-ceramics. Misguided by a research contractor and some promotion by the local government they thought that the neo-ceramics technology was sufficiently close to their ceramics technology to warrant the investment in contract research and some internal development. The technological difficulties were underestimated and a serious market study lacked. After more than two years of development a me-too product without market appeal was developed. Three years after the start of the

effort the whole project was canceled.

case E and F: After an exercise of technological forecasting at the end of the seventies, a large producer of photographic film for the graphic industry concluded that its main (photochemical) business would be squeezed out by electronics. Two cases of how the electronics technology was internalised by this chemical giant and this for different market segments were studied. For some market segments acquisition of companies were used, in another case internal development of a new laserprinter was pursued.

case G : A producer of industrial tyres came to the conclusion that under certain circumstances rubber could be replaced by polyurethane. In order to internalise this new technology research contracts with universities were made, as well as the acquisition of a supplier of the new material, who had a broad knowhow of how to process that material.

case H : With the introduction of plain paper copiers the producers of zinc-oxide coated paper used in a previous generation of copiers lost their market at the height of their commercial success. In this case we studied the resistance of one of these zinc-oxide coated paper manufacturers against the shrinking and gradual disappearance of its market, and the late attempts to switch to different technologies such as thermographic paper for fax-machines and small printers.

case I : a small producer of additives for feedstock imagines early on in the eighties that genetic engineering could reduce or even eliminate the need for additives, if plants could be genetically manipulated to have the correct nutritional balance. Being too small to launch itself a research effort into genetic engineering it was instrumental in the creation of a research joint venture with another agro-chemical companies in order to develop applications for its own business. In the mean time the research joint venture has grown into a successful industrial company in plant genetic engineering (De Meyer, 1989).

5. A framework for internal technological renewal

5.1. A stage approach

The internal technological renewal process is a dynamic process which requires a quite long period and which is characterised by three distinct stages. A first stage is the perception stage, in which at least one member of the top of the business unit recognises that a new technology exists, and that this new technology has the potential to complement or replace the core technology of the business unit. The

role of the topmanager here is not to to the traditional job of planning for the new technology, but rather to actively encourage debate and dissent. It is the top's task here to create opportunities for tension and divergent thinking, as Nonaka and Takeuchi (1986) describe.

The second stage is one of uncertainty reduction and knowhow acquisition. Good analysis is based on data of high quality and rich in variety. Gathering and processing information is a key to successful internal technological renewal (De Meyer, 1985). Good external intelligence systems (Ghoshal and Westney, 1988) are key in the success of this stage.

The third stage is the one in which the business unit internalises the technology (figure 1).

insert figure 1 about here

We have learned during the research project that the business unit has to go through each of the three stages to be successful, and that each of the stages requires the appropriate organisational structure. In an earlier study (De Meyer, 1985) it was already argued that the organisational structure through which information about technology will enter the company, is dependent on the stage in which the technology is, according to the technological life-cycle described by Utterback and Abernathy (1975). If not at least one member of the top is aware of the new technology, the appropriate resources for the uncertainty reduction will not be available, or the appropriate organisational structure for the uncertainty reduction cannot be created. And without the knowhow gathered during the uncertainty reduction, an appropriate organisational structure for the internalisation will be difficult to determine.

When we go back to the neo-ceramics case (case D), one might wonder why this producer of construction materials ever thought that neo-ceramics was sufficiently close to its own technology to invest in this new technology. The short description of the case will have made frown more than one reader. But a careful examination of the documents showed that, early on in the development, neither the research contractor nor the internal staff ever challenged the similarity. Actually both wrote technical reports emphasizing the similarity by using a jargon and terms common to the ceramics industry. The case turned out to be a failure because top management perception (stage 1) and the uncertainty reduction (stage 2) were both performed incorrectly. Topmanagement did not know what it was embarking on, but thought it to be a good P.R. exercise to be in 'high tech'. The business unit relied for the

uncertainty reduction mainly on the research contractor, with whom it had worked for more than 20 years on a more traditional type of projects. This research contractor had a stake in continuing the initial research effort, but had himself only a limited knowledge about the technology.

In the perception stage the timing of the perception relative to the competitors and the evolution of the technology is important. Is the business unit ahead or behind its competitors? Is the technology still in its infancy, or has it already reached the stage of applications? This timing will determine some of the options available to the business unit later during the stage of internalisation.

In the uncertainty reduction stage the emphasis is on collecting the information which will enable a smooth internalisation process. This information should enable the business unit to evaluate the impact the technology will have on the existing linkages in the business unit between knowhow, production process, organisational structure, customers and suppliers, as described by Clark (1985). The result of this evaluation will help the business unit to determine some of the necessary conditions which the organisational structure for internalisation must satisfy. If for example in the case of the photochemical company the switch to electronics implies that the core supplier network has to be revamped, then the internalisation structure must take this into account.

It will be clear that what we present here as a linear process, happened in our cases in a far less straightforward way, and that many feedback loops occurred during this process. But it was equally clear that the three stages had to be in place in order to have a successful internal technological renewal.

6.2. The contingency variables

From our case studies we derived three main categories of variables: internal variables, technology variables and strategic/company-culture variables. More variables were considered during the research project, but were dropped in a later stage, because they did not seem to have a real influence, or an influence going beyond one case study. We will first explain these variables before the impact of these variables is described.

The internal variables consist of the internal resources, the degree of exposure of the business unit to the technology, and the ability to mobilise external resources.

With respect to the internal resources both absolute amount available as well as slack in the resources play a role. Obviously the size of the resources a company can

mobilise determine its ability to start internal development, acquire companies, etc. But limits in resources do not have to be an absolute block on the choices of the companies. In both the CAD-CAM cases as in case I, small companies overcame the lack of resources with collaborative agreements and joint ventures. More important is the slack, i.e. the willingness to make time, financial resources, "space" available for the perception, evaluation and internalisation of the new technology. Large companies, such as the producer of zinc oxide coated paper, with large internal resources can deploy all these resources to defend the old technology, while small companies can have the reflex to create a proportionally large slack in their resources, in order to experiment with ideas, alien to the company's culture and experience.

Exposure to the technology, or familiarity as Roberts and Berry (1985) called it, are a second category of internal variables. It increases the business unit confidence in its capabilities to internalise the new technology.

The ability to mobilise external resources are a third category of internal variables. At first they were considered to be a separate group of external variables. Indeed to internalise new technologies, a business unit often has to rely on outside support. The support of the industry federation in the case of the cooperative effort to internalise CAD-CAM by small garment producers, proved to be key to the success of the internalisation. The nature of this support, the amount, the motivation, and the type will determine the type of the organisational structure for internalisation. During the research project we constantly asked ourselves the question why business units relied on external help. Two main reasons surfaced : the transfer of internalisation costs to other companies or partners, and the mobilisation of scarce resources controlled by the partners. Central in the effectiveness of the external support was the business unit's own ability to allocate the costs to other companies or to mobilise their resources (compare Von Hippel, 1989, or De Meyer, 1984). The small food additive company (case I) was very instrumental in creating a joint venture with universities and larger agro-chemical companies in order to use their resources and to raise the money to finance the research in genetic engineering. Consequently the influence of the external support is strongly modulated, in fact only exists through the business unit's internal ability. For that reason we grouped this variable of external resources under the category of internal variables.

To understand the impact of the technology we will use two different concepts. The first one is the well-known concept of the technological S-curve, which plots the performance of a technology as a function of the cumulative efforts invested in its development (Foster, 1986). The

position of a technology on this S-curve will be used as a first variable. This position is only a proxy for underlying characteristics of the technology such as its availability on the market, and its relative stability, i.e. the rate of change of the technology per time unit. A technology which is low on the S-curve will have a limited availability and a high variability. A technology which is high on the S-curve will be widely available and have a limited variability.

The second concept comes out of the sociology of science and the relation which can be observed between technology and science. As Allen (1977) summarises, the relation between science and technology is not necessarily one where science develops concepts which will be transformed in practical applications by technological developments. Sometimes technological developments lead scientific discovery, and sometimes there is no interaction whatsoever between theoretically related scientific disciplines and technologies. We used two concepts based on this relation between science and technology. The degree to which science provides a useful basis for technological developments is a measure of the extent to which a technology, even in its infancy can be analysed and codified with scientific rigour. The number of scientific disciplines from which the technology borrows was used as a measure of the complexity of the technology.

Notice that the two concepts which are provided by Perrow's task approach (1974), i.e. analysability and variability are captured in our concepts. The S-curve concept is related to Perrow's variability or the number of exceptions encountered when working with the technology. Low on the S-curve one encounters a high number of exceptions and vice-versa. The degree to which science nurtures technology is related to Perrow's analysability.

The third group of variables is the strategic/company-cultural variables. It might seem strange to take strategic and cultural variables together. But in many cases it was difficult if not impossible to distinguish whether a strategic choice to be a technological leader or a follower was a conscious choice (i.e. strategy) or a cultural value of the business unit. Is a statement like "we want to be the first to do this !" an expression of a culture or of a rational and conscious choice? Other variables in this category were the degree to which entrepreneurship was valued, risk taking behaviour was encouraged, or the extent to which topmanagement had some technological understanding.

6. Relations between contingency variables and organisational structure for internalisation

Between these contingency variables and a technologically successful organisational structure for internalisation we observed a number of relations. (table 2)

We do realise the limits of our research method, and we do not pretend that these relations will hold under any circumstances. Except for one instance we will not venture in describing interaction effects between the different categories of variables. Such interaction effects probably exist, but the research method did not allow to pick these up in a strong and clear way.

insert table 2 about here

6.1. Timing

The timing of the perception and the uncertainty reduction stage vis-a-vis the competition will determine the number of options open to the business unit. Early perception will enable the business unit to lead the market. Late perception will lead to a situation where competitors have already created entry barriers under the form of patents, control over key researchers or key laboratories, or exclusion from potential collaborative partnerships. The early perception by the photochemicals company of the threat posed by electronic imaging enabled them to experiment with different internalisation approaches. The very defensive reaction by the paper company producing zinc oxyde coated paper reduced their options in the final stage of technology internalisation to technology purchasing.

Even if the actual internalisation is delayed, an early perception and evaluation will create a favourable position for the business unit to choose the organisational form for the internalisation.

As we pointed out already, also the quality of the perception and the uncertainty reduction will determine the options open to the business unit. The producer of construction materials rushed into research on neo-ceramics, without having gone through the first and second stage. Resource commitments were made, competitive options chosen, and when the company concluded that it had taken the wrong approach, the money was spent, and the credit for other organisational structures had gone.

6.2. Influence of the internal variables

The absolute amount of resources do play a role in the freedom a company has to choose a particular approach. Development can require large amounts of scarce financial or human resources, and if the business unit does not have them available some forms of internal development, contract research or acquisition of other companies may simply not be possible. A lack of resources will favour collaborative forms of internalisation. -- Although the other options are not impossible if the perception happens at an early

stage.-- But the reverse is not true. An abundance of internal resources does not imply that going alone is the preferred organisational structure. In other words, all other things equal, a lack of resources will exclude particular organisational structures, but an abundance of resources will not favour particular options.

The slack in the resources, i.e. the room for experimentation within the existing resources, will at least partially determine the exposure the business unit has to the new technology, and consequently its capability to perceive and absorb new technologies. The availability of slack seemed also inversely proportional to the N.I.H. syndrome. As a consequence the availability of slack tended to increase the speed with which the business unit could internalise the new technology.

A high degree of exposure to the new technology, partially a consequence of the slack in the organisation, but partially also a consequence of the openness of the organisation to the external world, will open the option of internal development. A low degree of exposure to the technology will virtually exclude the option of internal development. The question can be raised whether such an exposure can be created and then followed by internal development. This would mean that in our three stage model we would add a fourth stage, i.e. a stage of creating exposure between uncertainty reduction and internalisation. Theoretically this is possible. In practice we saw that between perception and the moment the new technology has to be available for market introduction the time is too short for exposure creation and internal development. The threat posed by the new technology is often around the corner, and a reasonably fast reaction is required. Without previous exposure of the business unit to new alternative technologies, internal development can never be fast enough.

As we already pointed out, even if a business unit decides to follow a route without internal development, a minimum of internal research work will be required. Even if such internal work bears no fruit, and appears to be a waste of time and money, it is absolutely essential to carry it out, in order to provide the organisation with the capability to absorb the new product technology.

In many of the cases we studied, the most visible and explicit support came from the government or a government sponsored research organisation. Two attitudes were prevalent. An attitude of 'wait and see', where the business unit almost subcontracted the initiative and/or the development to the government partner. And secondly a proactive attitude where the business unit systematically asked the question : who can benefit from what we are doing, and is consequently prepared to bear some of the costs, or to provide some important resources. The proactive attitude led in general to a more appropriate form of

collaboration. Moreover the nature of the support and the organisational structure of that support were adapted from one stage to another. A proactive management of the external support and resources created consequently favourable conditions for internalisation of the new technology. The case of the manufacturer of industrial tyres was an example of such a proactive approach. A longstanding collaboration with several academic laboratories had enabled them to understand the capabilities of the different laboratories, and, at the appropriate time, their support could be enacted to evaluate some research or to solve some specific problems, at very low financial and organisational cost.

6.3. Influence of the strategy/company-culture variables

In terms of strategy/culture we observed that a more diversified company has a bigger choice of organisational options to internalise technology, than a non-diversified company. One of the explanations we found for this, is that in the case of a diversified company there is a chance that one of the other business units in the company has some exposure to the new technology or its components. In such a case a transfer of knowhow between the business units within the company is possible, the perception can happen at an earlier stage and the evaluation can be more effective.

There is a direct relation between the strategic choice 'early entrant versus late entrant' and the organisational structure chosen for internalisation. The early entrant has no choice but doing a fair amount of internal development, or to actively collaborate with the technological leaders. The late entrant has in theory the whole range of options available, but considerations about speed and effective resource utilisation will incline him to prefer acquisition of other companies or purchase of technology. Calory and Noel (1986) have found a similar relation between early/late entrant and internal development versus acquisition of technology. We observed that the early entrant can also be successful by collaborating actively with leading academics. The case of the small additives company which wanted to be an early entrant in genetic engineering is an example. Having no resources to do the development internally, it teamed up with some of the best academic researchers in the field, in order to get access to the technology.

6.4. Influence of the technology

We observed two relations between the degree of development of the technology, i.e. its position on the S-curve, and the way the company organises its internal technological renewal. First of all, the lower the degree of development, the less focused the perception and uncertainty reduction has to be organised. Indeed, technologies in their infancy are often developed in a wide variety of organisations, and by very different types of people. Often the network or organised R&D community (Rappa and Debackere,

1989) of geographically and organisationally dispersed scientists and engineers who are committed to solving a set of interrelated scientific and technological problems has not been organised yet. The business unit which wants to perceive and learn about the new technology has to tap into different sources of technological progress. A focused approach which would limit itself to a traditional set of contacts with one or a limited number of research organisations is inappropriate at this stage. To some extent this was a mistake made by the manufacturer of construction materials : they relied for their information on their traditional source of information, the research contractor. Sahal (1983) comes to a similar conclusion when he asserts that innovations are characterised by a large number of independent discoveries, and not by one big breakthrough discovery as it is suggested by the Schumpeterian model of innovation. Under such circumstances success in innovative activity critically depends on pursuing and following up on several small scale scientific and technical experiments at the same time. Internal technical renewal is best served by variety in activities of perception and uncertainty reduction when a technology is still in its infancy.

Secondly the degree of development of the technology has an impact on the degree of formalisation that can be used during the internalisation stage. The low degree of stability which exists at the bottom of the S-curve, require a high degree of flexibility from the business unit during the internalisation. More entrepreneurial types of organisations such as internal venture teams, small spin-off joint ventures and small contracts with university teams in order to get access to the informal R&D network seem to be indicated. However when the technology develops and 'climbs' the S-curve, the increased stability and availability of the technology allow more mechanistic structures to be used. Contract research, acquisition of other companies, or simple licensing contracts become more feasible, and probably more effective than entrepreneurial structures.

The degree to which scientific developments contribute to technological developments plays a role in the degree to which the business unit can rely upon contractual agreements and the degree to which internal development is needed for the absorption of the new technology. The higher the scientific contribution, the easier the codification and the higher the analysability of what is already known about the technology. In such cases transfer of the technology becomes easier. If the science-technology link is weak, technology probably follows a less analysable pattern, and more own development is needed internal in the business unit in order to increase its absorptive capacity. In the case of the photochemical company internalising electronics, it was discovered that the hardware technologies, which are codified and rely on clear scientific disciplines could rather easily be internalised by acquiring a company. But for the software side, which is far less based on science,

and more on difficult to codify heuristics, the business unit needed to develop a strong internal software capability in order to evaluate others' software capabilities.

The complexity of the technology finally determines the need for integrating mechanisms. Sources of information during the three stages of the internal technological renewal will be more differentiated, and the integration of these different sources will require a higher attention from the receiving business unit. Here we will refer to the only interaction effect we observed clearly. Increased complexity of the technology requires a higher amount of resources to be mobilised. For smaller companies this implied that the organisational structure for internalisation had to include collaboration with big partners.

6.5. Impact of the technology on the internal linkages

As we pointed out, one of the results of the uncertainty reduction stage will be the evaluation of the impact of the new technology on the existing linkages between the partners and the functions within the business unit. We observed that the higher the perceived impact was, the more 'externalised' the internalisation process became, i.e. the lower the internal control over the internal technological renewal was. The higher the impact the more the business unit had to rely on separate organisational entities such as external joint ventures, separate internal departments created for the internalisation exercise, or contract research. The problems of the integration of such external and separate entities are well-known (Doz et al, 1986), and especially in the case where the new technology has a sizable impact on the existing linkages within the business unit, the integration of the results of these separate organisations towards the main business requires very careful management of the integration (Roberts and Berry, 1985). 'Successful learning from new businesses seems to be difficult, as is the development of new core businesses from such ventures' (Doz, 1989). In the research joint-venture created by the small additives company (case I), the partners in the joint venture may have very different evaluations of the success of the research company, depending on their ability to draw on the results of the genetic engineering venture to improve their own technological position. This ability is determined to some extent by the impact genetic engineering has on the existing linkages in their business units, and the attention they paid to the integration process.

7. Conclusion

Through eight in-depth case-studies we explored the organisational mechanisms through which business units with a mature technology can organise an internal technological

renewal. We observed three types of conclusions.

Down to earth as it may seem, the first conclusion is that the business unit with a mature technology has a choice of organisational structures. The reason why we stress this conclusion is that some of the less successful cases were examples of companies which were almost unconsciously drawn into a particular type of organisational structure, either by an outside partner, or by mere tradition. Some of the most successful business units on the contrary were those where after perception and evaluation of the new technology a careful choice of organisational structure was made.

The second type of conclusion has to do with the sequence of activities. We observed three distinctive stages in the renewal process : perception at the top level, uncertainty reduction leading to an evaluation of the technology, and the organisation of the internalisation. There is no shortcut to avoid those steps. And the quality with which earlier steps are executed determine the options available in the third stage , and the effectiveness of the internalisation process. --It needs no stressing that these three stages are not necessarily a nice linear process, but that feedback loops are possible.--

The third type of conclusions relates to the contingency variables which influence the optimal choice of an organisational structure. We distinguished between three categories of variables : internal variables, including the internal resources and the ability of the business unit to mobilise external resources, strategic/cultural variables, and technological variables. We have described some of the relations we have observed between these variables and the organisational structure which was chosen. Being fully aware of the limitations of our research method, we are convinced that these observations have to be seen as food for further thought and research.

(1) For a detailed account of six case studies the reader should refer to the full report : 'The turnaround of Companies with an Aging Technology', Vlerick School for Management, Report to the Interuniversity College for Management Studies, Brussels, June 1988. The financial support for this project by the Interuniversity College for Management Studies was highly appreciated.

Bibliography

Abernathy W.J., The Productivity Dilemma : Roadblock to Innovation in the Automobile Industry, John Hopkins University Press, Baltimore. 1978

Abernathy W.J., K.B. Clark and M.A. Kantrow, Industrial Renaissance : Producing a Competitive Future for America, Basic Books Inc., New York, 1983

Allen T.J., Managing the Flow of Technology, M.I.T. Press, Cambridge, MA., 1977

Becker R.H. and L.M. Speltz, Making more explicit Forecasts, Research Management, july-august 1986

Boisot M.H., Markets and Hierarchies in a Cultural Perspective, Organisation Studies, vol. , pp.137-160, 1986

Burns T and G. Stalker, The Management of Innovation, Tavistock, London, 1961

Calori N. and R. Noel, Logics, Strategies and Organisation in High Technology Emerging Industries : Four Cases, paper presented at Essec Strategy Conference, june 1986

Clark K.B., Competition, Technical Diversity and Radical Innovation, in R.D. Rosenbloom (ed.), Research on Technological Innovation and Policy, Jai Press Inc., Greenwich, 1983

Clark K.B., The interaction of Design Hierarchies and Market Concepts in Technological Evolution, Research Policy, vol. 14, p. 235-251, 1985

Cohen W.M. and Levinthal D.A., Innovation and Learning : the two Faces of R&D, The Economic Journal, vol. 99, p.569-596, 1989

Cooper A.C. and D. Schendel, Strategic Responses to Technological Threats, Business Horizons, vol. 19, no.1, p. 61-69, 1976

De Meyer A., Technologiemanagement op het Strategisch Niveau, Vlaams-Technisch Wetenschappelijk Congres on Technoloy and Strategy, Antwerp, november 1984

De Meyer A., The Flow of Technical Information in an R&D department, Research Policy, vol.14, no.6, 1985

De Meyer A., Plant Genetic Systems (A), Insead Case Series

De Meyer A. and R. Van Dierdonck, Organising a Technology Jump or Overcoming the Technology Hurdle, paper presented at the 4th Annual Strategic Management Society Conference,

Philadelphia, 1984

Dowdy W.L. and J. Nikolchev, Can Industries De-mature ? Applying New Technologies to Mature Industries, Long Range Planning, vol. 19, no.2, 1986

Doz Y., Managing Technological Innovation in Large Complex Firms, the Contribution of Human Resource Management, in Evans P., Y. Doz and A. Laurent (ed.), Human Resource Management in International Firms, Macmillan, London, 1989

Doz Y., Angelmar R. and C.K. Prahalad, Technological Innovation and Interdependence : a Challenge for the Large Complex Firm, Technology in Society, vol. 7, no 2 and 3, 1986

Foster R.N., Innovation : the Attackers's Advantage , McKinsey and Co., 1986

Galbraith J.R. and Kazanjian R.K., Developing Technologies : R&D strategies of Office Product Firms, Columbia Journal of World Business, spring, p. 37-44, 1983

Gold B., Strenghtening Managerial Approaches to Improving Technological Capabilities, Strategic management Journal, vol.4, p.209-220, 1983

Kotter J.P. and L.A. Schlesinger, Choosing Strategies for Change, Harvard Business Review, march-april, 1979

Perrow C., Organisational Analysis : a Sociological View, Tavistock, London, 1974

Rappa M.A. and K. Debackere, The Emergence of a New Technology : the case of Neural Networks, M.I.T. Sloan School of Management Working Paper, no. WP 3031-89-BPS

Roberts E.A. and C.A. Berry, Entering New Businesses : Selecting Strategies for Success, Sloan Management Review, vol. 24, spring, 1985

Roussel P.A., Technological Maturity Proves a Valid and Important Concept, Research Management, jan-feb 1984

Sahal D. Patterns of Technological Innovation Addison Westley. London, 1981

Soukup W.R. and A.C. Cooper, Strategic Response to Technological Change in the Electronic Components Industry, R&D Management, vol. 13, p. 219-230, 1983

Utterback J.M. and W.J. Abernathy, A Dynamic Model of Process and Product Innovation, Omega, vol. 3, p 639-656, 1975

Utterback J.M. and L.M. Kim, Invasion of a Stable Business by Radical Innovation, paper presented at the 17th Vlaams

Wetenschappelijk Economisch Congres on Innovation and Entrepreneurship, Antwerp, april 1985

Von Hippel, The Sources of Innovation, 1989

Williams J.R., Technological Evolution and Competitive Response, Strategic Management Journal, vol. 4, no. 1, p 55-65, 1983

table 1 : Overview of the case studies

industry	new technology	internalisation mechanism
textile	CAD-CAM	technology purchase
textile	CAD-CAM	cooperation
textile	CAD-CAM	contract research
coating	high solids	internal development
coating	enzymatic technology	cooperation
coating	special purpose coating	internal development
photochemistry	micro-electronics	internal development
photochemistry	micro-electronics	acquisition
photochemistry	micro-electronics	acquisition
reprography	thermal coating	acquisition
reprography	dielectric technology	cooperation
ceramics	neo-ceramics	contract research
contractor	new material	internal development
additives	genetic engineering	joint venture
telecom	GaAs based chips	technology purchase
banking	artificial intelligence	joint venture
rubber	new material	acquisition
dairy	biotechnology	contract research

source : The Turnaround of Companies with an Aging Technology, report to the Interuniversity College for Management Studies, June 1988

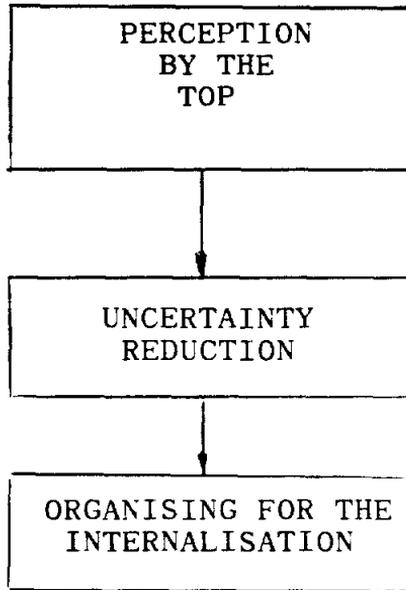
figure 1 : Three stage Model

table 2 : Summary of the relations

timing :

- early perception leads to more organisational options

internal variables :

- more internal resources available enables higher control
- slack in resources increases quality of perception and speed of internalisation
- high exposure enables more internal development
- proactive management of external resources improves internalisation

Strategy

- diversification increases exposure
- early entry implies internal development or collaboration with universities

Technology

- low degree of development requires broad perception
- degree of development is related to degree of formalisation
- high degree of scientific support for technology enables increased formalisation
- increased complexity requires higher resources and more integration

Internal linkages

- high impact on external linkages requires lower internal control

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