Trends in corporate R&D

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Management summary

For some time now there have been different and conflicting signals regarding R&D in the Netherlands. On the one hand, the extent of R&D would appear to be declining (for example at Fokker, DAF, Baan and Ericsson), or an increasing amount of R&D would move abroad (Unilever to India, DSM to the United States). On the other hand, there would seem to be an increase of R&D activities in the Netherlands (think, for instance, of the Philips campus that is currently being built in Eindhoven). What exactly is going on? In order to find out, this report sets out the most significant trends and developments in R&D, both from a macro and micro perspective.

Macro perspective
From a macro perspective, a number of things can be observed:

- From 1993 to 1999, the level of R&D activities undertaken by companies in the Netherlands increased by some 40% (corrected to take account of inflation).
- The number of companies that undertake R&D in the Netherlands has increased, among both Dutch and foreign companies.
- The share of R&D among the 'Big Seven', although showing a slight decline, is still large (50%).[1]
- This decline can be explained by the increase in the total amount of R&D undertaken in the Netherlands.
- The remaining amount of R&D is accounted for by a large number of small(er) firms that have begun undertaking more R&D (a total of about 12,000).
- The amount spent on R&D by large(r) companies within a particular sector is following roughly the same pattern.
- As far as the location of the R&D activities is concerned, this is mostly historically determined and as a result is largely fixed.
- In spite of the fact that foreign R&D expenditure by the 'Big Seven' has increased over the past few years, this has not been at the expense of these companies' existing R&D activities in the Netherlands.
- R&D has therefore not been relocated abroad.
- Moreover, the R&D activities that these companies have hived off in the Netherlands are being maintained. These laboratories are therefore not moving away from the Netherlands.[2]
- The share of foreign companies in the total volume of R&D in the Netherlands has increased, partly through acquisitions, whereby the location is retained.

[1] The 'Big Seven' are the seven largest R&D companies in the Netherlands: Philips, Akzo Nobel, ASML, DSM, Shell, Unilever and Océ.
[2] How can we explain the closure of Ericsson in Enschede? This concerns a sector effect: the telecommunications sector has had to cope with difficult economic conditions and as a result many companies are simply concerned with survival in the short term. This applies to Ericsson, but also to KPN, Alcatel, Lucent and Siemens. The Ericsson site in Enschede was new and was not actually up and running. In view of the problems in the telecommunications sector, the closure of this site was the most obvious choice, as was the closure of roughly thirty other R&D-related activities of Ericsson around the world. Incidentally, Ericsson retains a presence in Rijen, where R&D is also undertaken (*Het Financieele Dagblad*, 30 August 2002). In short, this shows a trend that is restricted to a specific sector, rather than a 'macro trend'.

The macro picture is therefore a fairly 'calm' one: a steady rise in R&D activities whereby there is no systematic relocation of R&D.[3] However, underneath this relatively smooth surface the situation is highly dynamic and heterogeneous.

Micro picture
In view of increasing competition and the acceleration of product and technology cycles, the most important strategic question with which companies are confronted is how to increase the speed and creativity of R&D (and the innovation process). The way in which this is done varies considerably from sector to sector and between companies, which makes it difficult to establish clear trends. Still, there is an emerging trend of the growing significance of state-of-the-art knowledge, as well as *access* to such knowledge wherever it is located around the globe. In order to create this access, many companies often decide to set up local R&D activities, by means of 'listening posts' for example. In developing such decentralised R&D activities, the homeland still continues to be very important: foreign R&D activities must complement the homeland's R&D activities, whereby the latter are dominant.

Macro and micro combined
The observation from the macro perspective that Dutch companies are developing an increasing amount of R&D activity abroad can in fact be regarded as a positive sign from a micro perspective. It shows that these companies are well connected to international knowledge networks that are relevant to them. As a result, this knowledge that has been developed abroad comes back to the Netherlands through Dutch companies. Of course the reverse is also true: knowledge developed in the Netherlands finds its way abroad. This is the 'new game' that is developing ever faster in the international R&D arena. This raises the question to what extent it should be considered a matter of concern if a (large) company undertakes all of its R&D in the Netherlands; to what extent is such a company able to possess sufficient state-of-the-art knowledge in its relevant areas of technology?[4]

Towards policy: from 'inside-out' to 'outside-in'
As far as the internationalisation of R&D is concerned, up to now the policy discussion has largely been characterised by an 'inside-out' focus: to what extent is R&D being moved from the Netherlands to other countries? As already stated, so far this has not proved to be the case. Because of this one-sided view, the other side of the coin of this trend towards internationalisation has not been examined adequately, namely the 'outside-in' focus: to what extent has the Netherlands benefited from the *extra* R&D activities that foreign companies have developed within the Netherlands (in order to obtain access to certain state-of-the-art knowledge in this country)?[5] This narrow focus is

[3] This does not alter the fact that the Netherlands continues to lag behind other countries in this area. From an international perspective, private R&D intensity in the Netherlands (1.13% in 2000) is slightly lower than the EU average (1.21%) and significantly lower than the OECD average (1.56%). Private R&D intensity comprises the private R&D expenditure as a percentage of the GDP.
[4] An example is DSM, which undertook all its R&D activities in the Netherlands until the mid-1990s. DSM has meanwhile decided to switch over from bulk chemicals to high-quality pharmaceutics and life sciences. The latter is a knowledge-intensive business that demands more R&D. As a result, DSM's R&D expenditure has risen since 1995, both in the Netherlands and abroad (especially in the USA).
[5] *'Extra'* here means R&D activities that do not come under R&D activities that have already taken place in the Netherlands, and are now in foreign ownership as a result of takeovers, etc.

illustrated by the fact that there is only a limited insight into this outside-in knowledge flows.[6]

Conclusion
For the present, the following conclusion can be drawn from the above[7]:

- There is an increasing internationalisation of R&D.
- Large Dutch companies are continuing their R&D activities in the Netherlands, while at the same time developing complementary R&D activities elsewhere.
- This means that R&D is not being moved to other countries.
- It is unclear to what extent the Netherlands has been able to benefit from this internationalisation of R&D by attracting extra R&D from abroad.

Finally: the future …
Can we therefore conclude that there is no need for concern? The answer is 'No': there is probably indeed something going on which should raise concerns. As the annual study by the IMD and the Economic Intelligence Unit (EIU) shows, the Netherlands has scored particularly well for a number of years as regards the competitive power of the economy and its appeal for doing business.[8] However, as far as the appeal of R&D investment is concerned, the Netherlands's average score is considerably lower. Although at first sight this may be no reason for concern, it could form a problem in the long term. In spite of the importance of the homeland, the significance of state-of-the-art knowledge and skills is increasing further. In this respect, excellence of knowledge becomes more important than nationality, and may mean that the relationship between R&D companies and their homeland will become less important. As a result, it is not inconceivable that investments will be made in new R&D locations in a small number of countries with a highly favourable innovative climate. The recent announcements from Philips and Unilever point in this direction.[9] If we do not want to miss the boat, action is needed now.

[6] These are our own findings, as well as those of Cornet and Rensman (2001). The scarce knowledge about this indicates that the Netherlands has only had limited benefit from foreign R&D investments in the Netherlands. This is also evident from a report by Dalton et al (1999). Additional research on this subject is nevertheless desirable.
[7] These conclusions were confirmed during a meeting with the R&D senior managers from a number of large Dutch companies and foreign companies with R&D activities in the Netherlands, on 6 November 2002 at the Ministry of Economic Affairs in The Hague.
[8] The most recent league table published by the EIU, part of the British Economist Group which also publishes the weekly magazine *The Economist*, shows that the Netherlands has the best business climate in the world.
[9] This refers to the statements by Mr Huijser, Chief Technology Officer at Philips. He said that it could not be ruled out that all R&D activities would have been moved from the Netherlands within 15 years. The reason that Mr Huijser gave for this was that foreign governments pursue a more active innovation and technology policy (*Het Financieele Dagblad*, 8 October 2002). Unilever too has expressed concern about the Dutch knowledge economy (*Het Financieele Dagblad*, 1 November 2002).

1 Introduction

For some time now there have been variable and conflicting signals concerning R&D activities in the Dutch business community. At one hand the extent of R&D would appear to be declining, referring to events in the past around Fokker, DAF and Baan as well as the recent closure of the Ericsson site in Enschede. There would seem to be an increasing relocation of R&D abroad too, such as Unilever to India, DSM to Canada and Organon to the USA. On the other hand, there would appear to be an increase in R&D activities in the Netherlands, whereby one could cite the Philips campus currently being built in Eindhoven.

This raises the question as to what exactly is going on. Is R&D being relocated, and if so how serious is that? And should the government do something about it, and if so, what? In order to answer these questions, this report sets out the most significant trends and developments in the area of R&D.

This report is structured as follows. First, paragraph 2 will discuss the macro picture of R&D in the Netherlands. Paragraph 3 sketches the micro picture by examining the R&D process within the business. Then both perspectives are brought together in paragraph 4 based on the choice of location, and collaboration with knowledge institutions in paragraph 5. In paragraph 6, conclusions are drawn and new questions formulated.

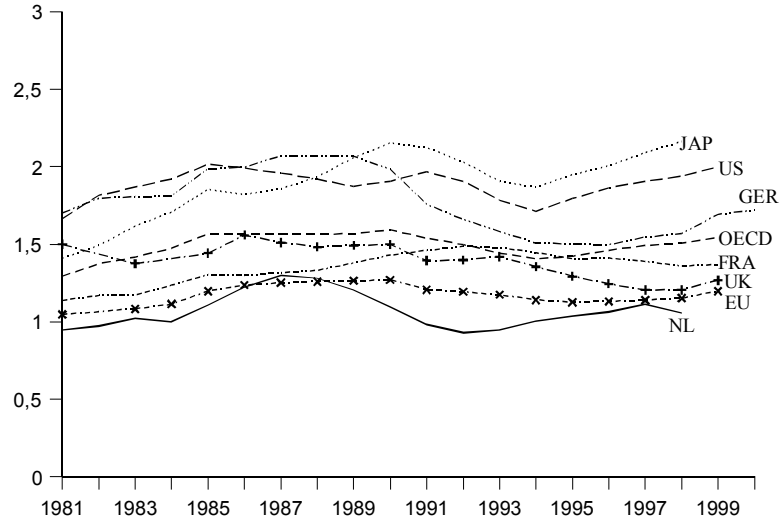
2 R&D in the Netherlands: a macro picture

This paragraph discusses a macro picture of the developments in R&D in the Netherlands. Paragraph 2.1 looks at the progress of R&D intensity, and with it the question to what extent the Netherlands lags behind other countries. In paragraph 2.2 we look in further detail at the 'Big Seven', the seven largest R&D companies in the Netherlands, and their policy with regard to R&D. Based on this, we discuss in paragraph 2.3 the question whether R&D is actually being relocated abroad. Our conclusions are set out in paragraph 2.4.

2.1 Development of R&D in the Netherlands

During the period between 1990 and 1999, R&D intensity in the Netherlands rose slightly[10], bringing total R&D expenditure, both public and private, to 7.6 billion euro in 2001 (CBS, 2001; CPB, 2001). Nevertheless, from an international point of view the intensity of private R&D in the Netherlands (1.13% in 2000) is slightly lower than the EU average (1.21%) and substantially lower than the OECD average (1.56%). Figure 1 shows in graph form that the R&D intensity among businesses in the Netherlands lags behind all the major countries and is slightly below the EU average.

Figure 1. Corporate R&D expenditure for major OECD countries and the Netherlands (as a percentage of GDP)



Bron: OECD, Main Science and Technology Indicators.

Of the total expenditure on R&D in the Netherlands, 45% is accounted for by the government, with which the Netherlands (0.88% of GDP) has a clearly higher score compared to the EU average (0.65%) and the OECD (0.67%). This means that R&D lags behind particularly in the area of private R&D expenditure.

[10] R&D intensity is defined as the total R&D expenditure expressed as a percentage of the GDP.

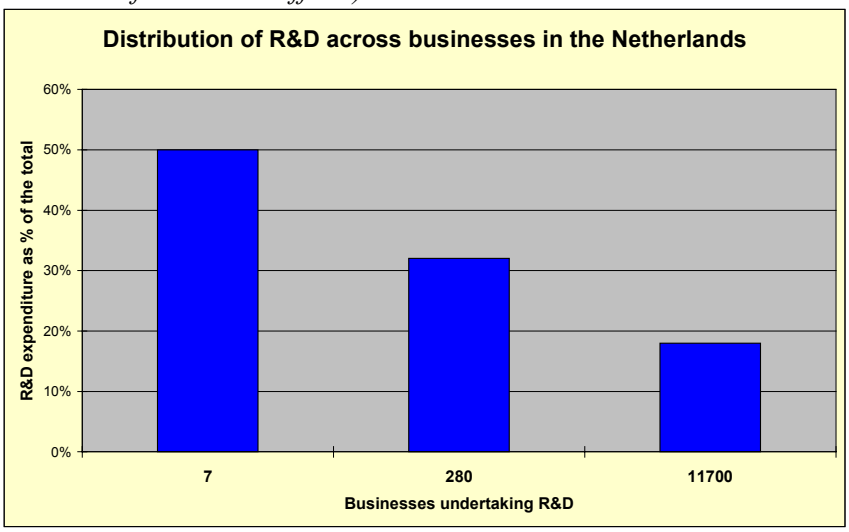
The question is how to explain why private R&D is lagging behind compared to other countries.

- The first reason for this concerns the sector structure of the Netherlands. The reasoning is that Dutch businesses are relatively strongly active in R&D-extensive sectors. In order to examine whether the Dutch sector structure is the reason why Dutch R&D is lagging behind, Verspagen and Hollanders (1998) analysed the differences between the Dutch R&D intensity and the average R&D intensity in a group of reference countries. Their research showed that almost half of R&D's lagging behind can be explained by the sector structure (see also the study by Ruiter (2002)). In the industrial sector this percentage is considerably lower, namely 28%. In order to explain the remaining part of this lagging behind, other reasons are mentioned in the literature.
- Another reason that is sometimes mentioned is the small scale of the Netherlands (see, for instance, Snijders, 1998). Verspagen and Hollanders (1998) demonstrate, however, that this is a 'myth': other small countries such as Sweden and Switzerland, with 2.7% and 2.3% respectively, clearly show a higher R&D intensity than the Netherlands.
- A third reason that is mentioned is the fact that much R&D in the Netherlands takes place in the public sector (see CPB, 2001). If this is so, naturally it is important for this new knowledge to end up with businesses. In other words, it is all about a proper link between public knowledge institutions and the business community. In the Netherlands, the link between the two is thought to be inadequate. The extent to which this is the case will be discussed in paragraph 5.
- Finally, a reason that is often mentioned is the internationalisation of R&D: Dutch multinationals are supposedly doing a substantial (and increasing) proportion of their R&D abroad. This subject will be dealt with in paragraph 2.4. First the distribution of R&D expenditure across businesses in the Netherlands will be examined.

2.2 Distribution of corporate R&D in the Netherlands

Figure 2 shows the distribution of the total R&D expenditure across businesses in the Netherlands in the year 2000 (the general line hardly deviates from this for other years).

Figure 2. Distribution of the total R&D expenditure across businesses (source: Ministry of Economic Affairs)



The above percentages are only an indication. As the figure shows, seven companies undertake 50% of the total private R&D in the Netherlands. The following group consists of 280 businesses that account for 32%. 11,700 businesses (±6000 in manufacturing and ±5700 in services) undertake the remaining 18% of the total private R&D in the Netherlands. The question now is from which group the 'most profit' can be achieved as far as increasing the extent of R&D in the Netherlands is concerned. We will return in detail to this question in paragraph 6. Since the 'Big Seven' account for the lion's share of the total Dutch R&D, these companies will be examined more extensively first.

2.3 The Dutch 'Big Seven'

During the 1990s, the major part of R&D expenditure was accounted for by 25 Dutch and foreign businesses. About 50% of all private R&D activities were undertaken by the 'Big Seven': Philips, Akzo Nobel, ASML, DSM, Shell, Unilever and Océ.[11] Over the years the share of the 'Big Seven' in the total R&D expenditure has declined (CBS, 1999; CPB, 2001). Three reasons can be put forward for this. Firstly, the arrival of a number of software companies (including, for example, Baan) caused the total amount of R&D in the Netherlands to rise (slightly). Secondly, several service sectors including banks, the wholesale industry and engineering firms have begun undertaking more R&D (Cornet and Rensman, 2001).[12] Thirdly, Philips has hived off a large number of divisions that are now continuing as smaller R&D businesses, such as AT&T/Lucent, Neways Electronics, Atos Origin and Solvay Duphar.

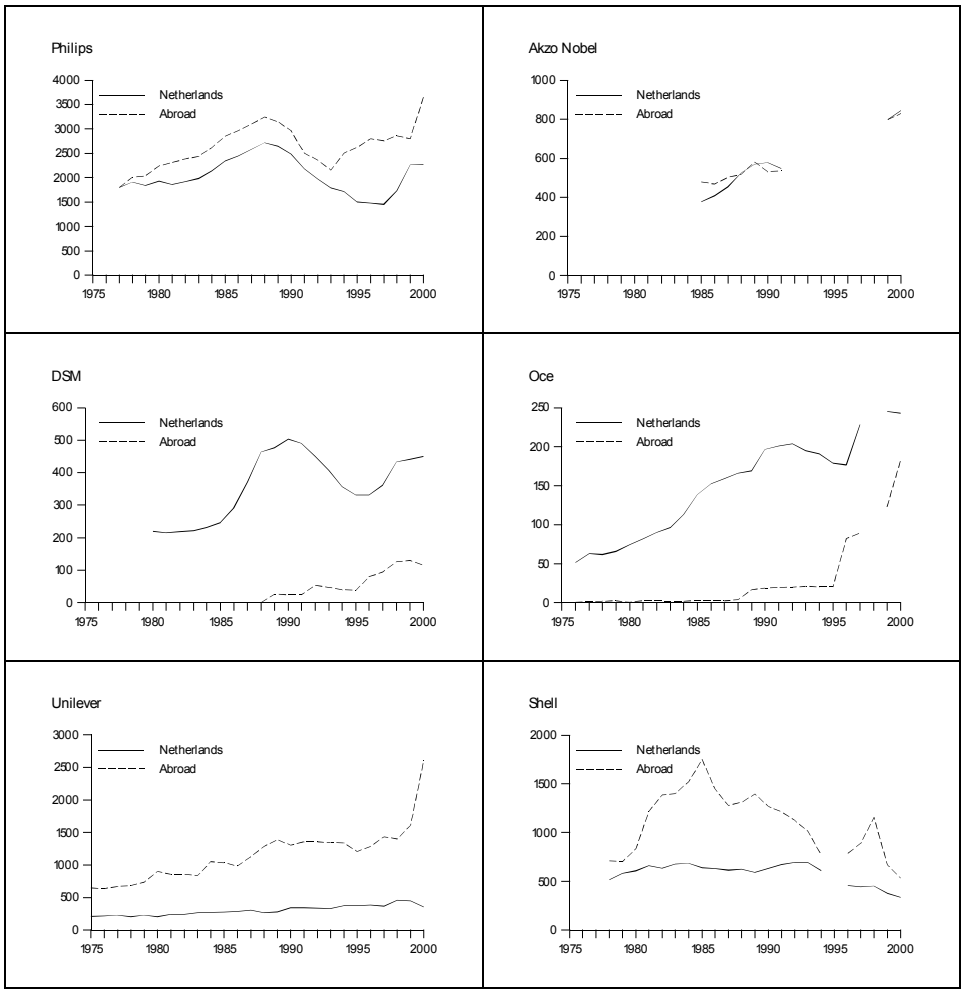
Development of R&D with the 'Big Seven'
Figure 3 shows a summary of the development of the 'Big Seven's' R&D expenditure for the period from 1977-2000. This figure shows that the share of R&D in the Netherlands has fallen with some companies (Unilever, for example). This concerns particularly the expansion of foreign R&D activities of these companies, rather than a scaling down of R&D activities in the Netherlands (Cornet and Rensman, 2001). In other words, expansion of foreign R&D activities is not at the expense of R&D activities in the Netherlands. Appendix 1 discusses the developments for each company in greater detail.

Extent of R&D expenditure among the 'Big Seven'
Figure 4 compares the R&D intensity of some of the 'Big Seven' companies with those of a major competitor. Although the amount and movement may vary between industries, the extent of corporate R&D expenditure within the industries themselves shows roughly the same pattern. There are two explanations for this.

Firstly, the identical pattern with regard to the R&D expenditure could be attributed to imitative behaviour between businesses. Minne and Rensman (2001) argue that the amount of R&D expenditure is particularly determined by what competitors do. According to the authors, businesses pursue such a strategy because they are afraid of losing their their competitive advantage if they do not imitate their competitors as far as R&D investment is concerned.

[11] In this respect, the position of the Netherlands is not exceptional compared to other (small) countries. In countries such as Sweden, Switzerland and Germany too, a small number of businesses carry out a significant proportion of corporate R&D. For example, in Switzerland only four companies undertake two-thirds of the total corporate R&D.
[12] Some of this is an optical effect, since the R&D of service companies is better recorded nowadays (CBS, 1999; CBS, 2001).

Figure 3. Visual summary of R&D decisions of the 'Big Seven' (ASML missing)

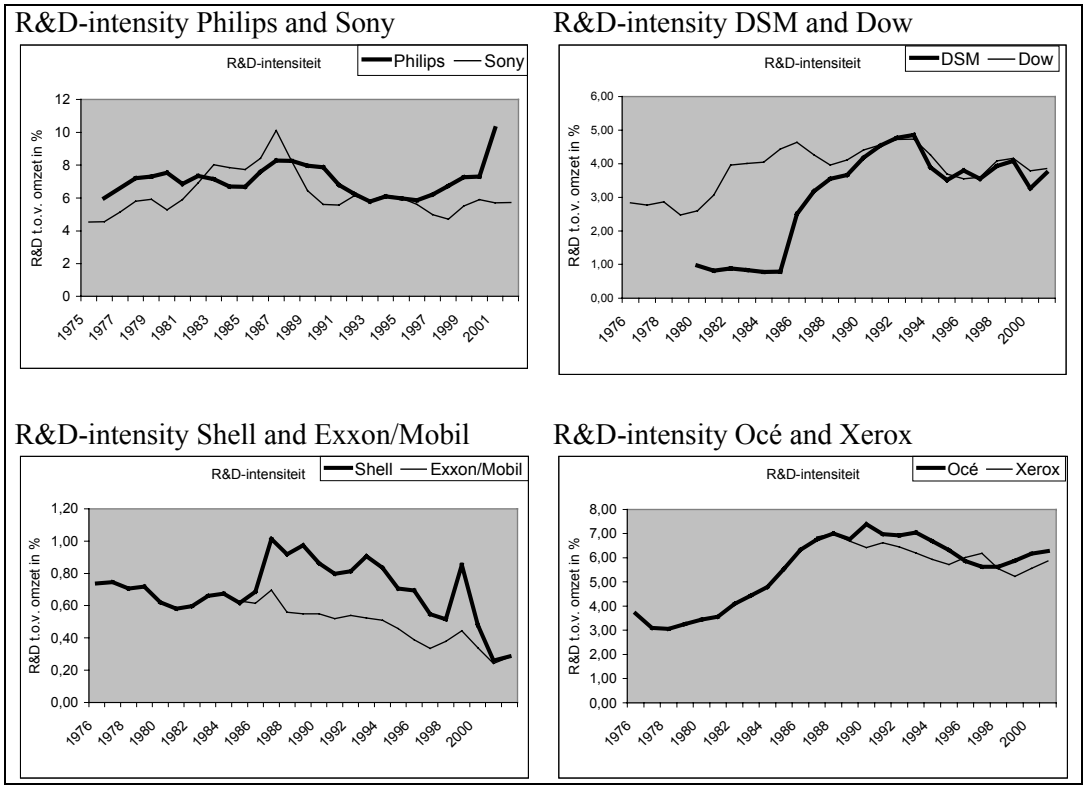


Source: Cornet and Rensman, 2001.

If a major competitor does more R&D, this provides an incentive not to get left behind. The reverse is also true: if a business reduces its R&D efforts, others follow suit in order to control costs. After all, R&D is a significant cost item that reduces profits (in the short term).

A second explanation is that businesses usually have common expectations of the future regarding the opportunities and risks of potential areas of technology. Businesses themselves also say that they follow the market and this leads to all businesses following roughly the same pattern. It is therefore not generally an explicitly strategic choice, but rather a sum of individual decisions. Businesses do examine retrospectively, though, whether the R&D expenditure as a percentage of the turnover is still on a par with expenditure of direct competitors.

Figure 4. Benchmark of 'Big Seven' with major competitors



Source: Minne and Verbruggen, 2002.

2.4 Relocation of R&D?

Research by Cornet and Rensman (2001) on the choice of location and the potential relocation of R&D identified the following points:

- Although for some 'Big Seven' companies the share of R&D expenditure in the Netherlands is falling in comparison to total R&D expenditure, the level of R&D expenditure in the Netherlands is in fact rising.
- New foreign R&D activities by major Dutch companies (e.g. through the acquisition of R&D-intensive foreign businesses) are usually in addition to the existing R&D activities in the Netherlands and not at their expense.
- Hived-off R&D activities (through the sale of subsidiaries, for instance,) remain in the Netherlands. The foreign businesses that take over these Dutch businesses often continue these activities at the same location in the Netherlands. During the 1990s, the share of R&D by foreign businesses in the total amount of R&D in the Netherlands has increased.
- A small number of Dutch businesses with limited R&D activities have taken over foreign R&D laboratories, which have thus been added to (and have not been at the expense of) their Dutch R&D activities.

The conclusion that can be drawn is that no proof can be found for (large-scale) relocation of R&D abroad. Foreign businesses that have taken over Dutch R&D facilities

continue these activities, as well as the location of the facility.[13] On balance, therefore, R&D is not being relocated, there is however a change of owner.

2.5 Macro picture: Conclusion

We observe, on a macro scale, the following trends in corporate R&D over the past ten years:

- The number of businesses (both Dutch and foreign) that undertake R&D in the Netherlands has increased.
- The share of R&D among the 'Big Seven', although slightly less, is still considerable (50%). The reduction can be explained by the increase in the total amount of R&D in the Netherlands.
- The development and the level of R&D intensity of competing businesses in the same market are similar.
- In spite of the fact that the foreign R&D expenditure of the 'Big Seven' has risen, this has not been at the expense of existing R&D activities that these companies undertake in the Netherlands. R&D is therefore not being relocated abroad.
- In addition, the R&D activities that the 'Big Seven' have hived off have remained in the Netherlands.
- The share of R&D of foreign businesses in the total amount of R&D in the Netherlands has increased, partly through acquisitions, whereby the location has been maintained.
- There is continuity in the existing R&D laboratories. On the one hand, existing R&D laboratories are being maintained, while on the other hand relatively few new laboratories have been added.

[13] There is insufficient empirical support to ascertain whether foreign direct investment in R&D is more or less beneficial for Dutch society than R&D investment by Dutch businesses (Cornet and Rensman, 2001). There would not therefore seem to be any empirical reason, from a policy point of view, to deal differently with foreign R&D investment already established here.

3. R&D Organisation : a micro picture

The micro picture is central in this paragraph, i.e. the way in which the R&D function is organised within businesses. For this purpose, we discuss briefly in paragraph 3.1 the changes in the external context of the R&D function. We then continue in paragraph 3.2 to discuss in detail the way in which the R&D function is organised and which considerations are made in that respect. In paragraph 3.3 we discuss the various types of commonly occurring R&D organisations. In paragraph 3.4, we consider in greater detail a number of recent as well as expected trends in the organisation of R&D. Paragraph 2.5 sets out our conclusions.

3.1 Context of R&D and innovation

The combination of an increasing emphasis on 'shareholder value' and a period of economic prosperity have generally led to the necessity for achieving a faster return on R&D investment (Jacobs and Waalkens, 2001). As far as the R&D research is concerned, there is a trend where technologies are slowly but surely becoming more science-based, i.e. their origins are increasingly found in science. In addition, new technologies are fast taking on a multidisciplinary character (Meyer-Kramer and Reger, 1999). On the demand side, businesses are confronted with ever shorter product life cycles and a further individualisation of customer wishes (Tidd et al, 1997). In this respect, the term '5th generation R&D' is used, whereby it concerns above all the integration of a number of different types of technology in such a way that different customer wishes can be responded to quickly in a targeted and flexible way (Rothwell, 1992).

The consequence of these developments for businesses is that they are increasingly being confronted with a new strategic question, namely *how to increase the speed and creativity of R&D (and the innovation process)*. The question on how to organise the R&D process is derived from this: all organisational measures that are taken must ultimately result in a faster production of new (or preferably: the newest) ideas, products and processes (Tidd et al, 1997; Jacobs and Waalkens, 2001).

3.2 Organisation of the R&D function

It is evident from existing literature research that there is agreement on one thing, that there is *no such thing* as *the best* organisational structure for R&D and innovation (Jacobs and Waalkens, 2001; Zander, 1999; Volberda, 1998; Tidd et al, 1997). Depending on the type of sector, the type of business, the type of innovation and the strategic objectives that have been set, businesses will regularly (have to) modify the way in which their R&D and innovation is organised. For this reason, it does not make much sense to say exactly what the most recent trends are for each business at present as regards the organisation of the R&D function. However, it can be stated in general terms what assessments are being made and how, in response to this, the R&D function can be organised as optimally as possible.

Research by Tidd et al (1997) and Jacobs and Waalkens (2001) shows that the choice for the best organisational form of R&D is based on four organisational dimensions, namely:
1. 'technology push' versus 'market pull',
2. centralisation versus decentralisation,
3. concentration within a country or distributed internationally,
4. internal versus external acquisition of knowledge.

'Technology push' versus 'market pull'
The extent to which R&D is technology-driven or more demand-driven varies depending on the type of industry. Naturally both forces always play a role in a mix that will vary depending on the type of innovation pattern that is dominant in a particular sector (Pavitt, 1984):

- 'Science-based' industries
  - strong emphasis on (scientific) research into new, technological products
  - Akzo Pharma, DSM Biologics, Philips Electronics, Unilever (food)
- 'Scale-intensive' industries
  - predominantly technology-driven process innovations and incremental product innovations
  - DSM (chemicals), Shell (chemicals), Unilever (detergents), KPN, Corus
- 'Specialised equipment' industries
  - process innovations and product innovations, close collaboration with customers/outsourcers, aimed at (parts of) complex systems such as machines and systems
  - ASML, Océ, Stork, Lucent, Ericsson
- 'Supplier-dominated' industries
  - particularly the adoption of process innovations developed by suppliers such as the ICT sector
  - Randstad, banks, insurance companies
- 'Information-intensive' industries
  - product innovations that are largely market driven
  - publishers, banks

Naturally this is only a general overview of the extent to which R&D is technology-driven or market-driven. Shifts occur in these patterns over time, and a business does of course have the freedom to make its own strategic choices. An example may clarify this.

Case 1. Market-driven management of R&D at Unilever
In the past the innovation process at Unilever was sequential: the R&D department developed the products and the marketing department put them on the market. Nowadays, product groups can draw on the knowledge available within the R&D department. The R&D department is now market-driven, with the assistance of integrated project teams. Those with final responsibility for R&D work together with those responsible for marketing. This is referred to as 'competitor research', whereby technology development goes hand in hand with business development (Jacobs and Waalkens, 2001, page 35).

Centralisation versus decentralisation
As far as the assessment of this organisational dimension is concerned, a distinction is made between fundamental research (research function) and applied research (development function).

Research function
As far as fundamental research is concerned, the (traditional) rule of thumb is that the more fundamental in nature the research is (i.e. with a longer time perspective and further removed from the market) the more centralised it is. The reasons for this are advantages of scale, the need to be close to the head office, and the desire to keep strategic knowledge within the business (Fors, 1998). However, when a business has a more diverse range of parts with only a limited synergy, fundamental research will be more decentralised. An important trend in this, however, is that fundamental research is driven more strongly by the market than in the past. This is a consequence of the increasing importance of shareholder value, and with it the more stringent requirements on return from R&D investments (Jacobs and Waalkens, 2001; Minne and Rensman, 2001). Businesses try to satisfy these return requirements on the one hand by allowing divisions to take the initiative on how the research should develop, and on the other hand through a drastic acceleration of product development. In this way, more emphasis is placed in the research on finding solutions fast to existing customer wishes, and less on the supply-driven (fundamental) research that focuses on potential customers and markets (Minne and Rensman, 2001). The result is that in spite of the fact that businesses do not publish information on the share of their fundamental research, it can be stated that the share of fundamental research in the total amount of R&D is small at present (Minne and Verbruggen, 2002).[14] Nevertheless, businesses do state that this does not mean that the importance of fundamental research is declining. Businesses attach great value to fundamental research, because they believe this research to be necessary for generating new ideas (Minne and Rensman, 2001). This is evident, for example, from the increasing amount of fundamental research being outsourced to universities and knowledge institutions, as well as the emerging ‘second knowledge infrastructure (for this, see also paragraph 5.3).

Development function
As far as the extent of centralisation/decentralisation of the development function is concerned, the determining factor for undertaking R&D decentrally is when modifications to products and processes in order to fit local market circumstances is a critical factor for success. Usually, it concerns here incremental modifications to centrally developed products. If there is no need for this, and if there are advantages of scale in research, centralisation of the development function will be preferred (Patel and Vega, 1999).

Concentration within a single country or distributed internationally
In a certain sense this dimension is related to the previous one, although it concerns here above all the geographical distribution of R&D. Here too, a distinction is made once again between the development function and the research function.

[14] The decline in fundamental R&D is also mentioned in virtually all annual reports, and also comes to the fore in the various interviews with corporate R&D senior exectives.

Development function
Generally speaking it can be said that R&D abroad concerns the development function. It concerns here above all the need, as already discussed, to be close to local markets ('market pull'). Since the driving force is formed by the sales of the most important 'core products', it is therefore largely to do with those areas of technology in which the business has a competitive advantage. This explains why, traditionally speaking, R&D activities are not undertaken abroad very often simply to compensate for weaknesses in the home base. There must therefore be a link to the strengths in the home base (Patel and Vega, 1999; Fors, 1998). From the mid-1990s onwards, however, a change can be observed in the above-described pattern, which concerns the research function in particular (Le Bas and Sierra, 2002).

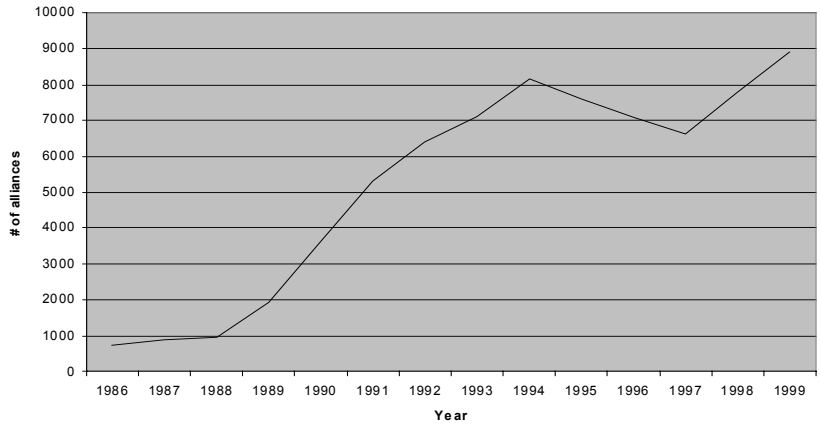
Case 2. Internationalisation at Unilever
Although there is central control at Unilever from within two divisions (Foods and Cosmetics), the market-driven character of innovation makes it necessary for certain products to be developed decentrally too. An example of this is tea. Tea is drunk around the world. While the Europeans prefer the brown teas in particular, the green teas are more preferred in India. In order to fit in properly with the local market, this tea is developed close to the market, such as in India itself (Jacobs and Waalkens, 2001, page 44).

Research function
The increasing degree of 'scientification' of technology and the increasing speed of change mean that businesses must to be able to access the latest information very fast, anywhere in the world (Meyer-Kramer and Reger, 1999). This means that businesses increasingly have (decentralised) research undertaken in countries that specialise in the technology concerned, since it is usually there that the best researchers, knowledge institutions and competing colleagues are found. Incidentally, this does not automatically mean large-scale research activities have been relocated. The availability of local 'listening posts' too can be included in this. These allow the businesses to pick up new knowledge fast and pass it on to the home base (Patel and Vega, 1999; Fors, 1998; Pearce, 1999). A trend associated with this, is that increasing use is being made of collaboration with third parties, the '4th organisational dimension'.

Internal versus external knowledge acquisition
The first three organisational dimensions regard R&D predominantly from an internal perspective. For many years this was the generally prevailing adage, namely that R&D should take place behind firmly closed doors. This gradually changed during the 1990s as businesses came to realise that it was becoming increasingly difficult and costly to (continue to) excel in a range of different area. As a result, many businesses increasingly started to acquire their knowledge from external sources. Also, with regard to external knowledge acquisition, one often refers to collaboration through strategic alliances.[15] Figure 5 shows clearly the rise in the number of strategic technological alliances being formed.

[15] Besides collaboration, as regards external knowledge acquisition one could also think of the outsourcing of research. We will return to this subject in paragraph 5, giving particular attention to the outsourcing of the knowledge infrastructure.

Figure 5. Number of strategic technology alliances each year (1986-1999)



Source: De Man and Duysters, 2002.

Strategic alliances focus on achieving synergy benefits through the technological complementarity of two or more parties. In this respect, strategic alliances form a good way of gaining (decentralised) access to state-of-the-art knowledge. In addition, alliances have the advantage of limiting the risk of R&D and innovation and increasing its speed.

Various international research projects in the field of strategic alliances have shown that there is a clear positive connection with innovative success (De Man and Duysters, 2002). In addition, it is evident that the effect of strategic alliances on innovation becomes greater the more intensive the collaboration becomes (i.e. the greater the degree of mutual dependency). It is therefore not surprising to discover that strategic alliances have increased dramatically in the past few years.

Case 3. Strategic alliances at VNU
Where businesses need to specialise in a wide range of competencies, it is worthwhile acquiring knowledge externally. For this reason, at VNU too the number of strategic alliances with other businesses is increasing. A notable joint venture is the alliance with the Randstad temporary employment agency in relation to the job vacancy website Newmonday.com. VNU is responsible for the channel, and Randstad for the expertise regarding agency activities and bringing together supply and demand (Jacobs and Waalkens, 2001, page 46).

Forms of collaboration can be brought about in several ways. Think, for instance, of the use of licences and R&D contracts, joint ventures or even research businesses. A striking form of collaboration that has arisen in the last few years is ‘corporate venturing’. This may involve (Jacobs and Waalkens, 2001):

- entrepreneurship: encouraging a feeling of ‘ownership’ and a more commercial approach among subsidiary companies, whether or not in competition with an internal department;
- setting up a separate small business: to encourage more radical innovations that would not flourish in the more incremental innovation logic of the parent company;
- limiting financial risk: if external parties can participate, more risks can be taken without alarming shareholders, while access can still be obtained to innovative ideas and plans.

Case 4. DSM: talent & technology scouting through 'venturing'
At DSM, an explicit 'corporate venturing' policy has been chosen for, implemented by the New Business Development department(NBD). About ten years ago, DSM discovered that it was not wise to rely on knowledge from its own laboratories only. In order to accelerate information, DSM wanted to acquire external knowledge by means of 'venturing'. It participated in the American venture capital fund Ampersand Venturing, which invests in start-ups in the chemical sector. For DSM NBD, Amperstand is a kind of window on the world. Every quarter it studies 225 requests for new initiatives, with DSM following the process too. Of the existing sixteen participations (with options for a takeover), two or three businesses each year qualify to become a part of DSM. Incidentally, DSM aims to take over a larger number of these businesses. The aim is for some fifty participations, of which about 10 fit in with the core competencies of DSM (Jacobs and Waalkens, 2001, page 74).

In many cases, the innovative venture (once again) becomes part of the parent company (or is taken over by one of the shareholders) if the innovation proves to be profitable.[16] At the same time, many initiatives that cannot live up to their promises are ended. The advantage of 'corporate venturing' is that access can be obtained to innovative ideas outside the company's existing knowledge network, which enables more creative output to be generated faster (Jacobs and Waalkens, 2001; Grandori, 1999). It is shown that companies such as Shell and DSM have had positive experiences of this. Paragraph 5 will discuss in greater detail the collaboration with the public knowledge infrastructure.

Alternatives to alliances are mergers and takeovers, whereby existing knowledge is internalised by an organisation. Research by De Man and Duysters (2002) has shown that businesses choose the merger option particularly to create advantages of scale in R&D, thus increasing the concentration of R&D. Disadvantages of mergers and takeovers are that they reduce attention for innovation in the short term, since the post-merger integration of businesses demands a great deal of the management's attention. In addition, there is the risk that organisational cultures will not dovetail well with each other, making it difficult to achieve the intended synergy effect (De Man and Duysters, 2002). This problem does not exist with strategic alliances.

3.3 Typology of the R&D organisation

The four different organisational dimensions that form the basis on which the R&D function is set up, must naturally be considered in their interrelated context. Organisational changes at one dimension (e.g. more decentralisation) will usually have implications for other dimensions (e.g. more collaboration with third parties in different countries). This produces 'logical combinations' of dimensions, based on which a typology of organisational forms of R&D can be developed.
Such a typology has been developed by Gassmann and Von Zedtwitz (1999) based on a study among 33 multinationals in the period from 1996-2000. They distinguish five types that can be described briefly in Table 1. For a more detailed description, please refer to Appendix 3.

[16] This trend is also referred to as a shift from R&D to A&D (acquisition and development).

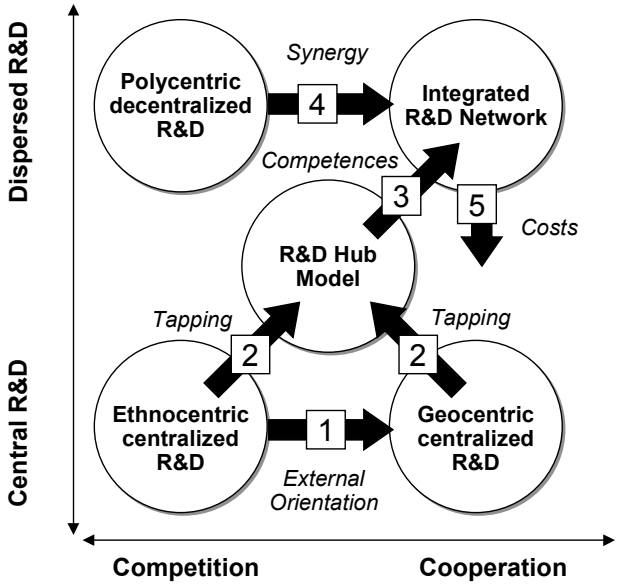
Table 1. Five forms of R&D organisation

Type of R&D organisation	Organisational structure	Behavioural orientation
1. Ethnocentric centralised R&D	Centralised R&D	National orientation
2. Geocentric decentralised R&D	Decentralised R&D	International co-operation
3 Polycentric decentralised R&D	Highly dispersed R&D, weak 'centre'	Competition between independent R&D units
4. R&D hub model	Dispersed R&D, strong 'centre'	Supporting role for foreign R&D units
5. Integrated R&D network	Highly dispersed R&D, several competence centres	Synergy-promoting integration of international R&D units

Source: Gassman and Von Zedtwitz, 1999.

These five types cannot be regarded as separate entities, since there is currently a shift away from the previously dominant types 1, 2 and 3 towards types 4 and 5. See also Figure 5. This trend can be explained by the increasing importance of state-of-the-art knowledge as mentioned earlier, and with it the growing need to have fast and immediate access to it, anywhere in the world. This creates the need for a new organisational form such as the integrated R&D network, consisting of a combination of centralised and decentralised R&D activities. The following paragraph will discuss this trend as well as a number of other trends.

Figure 5. Developments in corporate R&D planning policy



Source: Gassman and Von Zedtwitz, 1999.

3.4 Trends in the organisation of R&D

As far as the (expected) changes in the points discussed above are concerned (relating to the organisation of the R&D function), Gassmann and Von Zedtwitz (1999) discuss five trends:

- A first trend that the authors identify is that businesses with a centralised R&D function begin to adjust more and more to the international environment. It becomes increasingly clear that it is necessary to adjust to both local and international market needs. This implies a shift from an ethnocentric direction to a geocentric R&D organisation (trend 1 in Figure 5).
- A second trend is the increase in the number of 'listening posts', as already discussed, at locations where state-of-the-art expertise is to be found. These listening posts will increasingly become the most important sources of new knowledge. This is trend 2 in Figure 5 towards the R&D hub model.
- A third trend is that a strict control over the business's own, international R&D organisation is reduced in favour of more autonomy and 'empowerment' of decentralised R&D units. The significance of decentralised R&D units increases and their flexibility and creativity is enhanced. In this respect it is important for information to be exchanged freely between these separate units. The increasing importance of co-ordination leads to more integrated R&D networks (see trend 3 in Figure 5).
- Trend 4 is an increasing degree of work distribution between the various R&D units within a business. Centres of Excellence are created, focusing on specific areas and reducing the risk of duplication of R&D (trend 4 in Figure 5).
- A fifth trend, according to the authors, is the increasing significance of an integrated R&D network within the business, in which there is optimal *cost-effective* working and *co-ordination* between the various units. In a certain sense this is recentralisation, particularly when the number of individual R&D units is reduced to a limited number of centres of excellence (trend 5 from Figure 4, in which cost control of the integrated R&D network is central).

These trends are an extension of each other, and at the same time show the field of tension that continually exists when trying to find the best possible mix of the four organisational dimensions as discussed above.

3.5 Micro picture: Conclusion

The strategic question confronting businesses when organising their R&D function concerns increasing the speed and creativity of the R&D and innovation process. For this purpose, four organisational dimensions are considered when setting up the R&D function:

- The extent to which R&D is technologically driven or market driven, is initially determined by the sector in which a business is active. Businesses can naturally make their own strategic choice in this.
- In considering the centralised/decentralised and home base/international dimensions, traditionally it is the development function in particular that takes place at a decentralised level depending on the local market conditions, and is distributed across a number of different countries.

- We have recently seen that the research function can also be more decentralised, through developing activities in other countries in which state-of-the-art knowledge is available.
- Increasing use is made for this of external knowledge acquisition, such as in the form of strategic alliances.

As already stated, it is not possible to state particular systematic trends, since the differences per sector and per business are too great. However, one trend that seems to cross sector boundaries is the increasing importance of state-of-the-art knowledge, and the ability to access it fast and directly, anywhere in the world. This also explains the emergence of the integrated R&D network as a new organisational form, consisting of a combination of centralised and decentralised R&D activities.

Potential role of government
In a certain sense, the first two organisational dimensions ('technology push' versus 'market pull' and centralised versus decentralised), as viewed from the government's perspective, can be taken as a 'given'. As already mentioned, these two dimensions are determined above all by the type of sector (dominant innovation pattern) and the strategic choices of a business. The other two organisational dimensions (the choice of location, as well as the degree of collaboration with third parties) *could* possibly be influenced more by the government. This is examined further in paragraphs 4 and 5.

4. Choice of location for R&D

This paragraph discusses the macro picture from paragraph 3 and the micro picture from paragraph 4 together, based on the choice of location for R&D. For this purpose we make a distinction between existing R&D locations (paragraph 4.1), a choice for new R&D locations (paragraph 4.2) and the climate for establishing a business in the Netherlands.

4.1 Existing R&D locations

According to research by Cornet and Rensman (2001) it is the *past* that is the most important deciding factor when choosing where to set up R&D. This is broadly confirmed by other research (Gassmann and Von Zedtwitz, 1999). In short, R&D is fairly immobile. Existing laboratories in the Netherlands are not readily relocated abroad. The reverse is also true, in that few new laboratories are established in the Netherlands from abroad. Evidently R&D is (still) strongly rooted in the environment in which it operates. There are indications in the literature, though, as to the (possible) reasons for this. In his thesis, Goedegebuure (2000) points out that R&D employees usually build up a local network with suppliers and knowledge institutions for which geographical proximity is important, particularly in the transfer of 'soft' knowledge and skills. The relocation of R&D is thus at the expense of this tacit knowledge that is indispensable for R&D, and therefore goes against the idea of 'death of distance' as a consequence of ICT, through which R&D activities too would become 'footloose'. In other words, most businesses often choose for their existing R&D locations to enable them to benefit from advantages of scale and the local networks with which their research is often closely intertwined.[17] With this, the location of R&D is therefore not only tied to a particular country, but also and above all to a particular region, city or town. For foreign businesses, the same thing generally applies: they will be more likely to choose for the Netherlands if they are already active here with a factory, distribution centre or research laboratory (Cornet and Rensman, 2001). As stated in Paragraph 2, the latter is confirmed by the macro picture: R&D activities that have been taken over remain in the Netherlands.

Case 5. Central R&D at Organon for historical reasons
In the case of Organon, historical reasons are important for concentrating research at a central location in Oss. This is the view of Jacobs and Waalkens (2001, page.40): 'Our discussion partner at Organon said that the concentration of research in Oss can be explained historically. In fact, it would be better to undertake this R&D in the United States, but it works very well too the way it is organised now. The plan is therefore to maintain the central R&D in Oss, even though the Organon head office is to be transferred from Oss to New Jersey in the United States.'

[17] A comment that could be noted from the conclusions by the CPB about the choice of location, is that these seem to be determined specifically from an emphasis on fundamental research (whereby the proximity of local knowledge institutions is extremely important). It is another story as far as the development function is concerned: a comparative assessment is made between advantages of scale in research on the one hand, and the proximity to local markets on the other hand (Patel and Vega, 1999). Depending on the type of sector and naturally the business concerned, this comparative assessment will be made differently: for more market-driven innovations the geographical proximity is important (such as the food sector), while for scale- or technology-driven innovations the concentration at a single location will be the preferred choice by far (as in the chemical or electronics industry) (Patel and Vega, 1999).

4.2 Choice for new R&D locations

Recent research by Le Bas and Sierra (2002) concerning the choice for setting up new R&D activities abroad has shown that businesses use (roughly) two strategies:

'Home-base exploiting strategy'
R&D is undertaken centrally from the home base and local R&D activities are started up in response to the necessity of adaption to local market conditions. These R&D activities thus have a supporting function for the centralised R&D at the home base, and the choice of location is brought about as a result of the necessity of nearby markets.

'Home-base augmenting strategy'
R&D activities are developed at locations where there is obvious strength in the same area of technology. These new local activities are complementary to the central R&D activities and focus on increasing the business's knowledge base.[18]

Research by Le Bas and Sierra (2002) and Gassmann and Von Zedtwitz (1999) has shown that during the 1990s the second strategy increased in importance. In the case of this second type of strategy it is, above all, the quality of the local knowledge environment that plays a role. With this, determining factors in the choice of location include the availability of high-quality R&D personnel and the quality of the public knowledge infrastructure (Cornet and Rensman, 2001). However, the local knowledge environment can be viewed much more broadly. Porter (1990, 1998) points to the importance of the presence of 'lead-users' and/or specialised suppliers that can persuade businesses to develop local R&D activities. These R&D activities can then bear fruit elsewhere, including the home base. Porter (1990, 1998) notes that not only these factors play a role, but also the 'innovation climate' in a broader sense, including such aspects as the fiscal climate, the infrastructure and other *typical* macro-factors for setting up a business.

The conclusion that could be drawn from the above is that costs play no decisive role in the choice of a R&D location. There are indeed indications that quality in particular is the determining factor, rather than the (wage) costs of R&D. (Cornet and Rensman, 2001; Patel and Vega, 1999).

4.3 Climate for establishing a business in the Netherlands

A benchmark carried out by Cornet and Rensman (2001) shows that the climate in the Netherlands for establishing R&D is sufficiently competitive compared to other OECD countries, but no more than that. In spite of the fact that the quality of research at Dutch universities is of the highest level, the Netherlands does not occupy the top position. Nevertheless, the case below shows that the high quality of the Dutch knowledge infrastructure has been a reason for certain companies to locate their R&D activities in the Netherlands.[19]

[18] The research of Le Bas and Sierra (2002) shows that it is above all the small countries that make use of this strategy, such as Denmark, Norway, Switzerland and the Netherlands. Japanese businesses also makes extensive use of this strategy.
[19] Source: Senter (with acceptance of Fuji Photo Film).

Case 5. The Establishment of Fuji Research in The Netherlands
Fuji Photo Film moved to Tilburg in 1984, starting with 60 employees. Nowadays Fuji employs 1500 people. Their production and distribution has been extended with product development and research in various fields. Today Fuji co-operates with large European, but overall Dutch universities and knowledge institutes. Fuji did not choose to locate their R&D in a relatively low-wage country, because its production facility requires high-skilled employees. Furthermore its research activities benefit from co-operation with a high-quality knowledge infrastructure. Fuji is very positive about this co-operation: "Fuji wants to excel in its research. In the Netherlands we have found a suitable environment to realise this goal."

Also, the quality of the labour supply in the Netherlands is high, although less than in the Scandinavian countries and the USA. A growing cause of concern is the quantity, in particular if we look to the future: the number of schoolchildren choosing a technical study is declining. In addition, the number of technical students aiming for a career in R&D is falling (CBS, 2001). This is clearly a matter of concern. The scarcity of certain knowledge workers (groups of highly-educated people) can slow down innovation processes and may even cause Dutch businesses to relocate their knowledge-intensive activities abroad and foreign countries to prefer countries other than the Netherlands for setting up R&D (Marey et al, 2002). The Innovation Survey of the CBS shows, for example, that in the second half of the 1990s, one in five innovative businesses had to cope with shortages of qualified personnel. Marey et al (2002) estimate that serious bottlenecks will continue to occur in most HRST occupations until 2006 (HRST stands for 'human resources in science and technology') and most research occupations.

The average score for the Netherlands as a country in which to establish a business can be explained to some extent by the macro picture (as discussed in paragraph 2). Apparently businesses do not have a specific preference or aversion to the Netherlands. This means that the R&D expenditure does not appreciably rise or fall, among both the Dutch businesses and the foreign businesses in the Netherlands.

One point of attention in this respect is as follows. As is evident from the annual study undertaken by the IMD and the Economic Intelligence Unit (EIU), for a number of years the Netherlands has been achieving a very high score as far as the competitive power of the economy and the attractiveness of doing business are concerned.[20] However, when it concerns the attractiveness of R&D investment, the Netherlands manages only an average and thus a substantially lower score. The question now is where exactly these differences are to be found, and how foreign R&D businesses perceive the Netherlands when it comes to setting up their R&D activities in the country. An aspect related to this is the question to what extent R&D by foreign businesses in the Netherlands is prompted by market considerations, through the proximity of the European market, for instance (viewed from the development function), or through the unique knowledge that is available in the Netherlands (assuming the research function).

[20] The most recent league table of the EIU, part of the British Economist Group which also publishes the weekly magazine The Economist, shows that the Netherlands has the best climate in the world for establishing a business (see for instance *NRC Handelsblad*, 14 August 2002).

5. Collaboration with public knowledge institutions

As already mentioned in paragraph 3, external knowledge acquisition is the '4th organisational dimensions of R&D. A part of this is collaboration with third parties. Collaboration with third parties is increasing in importance, partly due to the fact that businesses are withdrawing from fundamental research and placing part of it with public knowledge institutions (see paragraph 3.2 for a further explanation of this point). This paragraph considers in greater depth the collaboration with third parties, in particular the collaboration between businesses and public knowledge institutions. For this purpose, we discuss the public/private collaboration (paragraph 5.1), the bottlenecks in the collaboration (paragraph 5.2) and finally the role of technostarters (paragraph 5.3).

5.1 Public/private collaboration

By public/private collaboration we mean the collaboration between businesses and public knowledge institutions (universities, research institutes, etc.). Research by Poot and Brouwer (2001) into such public/private knowledge relationships in the Netherlands has shown that almost 50% of the businesses in the industry have both public and private collaborative relationships, although these are mostly the larger companies (200 employees or more). Private and public knowledge relationships prove above all to be complementary. For businesses, in their relationships with public knowledge institutions it is largely about acquiring knowledge for future innovations. Such relationships focus more on a 'one-sided' transfer of knowledge, while collaboration with other businesses is more interactive. Poot and Brouwer (2000) also point out that after two years, businesses with a public knowledge partner have a higher added value than businesses without an external knowledge partner. Research by De Man and Duysters (2002) shows that the results of public/private collaborative ventures demonstrate a somewhat positive picture. In general, businesses choose for a public/private construction for projects they estimate as being higher-risk.

Disadvantages
In spite of the potential advantages of a public knowledge partner, there are disadvantages associated with it too. More than 25% of the innovative businesses refer to the danger of knowledge leaking away to competitors, especially when secrecy is required. An alternative strategy for collaboration is therefore to choose to outsource research by means of contracts, i.e. to pay institutions to undertake research. Such outsourcing of research has indeed increased substantially: during the period from 1995-2000, the sum involved (1.2 billion euro) doubled (CBS, 2001). However, research by Poot and Brouwer (2001) has made clear that businesses say they are concerned about the danger of too much contracted research by knowledge institutions. Without the development of new fundamental knowledge, the academic role of universities could be at risk. Businesses therefore advise not to take this too far.

Role of Dutch businesses compared to foreign businesses
Dutch businesses appear to work together with the local infrastructure at their home base much less than their German and English counterparts (CBS, 2001). At the same time, though, these Dutch businesses are strongly interwoven with local businesses such as suppliers and outsourcers, so that the impact of their R&D is still extensive. As far as the R&D activities of foreign businesses in the Netherlands is concerned, it is noticeable that

they make relatively greater use of the public knowledge infrastructure than the Dutch businesses do. In particular where it concerns the outsourcing of research, they make substantially more use of Dutch local knowledge institutions (about three times as much). As a result, the impact of these foreign businesses seems to be substantially less due to the fact that they would mostly use the Dutch knowledge infrastructure and would add less knowledge themselves. The question is whether this picture is actually true and how damaging it is.

5.2 Bottlenecks in collaboration with knowledge institutions

There are indications that the large(r) companies in particular are making increasing use of the (public) knowledge infrastructure (Poot and Brouwer, 2001). Nevertheless, certain bottlenecks do arise as far as collaboration between businesses and knowledge institutions is concerned. Research into the bottlenecks when seeking external technological knowledge has shown that businesses may experience three types of bottleneck, although it cannot be said that they will always occur (Bureau Bartels, 2000). These three bottlenecks are: non-transparency, collaboration and accessibility.

Non-transparency
As far as non-transparency is concerned, two aspects can be distinguished. Firstly, from which knowledge institutions is certain (specific) knowledge available? A second point is that technologies are becoming increasingly multidisciplinary, while the knowledge infrastructure has a strong monodisciplinary orientation. This means that knowledge, distributed across a variety of knowledge institutions, has to be combined by businesses in order for it to be commercially attractive to them.

Collaboration
There may also be bottlenecks in the collaboration itself, such as cultural differences between businesses and knowledge institutions, but also the (high) costs and capacity problems on the part of knowledge institutions. With the latter point, one could think of the shortage of knowledge workers in the labour market (see also paragraph 4.3). Shortages of particular groups of knowledge workers can slow down the innovation processes (see Marey et al, 2002, Table 4.8 on page 37).

Accessibility
A third bottleneck is formed by strict knowledge protection, making knowledge inaccessible to businesses. It is precisely the increase in contracted research, aimed at preventing knowledge from leaking away (see paragraph 5.1), which is at odds with the broad knowledge diffusion of public knowledge.

There is a variety of knowledge transfer mechanisms for increasing the links between the knowledge infrastructure and the R&D businesses, such as technological top institutes (TTIs), the use of licences, etc. A more recent mechanism that is emerging rapidly is that of the technostarters, which will be discussed in more detail in the following paragraph.

5.3 Technostarters and fast-growing businesses

Technostarters have been emerging rapidly in the past few years and form, together with other knowledge-intensive service providers such as private R&D laboratories, a kind of 'second private knowledge infrastructure' (Bekkers and Van der Steen, 2002). As far as the diffusion of knowledge is concerned, technostarters have a number of advantages over more 'traditional' knowledge transfer mechanisms. Firstly, technostarters make it possible to transfer the more soft and tacit knowledge, especially if the original inventor remains closely involved. A second advantage is that unlike established R&D businesses, technostarters do not have any sunk investments in existing technologies and production methods, which allows them to concentrate on more radical areas of technology. A third advantage is that they often have a close relationship with universities and can continue to work closely with them, leading to mutual advantages.

Although the advantages of technostarters must be weighed up against alternative knowledge transfer mechanisms, the conditions under which these advantages are best exploited are as follows (Bekkers and Van der Steen, 2002):

- Where it concerns more radical, new technology.
- If there is a chance that existing businesses are not able or willing to invest in this.
- If the transfer of tacit knowledge is important for the effective absorption of the new (coded) technological knowledge.

The emergence of technostarters fits in with the trend discussed earlier towards more external 'venturing' as a means to enhance the creativity and speed of the R&D process (see also paragraph 3.2). However, the technostarter does not have to be a stable business form in itself. There is therefore a certain degree of complementarity between technostarters and large R&D businesses. Just as with external 'venturing', A&D (acquisition and development) is often also applicable to properly functioning technostarters. Nevertheless, it can be stated that technostarters offer advantages, both from the knowledge infrastructure (supply side) and from R&D businesses (demand side), and can partially remove the bottlenecks already mentioned between both parts. The problem with this, however, is that technostarters in Europe are less successful than their American counterparts when it comes to continued growth (OECD, 2002).

Within the context of the advantages that technostarters offer as a means to enhance the creativity and speed of the R&D process, one can also point to the role of fast-growing businesses. The fast growth of a business (after the starter phase) is a second phase in the entrepreneurial process. Prince (2002) demonstrates that fast-growing businesses are more innovative than businesses that grow more slowly.
Fast-growing businesses, for instance, spend more on R&D, invest more in human capital, have a more active innovation strategy and appear also to introduce new products more frequently than slow-growing businesses.[21]

[21] Verhoeven and Bruins (2001) have studied how many fast-growing businesses there are compared to other countries. They find that the number of fast growers in the Netherlands increased by 6% (percentage of the total number of businesses with 50-1000 employees) in the period from 1989 to1993, to 10% in 1995-1998. In spite of this increase over time, this share (10%) is low compared to other countries. Germany (12%), Belgium (13%) and Denmark (13%) all scored higher than the Netherlands in the period from 1995-1998. The United Kingdom and the USA achieve percentages of 22% and 26% respectively. Only Japan with 5% scores lower than the Netherlands.

6. Conclusions and questions

This paragraph discusses a number of findings based on the preceding analysis. Most of these findings are based on extensive research in the literature. Nevertheless, some conclusions are only tentative and potentially require additional research.

1. Two important strategic points of attention: extent of R&D and its location
The two most strategic points of attention as far as R&D is concerned (viewed from the national government) are the amount of the R&D expenditure and the location. The amount of R&D expenditure of large(r) businesses within a sector follows roughly the same pattern and is largely dictated by what the major competitors do. As far as the location is concerned, this is strongly historically determined and is therefore largely fixed. The implication is that these two strategic points of attention are almost entirely outside the sphere of influence of the government. This is a significant observation and puts into perspective the discussion that has been going on for several years on the subject. This does not alter the fact, however, that it is extremely important to continue to create the right preconditions, as will be stressed in the following points.

2. Relocation of R&D
In spite of the fact that the foreign R&D expenditure of the 'Big Seven' has risen over the past years, this has not been at the expense of the existing R&D activities that these companies undertake in the Netherlands. Furthermore, the R&D activities that they have hived off in the Netherlands have been continued. There is therefore no relocation of R&D, but only a change of owner. This relocation of R&D by large R&D businesses fits in to a clear trend of internationalisation of R&D, whereby it is increasingly about obtaining access to state-of-the-art complementary knowledge that is available abroad. In short: at present there is no relocation of R&D abroad, but instead an expansion of R&D in foreign countries. This too is an important conclusion.

3. Choice of location and the importance of the home base
As already stated, the choice of location for R&D is largely historically determined. However, the quality of the (public) knowledge infrastructure and the availability of high-quality R&D personnel also clearly play a significant role, particularly with the creation of new R&D activities. In addition to these elements of the home base, other elements play an important role such as the financial climate and the 'on-going' entrepreneurial climate.[22] In short, the importance of the home base for R&D activities still applies, partly in view of the fact that foreign activities must be complementary to the activities of the home base, whereby the latter will give the lead.

4. Attractiveness of the Netherlands and possible changes
In contradiction to point two is the fact that the Ministry of Economic Affairs regularly hears rumours that R&D is indeed being relocated abroad. The question is why this is so. Do these signals refer more to the (near) future, while the data and research results presented here concern primarily the past? Or are there other conceivable reasons?

[22] With this one should think of legislation and regulations that may have a restrictive effect on technological research, such as the prohibition on stem cell research in the Netherlands compared to a country such as Singapore.

As already discussed, the Netherlands occupies a middle position where its attractiveness for R&D investment is concerned. Although at first sight this would not appear to be a matter of concern, it may become a real problem in the long term. In spite of the importance of the home base, the significance of state-of-the-art knowledge and skills is increasing further and in this respect excellent knowledge is becoming more important than nationality. This may mean that the relationship between R&D businesses and their home base decreases in significance. Over what period and in which industries this may occur is still insufficiently clear.

5. Towards a policy: from 'inside-out' to 'outside-in'
As regards the internationalisation of R&D, up to now the policy discussion on R&D in the Netherlands has been characterised above all by an 'inside-out' focus: to what extent is R&D being relocated from the Netherlands to countries abroad? As already mentioned above, this has not been the case so far. As a consequence of this one-sided view, the other side of this trend towards internationalisation has not been examined sufficiently, namely the 'outside-in' focus. After all, the question can be asked to what extent the Netherlands has benefited from the *extra* R&D that foreign businesses undertake in the Netherlands, in order to obtain access to particular state-of-the-art knowledge?[23] There would seem to be not enough known on this subject.[24] These are our findings as well as those of the CPB (see Cornet and Rensman, 2001).

6. Increasing the amount of R&D in the Netherlands
In order to achieve a structural increase in R&D intensity in the Netherlands, the policy must develop along the following four lines. Firstly, there must be improvements in the innovative climate (by encouraging more demand-driven research), secondly the stimulation of top research in collaboration with universities, thirdly a better availability of knowledge workers and R&D personnel, and finally a favourable fiscal climate. These policy measures aim to exert a favourable influence on the innovative climate. In addition, for its economic future the Netherlands will have to rely on technological spearheads with a high added value. In selecting these technological spearheads, the most important thing must be that areas are involved in which the Netherlands is already strong. Furthermore, they must have promising economic potential and provide a prospect of achieving a position among the best in the world.

Moreover, the policy will have to focus better on the smaller R&D businesses (the 'tail-end'). This can be done along two lines of policy. Firstly, it involves influencing the foreign businesses' choice of location when setting up new R&D activities. This point is even more important in view of the fact that new R&D activities arise where unique state-of-the-art knowledge is available. This occurs on the one hand by the presence of innovative clusters (think of Silicon Valley) and/or due to unique knowledge within the knowledge infrastructure. Of course, in the latter case, naturally a good diffusion and transfer of this knowledge is essential. A second line of policy is to aim to increase the number of technostarters. As already discussed, technostarters are responsible for the development and transfer of new radical technological knowledge from the public knowledge infrastructure to commercial applications.

[23] Here, *extra* is taken to mean R&D activities that do *not* come under R&D activities that had already taken place in the Netherlands, and which have fallen into foreign hands, for example through a takeover.
[24] The scarce knowledge concerning foreign R&D's effect on prosperity in the Netherlands indicates that the Netherlands has benefited from this only to a limited extent, as is evident from a report from Dalton et al (1999). Additional research in this area would seem to be desirable.

These two lines of policy are not independent of each other, but are in fact an extension of each other. Increasing the number of technostarters encourages the diffusion of new knowledge, which makes it more attractive to foreign companies as well as Dutch businesses to create new R&D activities or expand existing activities. Through mechanisms such as licences and (increasingly) external 'venturing', the creativity and speed of the R&D process at these businesses can be increased. An increase in the number of these (large) businesses in the Netherlands then makes it more attractive to researchers to set up such a spin-off, since the probability of acquiring an attractive contract is higher.

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Appendix 1. Concise summary concerning R&D decisions of the 'Big Seven' (based on Cornet and Rensman, 2001)

Philips
Philips' Dutch and foreign R&D expenditure showed a constant pattern until the early 1990s. From that moment onwards, it can be clearly seen that foreign R&D expenditure rose, while R&D expenditure in the Netherlands declined. Explanations for this are the 'Operation Centurion' reorganisation and Philips' concentration on a number of technology areas (semi-conductors), something that becomes clear when one looks at the R&D facilities that were hived off, such as Signaal and ASML. During the second half of the 1990s, domestic R&D expenditure increased again compared to foreign expenditure. Foreign R&D expenditure, on the other hand, continued to rise (particularly in the USA and Asia), but domestic expenditure rose faster. An explanation for this is for instance the building of a new high-tech campus in Eindhoven. In 2000, foreign R&D expenditure rose faster than the domestic R&D, but not at the expense of domestic R&D. Takeovers of foreign R&D-intensive companies (ADAC, Agilent) and the establishment of new R&D laboratories in China and India were responsible for the rise in foreign R&D expenditure. The Dutch campus is still being built and domestic R&D expenditure has been slowed down somewhat (also due to the slowed growth in the R&D-intensive chip industry). Nevertheless, Philips continues to invest in the semi-conductor and component technologies due to more positive long-term expectations.

Akzo Nobel
Akzo Nobel presents little data on its domestic R&D expenditure. It can be concluded from the available data that domestic and foreign R&D expenditure follow roughly the same pattern. About half of all R&D is carried out in the Netherlands. Recently Intervet, Akzo Nobel's veterinary subsidiary, took over a number of foreign R&D-intensive businesses in order to obtain a larger market share. In addition, a number of business units have been hived off (e.g. Acordis), but these businesses have continued operating in the Netherlands. This leads to the conclusion that there is no reduction of R&D activities in the Netherlands by (former business units of) Akzo Nobel.

DSM
In the mid-1980s, DSM added a number of fine chemical products to its portfolio, relative to its activities in the basic chemical industry. This strategic change of direction ensured at the same time that the amount of R&D investment rose. After all, with a new product portfolio a higher R&D intensity is required, comparable with that of one's competitors. The new strategy after 1985 was regarded not only as a cost item, but also and above all as a means to grow and develop. The second half of the 1990s saw a rise in R&D expenditure, particularly a substantial rise in foreign R&D expenditure. The shift towards specialist products was intensified, towards a portfolio of high-quality chemicals, materials and biotechnological products. At present DSM is trying to expand its knowledge regarding the new portfolio through takeovers (e.g. Catalytica Pharmaceuticals). These developments, however, have not been at the expense of DSM's domestic R&D-activities. R&D activities in the Netherlands have actually increased during the past few years, probably as a result of expanding the range of pharmaceutical products.

Océ
Océ expanded its Dutch R&D activities fast in the Netherlands in the 1970s, 1980s and 1990s. Fast growth of foreign R&D, largely through takeovers, began in the 1990s. The recent shift in demand from analogue to digital photocopiers forced Océ to acquire essential knowledge from abroad. The rapid expansion of foreign R&D has not been at the expense of domestic R&D. Nevertheless, an acceleration of foreign R&D in 2000 has been observed and R&D activities are stagnating in the Netherlands.

Unilever
In the course of time, Unilever's foreign R&D expenditure has risen slightly faster than the domestic R&D expenditure. Recently, domestic expenditure even fell slightly. It would seem, however, that R&D in the Netherlands (and the UK) is fairly stable. It cannot be predicted how the emergence of the Asian markets will change this situation. However, it is worth mentioning that Hindustan Lever (India) is currently one of the four core laboratories of Unilever. In addition, Unilever is disposing of a large number of brand names which may affect its policy on establishing its R&D organisations.

Shell
Shell has reduced its foreign R&D activities substantially by hiving off a number of R&D-intensive chemical divisions. The domestic R&D activities have also been reduced. For example, Shell has closed the Billiton laboratory in Arnhem and a number of R&D activities have been moved to the UK. Nevertheless, the reduction in domestic R&D was less (and occurred later) than the reduction in the total R&D. This is a striking trend. Compared with the five multinationals already described, Shell is the only one which has cut down on its foreign R&D activities.

ASML
Until recently, ASML undertook all its R&D in the Netherlands. Recently ASML opened and took over various organisations in the USA. For example, the takeover of the US Silicon Valley Group in 2001 will make a significant contribution to the increase in the share of foreign R&D in the total R&D.

Appendix 2. Summary of management techniques (based on Jacobs and Waalkens, 2001)

Once the comparative assessments have been made within the four organisational dimensions, a range of management techniques can then be used to enable businesses to exploit the chosen organisational structure in such a way that the speed and creativity of R&D and innovation processed increase. Based on the literature and interviews, Jacobs and Waalkens (2001) present seven ways that businesses can achieve this:

1. sharpen the strategic focus;
2. the role of the 'human resource' policy and its reward;
3. an alternative portfolio technique;
4. 'time pacing': programming innovation via the calendar;
5. competition between different departments and teams;
6. 'Competitor engineering', extending to 'competitor research';
7. support for product development via the Internet.

1. Sharpen the strategic focus

Businesses are increasingly aware of the need for strategic clarity and core competencies. Innovations must be geared to this. To give an example: ING, Randstad and Achmea develop strategic themes from a central level, with which they endeavour to generate more radical forms of service innovation.

2. The role of the 'human resource' policy and its reward

The rewards for R&D personnel have to be taken into account. Without extra rewards for R&D personnel (in the form of options, for instance), a business is merely a training institute for other businesses, which will at a certain moment buy out the best R&D personnel. Other factors also play a role in attracting suitable R&D personnel: vanity, curiosity, image, power, etc. Clever 'human resource' policy takes this into account.

3. An alternative portfolio technique

Businesses have modified their portfolio and focus on a certain number of core activities. By focusing on them, businesses endeavour to increase their potential in these activities and achieve a competitive edge on these elements. The result was that businesses hived off non-core activities, which led to an increase in the number of takeovers and mergers in order to consolidate the core activities' position in the market (Minne and Rensman, 2001). DSM, for instance, aims to specialise in high-quality chemicals, materials and biotechnological products (Cornet and Rensman, 2001). Shell profiles itself as the 'energy company'. Unilever is limiting the number of A-brands and is focusing on food and care products. Akzo Nobel is aiming for a prime position in pharmaceuticals and coating. Takeovers of other businesses, and with them the R&D facilities, is therefore done not only in order to acquire knowledge, but also for competitive and strategic considerations and for maintaining leadership (Minne and Rensman, 2001).

4. 'Time pacing': programming innovation via the calendar

'Time pacing' provides regularity and predictability. One tries to arrange the timing of an innovation in a pro-active way. This means that the portfolio must be continually filled with new ideas and projects. This method would appear to be best suited for businesses in rapidly changing markets.

5. Competition between different departments and teams
Through internal competition, a business ensures that it is not dependent on new ideas from just one department. What's more, the hope is that internal competition will have an incentive effect.

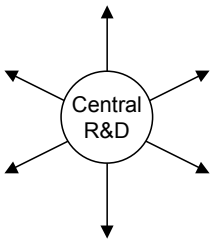
6. 'Competitor engineering', extending to 'competitor research'
Certain elements of the innovation process are undertaken in parallel or co-ordinated with each other instead of one after the other, so that the process is faster. The costs may increase for an organisation, so the benefit to it is above all in the speed.

7. Support for product development via ICT
The use of ICT is just one of the ways in which knowledge management could be controlled. The administrative paperwork can also be limited by using ICT (all information in digital form), thus increasing the innovative speed. Moreover, research-using ICT has become almost a mechanical/automatic process. The pharmaceutical industry is a prime example.

Appendix 3. Typology of the R&D organisation (based on Gassman and Von Zedtwitz, 1999)

1. Ethnocentric centralised

Ethnocentric centralised R&D is characterised by a lack of trans-national R&D processes, since all R&D activities are concentrated at the home base.



Behavioral Orientation

Ethnocentric inward orientation
Think tank as national treasure in home country
Protection of core technology against competitors
Homogeneous R&D culture

Configuration

Central R&D in home country
Central and tight coordination and control of R&D program

Examples

Balzers
British Gas
General Dynamics
Microsoft
Nippon Steel
Sigg
Toyota
Volvo

Strengths

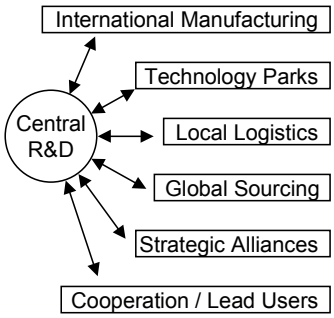
High efficiency
Low R&D costs (scale effects)
Short cycle times
Protected core technologies

Weaknesses

Lack of sensitivity for local markets
Danger of missing external technology
NIH syndrome
Tendency towards rigid organization

2. Geocentric centralised

Geocentric R&D organisations overcome the lack of market activity.



Behavioral Orientation

Geocentric external orientation
Close cooperation with other sites
Unrestricted information flow
Change agents enable internationalization

Configuration

Central R&D in home country
Close contact with international sites
International secondments and recruiting

Examples

ATR
ETL
Hilti
Kubota
MTU
Nissan

Strengths

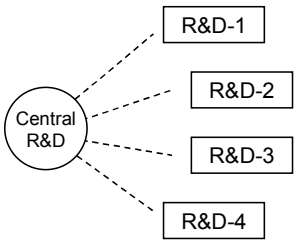
Efficiency due to centralization
High sensitivity for local markets and technological trends
Cost-efficient R&D internationalization

Weaknesses

Danger to neglect systematic internationalization
Local content restrictions and local market specifications insufficiently considered

3. Polycentric decentralised

The biggest challenge of polycentric decentralised R&D organisations is to avoid the isolation of the independent R&D units and to integrate them into the wider R&D network.



Behavioral Orientation

Polycentric orientation
Customization before standardization
Local effectiveness before global efficiency
Arm's length principle

Configuration

Decentralized R&D
Dominance of product-related R&D
Little coordination between R&D units

Examples

Philips (in 80s)
Royal Dutch/Shell
Sulzer
Schindler (in 80s)

Strengths

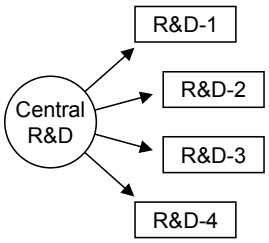
Strong sensitivity for local markets
Adaptation to local environment
Usage of local resources

Weaknesses

Inefficiency and parallel development
No technological focus
Problems with critical mass

4. R&D hub model

The R&D hub model is usually a reaction by centralised businesses to the internationalisation of resources.



Behavioral Orientation

Decentralized R&D tightly controlled by center
R&D center has technology lead
Global coordination of R&D direction and budget

Configuration

Ethno- or geocentric orientation
Node structure with clear dominance of center
Cooperation of units centrally controlled

Examples

BASF, Boehringer Ingelh., Bosch
Daimler
Eisai, Fujitsu
Kao, Matsushita
Mitsubishi, NEC
Sharp
Siemens, Sony
United Technologies
Zeneca

Strengths

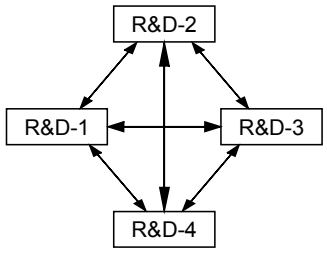
High efficiency due to coordination of R&D
Avoidance of redundant R&D
Exploitation of all available strengths
Realization of synergies

Weaknesses

High costs of coordination and time
Danger of suppressing creativity and flexibility through central directives

5. Integrated R&D network

The integrated R&D network is characterised by the development of technology and component technology based on the individual capacity of the R&D units.



Behavioral Orientation

Geocentric orientation, lead-country concept
Partnership among all competency centers
Unrestricted flow of information

Configuration

Highly internationalized R&D
Global responsibility of competency centers for technologies or products
Multi-dimensional coordination and information

Examples

ABB
Canon
Hoechst
IBM
Novartis
Philips
Roche
Schering
Schindler

Strengths

Coupling of specialization and synergy effects
Global before local efficiency
Organizational learning across many locations
Exploitation and refining of local strengths

Weaknesses

High coordination costs
Complexity of institutional rules and decison processes