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The location of R&D in the Netherlands

Trends, determinants and policy

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Preface

The public debate on Research and Development in the business enterprise sector has seen arguments that business R&D intensity is low in the Netherlands, and, moreover, that firms relocate R&D operations from the Netherlands to foreign sites. This study analyses the R&D location behaviour of Dutch and foreign firms present in the Netherlands, the factors that determine the R&D location decision, the quality of those R&D location factors in the Netherlands, and the scope for public policy to improve upon those factors.

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F.J.H. Don
Director of CPB

1 Introduction

Recent years have seen a lively debate on Research and Development (R&D) in the business sector in the Netherlands.[1] Private R&D investments are said to be relatively low in the Netherlands. Moreover, it is argued that the trend is negative: firms relocate R&D facilities from the Netherlands to other countries. Since domestic R&D is an important engine for local productivity growth, such a trend could be a reason for public concern and for public policy initiatives in the Netherlands.

This study analyses these arguments:

- Do firms relocate R&D activities from the Netherlands to other countries? Do Dutch-owned[2] companies differ from foreign-owned companies in this respect?
- Is the Netherlands an attractive location for business R&D? What are the decisive location factors for R&D and what is the quality of these factors in the Netherlands compared to other countries?
- What is the scope for public policy in this field?

Our findings are the following:

- Firms continuously restructure their R&D operations in terms of size and subject, but the mortality of R&D locations is low. Once established, R&D sites tend to continue to exist.
- History is an important determinant of the location of R&D, since firms typically co-locate new R&D operations with existing non-R&D activities or expand existing R&D facilities.
- Decisive location factors for R&D (in addition to history) are the supply of qualified researchers and the quality of the public knowledge infrastructure, including the knowledge transfer between science and industry.
- A benchmark study of R&D location factors (apart from history) reveals that the Netherlands takes an average or higher position in a ranking of OECD countries according to R&D attractiveness. The size of the R&D labour force in the Netherlands lags behind those in a group of leading countries. The quality of the Dutch public knowledge infrastructure is relatively high. Indicators are inconclusive about the quality of the science-industry knowledge transfer.
- Actual R&D location decisions show that firms neither strongly favour nor strongly disfavour the Netherlands as a location for R&D relative to other European countries.
- The rationale for (more intensive) public policy that fosters the location of Dutch- and foreign-owned R&D in the Netherlands is strong, since the social return to a unit domestic R&D is

[1] See, e.g., Snijders (1998a and 1998b), Verspagen and Hollanders (1998), and the discussion in the Dutch Lower House (February 2, 2000, Lower House document 44290).

[2] We use the adjective 'Dutch-owned' for companies headquartered in the Netherlands, and 'foreign-owned' for companies with operations but without a headquarter in the Netherlands.

larger than the social return to a unit R&D in a foreign country, and since the social returns to R&D exceed the private returns. This strong rationale does not necessarily imply that policy initiatives are always effective and efficient: the elasticities and the social (opportunity) costs should be taken into account.

The empirical evidence supporting these findings is drawn from a number of sources:

- The CPB company R&D database. This database provides quantitative and qualitative information on R&D activities of a large number of enterprises operating in the Netherlands.[3] Quantitative R&D data are available for 130 small and large Dutch- and foreign-owned companies. These firms account for a lion's share of business R&D performed in the Netherlands. However, a few active R&D players are missing because they do not publish information on R&D. The scope of the database is confined to R&D, so data on 'innovation' are absent.
- Interviews with R&D managers and other experts. We conducted a number of interviews in order to discuss the issues raised in this paper with field experts. We interviewed eight R&D managers of Dutch multinationals and foreign R&D-intensive companies operating in the Netherlands. These companies represent nearly 70% of Dutch R&D by Dutch-owned companies and about 15% of all foreign-owned R&D in the Netherlands. They are active mainly in electronics and chemicals. We also interviewed six experts from academia, government, employers' organizations, and location consultancy firms. Interviews were held from August to December 2000.
- Various data sets are used to compare R&D location factors in the Netherlands with those in other countries. We pooled own calculations with indicators presented by other authors.
- An international data set on foreign direct R&D investment projects provided by Ernst & Young, a location consultancy firm.
- The international empirical literature on (the location of) R&D (in the Netherlands).

The study is structured as follows. First, we describe the trends in business R&D in the Netherlands over the past 25 years and we find out whether or not firms relocate R&D from the Netherlands to other countries (section 2). Next, we discuss the decisive location factors for R&D and we benchmark the Netherlands against other countries on these factors (section 3). Then, we turn to the rationale for R&D location policy and we set out the benefits and opportunity costs of some policy options (section 4). Finally, we summarize our findings (section 5).

[3] See Verbruggen (2000) for an extensive description of the database. A list of top R&D spenders is available from the internet at http://www.cpb.nl/nl/general/org/afdelingen/ti/research/

2 R&D location in the Netherlands, 1975-2000

2.1 Introduction

What trends do we observe in the location of R&D by companies with operations in the Netherlands? How does the structure and size of Dutch business R&D change through the years? And what trends do we observe at the firm-level? In particular, do companies headquartered in the Netherlands re-locate R&D to other countries? And do foreign companies locate many R&D activities in the Netherlands?

Section 2.2 analyses the aggregate R&D structure in the Netherlands. Sections 2.3 and 2.4 focus on developments in Dutch R&D by individual Dutch-owned and foreign-owned companies respectively. Section 2.5 concludes. The empirical analysis draws heavily on the CPB company R&D database.

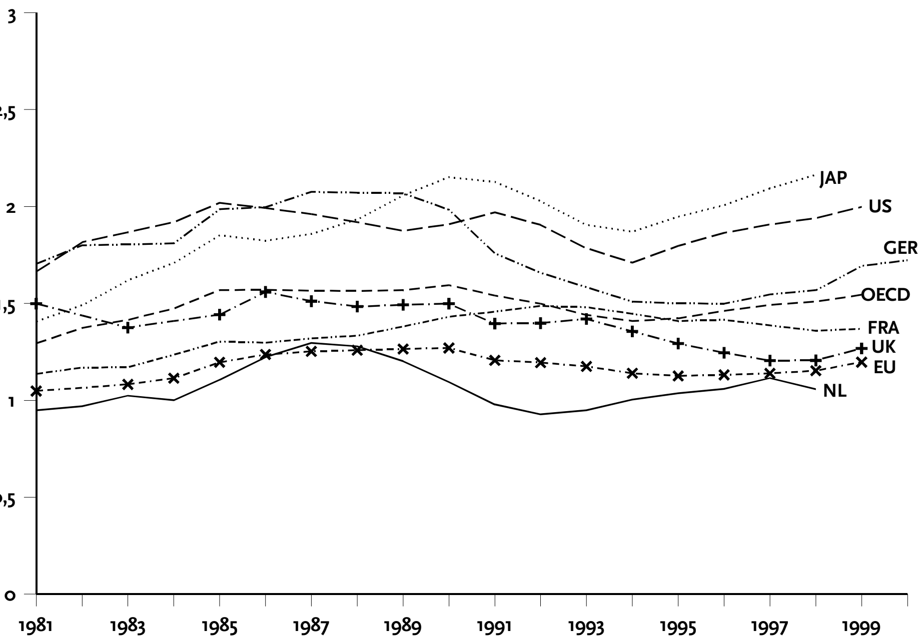
2.2 Structure and size of company R&D

What are the trends in aggregate business R&D in the Netherlands? Has size and structure changed through the years? We capture the main characteristics of company R&D in the Netherlands, with particular attention to the larger R&D spenders.

The macro picture

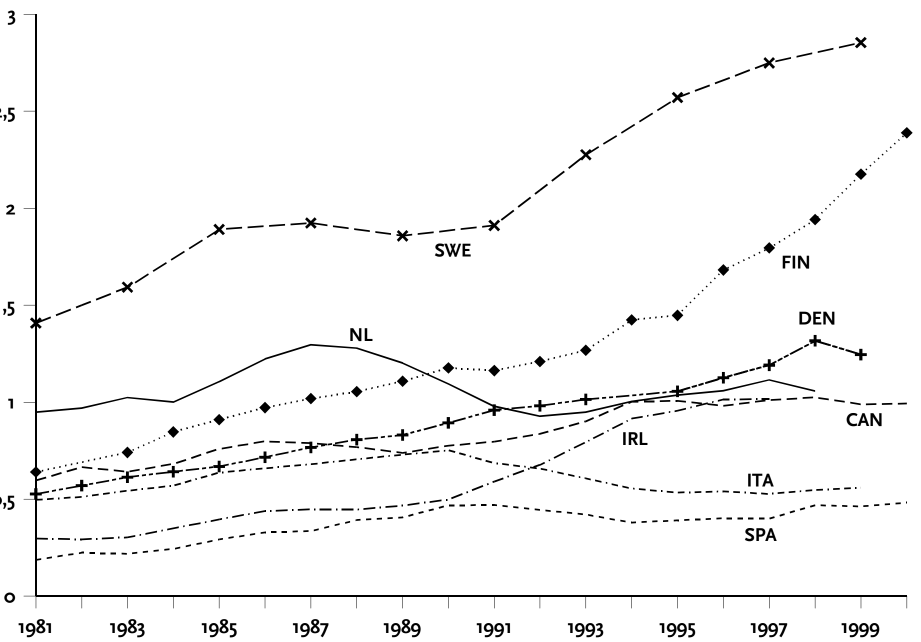
R&d intensity measured as business R&D expenditure as a share of GDP is relatively small in the Netherlands, see figures 2.1 and 2.2 . The Netherlands lags behind the large OECD economies and the Scandinavian economies. R&D intensity in the Netherlands rose to 1.3% of GDP throughout the 1980s, declined towards 0.9% in 1992, and was back at 1.1% in 1999. The share of OECD R&D performed in the Netherlands (an alternative indicator measuring the 'R&D market share') experienced a similar roller coaster ride: up to 1.4% in 1987, down to 1.0% in 1992, and back to 1.2% in 1999. In sum, business R&D in the Netherlands came back from the low level in the beginning of the 1990s, but is still small relative to the large OECD economies and to Scandinavia.

Figure 2.1 Business R&D expenditure in large OECD economies and in the Netherlands, as a share of GDP



Source: OECD, Main Science and Technology Indicators.

Figure 2.2 Business R&D expenditure in medium-sized OECD economies, as a share of GDP



Source: OECD, Main Science and Technology Indicators.

Top R&D spenders in the Netherlands

Table 2.1 presents Dutch-owned companies each spending recently more than Dfl 25 million on R&D in the Netherlands, and Table 2.2 shows foreign affiliates in the Netherlands with Dutch R&D amounting to more than Dfl 10 million.[4] Total 1999 Dutch R&D spending by the 130 companies covered in the CPB database was Dfl 8,3 billion.[5] Dutch-owned companies spent much more on R&D than foreign-owned companies.[6] The 23 Dutch-owned companies listed in Table 2.1 account for nearly three quarters of total company R&D in the Netherlands, while the share of the 29 foreign affiliates reported in Table 2.2 is about one fifth. Together, the 52 big R&D spenders explain 94% of R&D spending by all 130 companies. Philips, the Dutch electronics giant, dominates all other firms with its share of more than one quarter in Dutch R&D.

[4] Dfl = Dutch guilders. One Dutch guilders is about 0.45 euro.

[5] This picture of the aggregated structure of business R&D in the Netherlands is based on the CPB company database rather than the official R&D statistics published by Statistics Netherlands. Smaller R&D companies are included in the aggregates presented here. The latest year of observation is 1999 on average.

[6] Studies have shown that the higher R&D (or innovation) expenditures, in general the higher also R&D intensity, measured as R&D as percentage of turnover or R&D per employee. See for instance, Cantwell and Janne (1999), and CBS (1999, pp.270-171).

Table 2.1 R&D effort in the Netherlands by Dutch-owned companies (R&D expenditures > 25 mln Dfl)

	main activity	year	R&D in Netherlands (mln Dfl)		Dutch R&D employment	
Philips	electronics	2000	2336		8683	
AKZO Nobel	chemicals/pharmaceuticals	2000	869	c	3237	('99)
ASM Lithography	integrated circuits equipment	2000	519.4	a	1500	
DSM	chemicals	2000	463		1525	
Unilever *	food, personal care	2000	350		1400	
Shell *	oil & gas	2000	346		2101	('98)
Océ	copiers	2000	250		1075	
Stork	machinery, engineering	2000	130	a	865	
KPN Telecom	telecommunication	2000	125.6	a	435	
ASM International	semi-conductor equipment	2000	81.3	a	60	('90)
Advanta	seeds	1999	60	a	338	
Draka	cables for communication	2000	57.3	a	126	
Acordis	chemicals	1999	54	a	300	
Campina	food, biotechnology	2000	53	a	220	
Numico	food	1998	40	b	200	
Toolex	optical disc equipment	2000	39	a	121	
Twentsche Kabelmij	cables for communication	2000	38.7	a		
Avebe	food	1999	34	a	116	('97)
Friesland Coberco	food	2000	34	a	85	('95)
Aalberts	machinery	2000	31	a	100	
Vredestein	rubber	1989	30	a		
Delft Instruments	medical instruments	2000	27.2	a	125	
Besi	machinery	2000	25.2	a	68	
Total of the above 23 companies			5993.7			
Total of 130 companies in CPB company database			8254.5			

Main source: CPB company database, November 2001.

* Unilever and Shell are headquartered in the UK and the Netherlands

[a] Assumption: all R&D is performed in the Netherlands, except for ASM International, Advanta, Draka and Acordis, which are assumed to perform 50% of their total R&D in the Netherlands.

[b] Basis for calculation R&D is number of R&D employees, multiplied by 200 thousand Dfl, the guesstimated R&D costs per employee in recent years (The CBS figure for 1997 is 193 thousand Dfl).

[c] Source: Tolsma (2001).

Table 2.2 R&D effort in the Netherlands by foreign-owned companies (R&D expenditure > 10 mln Dfl)

	country of head-quarter	Dutch affiliate	main activity	year	R&D in the Netherlands (mln Dfl)		Dutch R&D employment	
Lucent	USA		telecom equipm.	2001	240	b	1200	
Ericsson	SWE		telecom equipm.	2000	220	b	1100	
Invensys	GBR	Baan Company	IT services	1999	140	a	805	
Corus	GBR	Hoogovens	basic metals	2000	121		450	('01)
Solvay Pharmac.	BEL		pharmaceuticals	2000	111	b	555	
Medtronic	USA	Bakken/Vitatron	medical instrum.	99/00	92	d	335	
Benteler	GER	PD&E	cars	2000	84	b	420	
ICI	GBR	Quest	chemicals	1999	74.3	a		
Dow Chemical	USA	Dow Benelux	chemicals	2000	72		258	
Paccar	USA	DAF Trucks	automobiles	2000	71	b	355	
Thales	FRA	Thales Nederland	military equipm.	2000	70.2	a		
Yamanouchi	JAP	Yaman. Europe	pharmaceuticals	2000	50	b	250	
GE Plastics	USA		chemicals	2000	44	c	205	
Cap Gemini	FRA		IT services	1992	37.8		189	
Bosch	GER	V.Doorne's Trans.	machinery	2001	33		120	
SKF	SWE		metal products	2000	32	b	160	
Johnson&Johnson	USA	Cordis	medical instrum.	1997	31.8		42	('95)
Novartis	SWI	Novartis Seeds	pharmaceuticals	1993	30	e	211	
TotalFinaElf	FRA	Sigma Coatings	chemicals	2000	22	c	140	('01)
Wartsila NSD	FIN	Stork Wartsila	machinery	2000	21	a c	89	
Sara Lee/DE	USA		food	2000	20	b	100	
Glaxo Smith Kline	GBR	GSK Nederland	pharmaceuticals	1998	18.5		80	
Hercules	GBR		chemicals/biotech	2000	17.2	b	86	
Eli Lilly	USA		pharmaceuticals	1999	15	c	10	('94)
Q8 Petroleum	KUW		oil	2000	14		54	
Honeywell	USA		telecom equipm.	1995	12.2		40	('93)
Huhtamaki	FIN	Van Leer	metal products	1998	12	a		
Avery Dennison	USA		chemicals	1990	10		80	
Suez Lyonnaise	FRA	Ondeo Nalco Europe	chemicals	2000	10	a b	50	
Total of the above 29 companies					1726.0			
Total of 130 companies in CPB company database					8254.5			

Main source: CPB company database, November 2001.

[a] Signaal and Stork Wartsila are assumed to perform all R&D in the Netherlands, Baan and HVL 50%, Quest 100% of its Food R&D. Nalco Europe employs 100 people, of which it is assumed half of them do R&D.

[b] Basis for calculation R&D is number of R&D employees, multiplied by 200 thousand Dfl, the guesstimated R&D costs per employee in recent years (The CBS figure for 1997 is 193 thousand Dfl).

[c] Source: Tolsma (2001).

[d] Tolsma (2000): Bakken Research = 55 mln Dfl, Tolsma (2001): Vitatron = 35 mln Dfl in 1999. Intermediair Jaarboek (June 2001): R&D employment of Bakken = 200 (in 2000). On the basis of R&D costs per R&D employee of Bakken, Vitatron's R&D employment is 135.

[e] In 2000, Zeneca agrochemicals and Novartis agribusiness merged into Syngenta. Novartis Seeds turned into Syngenta Seeds (and Crop Protection), and Zeneca Mogen (Leiden) became Syngenta Mogen. Mogen spent about 8 mln Dfl in 1999. Dutch R&D by Syngenta Seeds and Crop Protection is not known.

In which sectors?

The largest Dutch-owned R&D firms are primarily active in electronics, chemicals and pharmaceuticals, and food (table 2.1). Many of the large foreign-owned R&D also operate in these industries (table 2.2). Does this specialization pattern of foreign R&D firms in the Netherlands indicate a Dutch comparative advantage in these industries, or does the pattern simply reflect that the internationalisation of R&D mainly occurs in these industries?

Niosi (1999) provides evidence for the latter thesis, i.e., the internationalisation of R&D is mainly confined to chemicals and electronics. Patel and Pavit (1998), however, find that patent data reveal a Dutch comparative advantage in industrial chemicals and electronics, in particular telecommunication. These advantages decrease somewhat over the past decades. They also show that a comparative advantage in fine chemicals slipped away in the 1980s. Verspagen and Hollanders (1998) observe a comparative advantage in 'other chemicals' (i.e. not in pharmaceuticals), oil, and electrical machinery. Kusters and Minne (1992) identify a specialization in the food industry which is not matched by R&D-intensive foreign investments.

This evidence thus suggests that for some industries foreign R&D investments in the Netherlands can be attributed to a comparative advantage (e.g., industrial chemicals), while for other sectors such investments mainly stem from a world-wide trend of R&D internationalization (e.g., pharmaceuticals).

Table 2.3 Company R&D structure in the Netherlands, 1999 and 1993

	1999 No. of firms	R&D (mln Dfl)	Share (%)	1993 No. of firms	R&D (mln Dfl)	R&D (mln Dfl, 1999 prices)	Share (%)
'Big Seven'*	7	5133	62	7	3456	4019	68
- - Of which 'Big Five'*	5	4364	53	5	3250	3779	64
Other Dutch-owned companies	68	1273	15	31	944	1098	19
All Dutch-owned companies	75	6406	78	38	4400	5116	86
- - Of which above 25 mln, Tab. 2.1	23	5994	73				
All foreign-owned companies	55	1848	22	19	690	802	14
- - Of which above 10 mln, Tab. 2.2	29	1726	21				
All companies	130	8255	100	57	5090	5919	100
- - Of which top R&D spenders	52	7720	94				
Number of companies of which R&D is unknown but supposedly do R&D	app. 35	na		app. 20	na		
Business enterprise R&D (BERD), official CBS statistics		9227			5749	6685	
Dutch domestic product, market prices (GDP)		823983			581466	676123	
R&D of companies as % of GDP	130	1.00		57	0.87	0.87	
BERD as % of GDP		1.12			0.98	0.98	

* Big Five: Philips, Akzo Nobel, Unilever, Shell, DSM; Big Seven: Big Five plus ASML and Océ.
Sources: 1999: CPB company database, November 2001; CBS press release 14 March 2001, "R&D uitgaven stijgen weer", provisional figure. 1993: Minne (1995) recalculated with R&D expenditure by Big Seven; OECD (1998b). Nominal values of 1993 are deflated with the price index of the Dutch domestic product in market prices (CPB, 2001). The price index for 1993 is 0.86 (1999=1).

Concentration of Dutch R&D at big companies

A few large multinational companies perform the lion's share of business R&D in the Netherlands (see also Hollanders and Verspagen, 1998). The so-called 'Big Five' (Philips, Akzo Nobel, DSM, Unilever and Shell) account for more than half of the aggregate company R&D in 1999. Recently, ASML surpassed Shell, Unilever and DSM in the R&D ranking, and also Océ is steadily increasing its Dutch R&D over the years. The 'Big Seven' R&D firms in the Netherlands account for 62% of total R&D (Table 2.3).

Table 2.3 shows that the degree of concentration was higher in 1993 than in 1998. Before the 1990s, Dutch R&D was even more concentrated (CBS, 1999, p.89). Hence, the concentration of R&D has declined gradually in recent years.

Such high R&D concentration rates do not deviate fundamentally from those in other advanced economies. Minne (1997) finds that in the first half of the 1990s, the top-10 of R&D spenders in the US accounted for almost one quarter of the total US business R&D. In Germany, the top-8 accounted for 60% of national R&D. These concentration ratios were only gradually reduced since then.

R&D tends to be concentrated at large firms, as these firms are, by their large scale, able to meet the high fixed costs and risks of research projects. That is, the economies of scale and scope are large in several field of technology. Furthermore, firm-specific knowledge is accumulated relatively easily within large firms (Minne, 1997).

Share of foreign-owned R&D increased

Table 2.3 shows that the share of foreign-owned companies in Dutch R&D has increased from 14% to 22% between 1993 and 1999. A substantial part of the increase is due to the wave of mergers and acquisitions in the 1990s.[7] For example, Corus is the product of a merger between Hoogovens and British Steel, and is headquartered in the UK. Bosch acquired Van Doorne's Transmissie in 1995. Although Bosch was present in the Netherlands already before, it is supposed to have had no Dutch R&D activity before. Furthermore, ICI took over Quest International from Unilever in 1997, and DAF Trucks was acquired by Paccar in 1996. These formerly Dutch-owned companies continued their R&D activity in the Netherlands. The acquisition of Baan by Invensys (UK) in 2000, and PDE (from Nedcar) by Benteler (Germany) in 2001, further increased the foreign influence in Dutch R&D.

Comparing the levels of R&D spending in 1993 and 1999

Company R&D activities (in 1999 prices) rose by approximately Dfl 2,3 billion or 40% between 1993 and 1999 (Table 2.3). A part of the increase may be due to a better registration of R&D activities by companies themselves, particularly by the smaller ones. Besides, the general trends shown by empirical studies on business R&D indicate that the number of firms conducting R&D has been increased. Furthermore, also as a percentage of gross domestic product, R&D efforts increased.

The accelerating R&D efforts of ASML and Océ were about half of the total increase of R&D by the Big Seven. R&D spending by other Dutch-owned companies increased 16%, even though several traditionally important R&D firms disappeared from this category because of mergers and acquisitions by foreign companies. R&D efforts by affiliates of foreign firms in the Netherlands rose more than twice, partly because of acquisitions of Dutch R&D by foreign companies.

[7] Note that we do not consider individual companies through the years, but compare the overall R&D structure and the influence of foreign-owned companies as a whole in this R&D.

Are foreign affiliates more or less engaged in Dutch R&D than domestic-owned companies?
Hitherto, the absolute size of R&D efforts by both domestic and foreign companies is scrutinized. We found that Dutch-owned companies spent much more on R&D than foreign-owned companies do. However, the size of R&D in relation to the size of the business activity of the company in the Netherlands is probably a better indicator for the engagement of companies in Dutch R&D.

Table 2.4 summarizes data on average R&D expenditures per company and R&D expenditures per employee of the 125 companies in the CPB company database. Employment is used as a proxy for the size of business activity by the company in the Netherlands.[8] In order to assess the reliability of the R&D data, data on innovation expenditures collected by CBS in the CIS survey are also presented.[9] We emphasize that innovation expenditures consist of R&D expenditures for a large part, next to expenditures to among other things marketing and training.

Like in Table 2.3, we observe from the upper part of Table 2.4 that Dutch-owned companies spent much more on R&D and knowledge activities than foreign-owned companies did, also measured as average R&D expenditure per company. However, the data on the relative size of the R&D activity measured as R&D expenditures of employee show that the differences are much less large. The data on innovation expenditures confirm this conclusion.

The lower part of Table 2.4 sketches the relative size of R&D and innovation activity by companies split by country of origin.[10] The countries are ranked according to the relative size of Dutch R&D by the companies originating from these countries. Swedish companies show the highest activity, whereas Danish companies rank lowest. Furthermore, American companies outnumber the other foreign companies, but are just ranking at average in relative size of R&D. Dutch-owned companies rank fourth.

Comparing the R&D data with those of the CIS survey, the rankings for Swedish, Belgian, American, German and Danish companies match well. Due to the small sample size in the R&D data, outliers can bias the ranking. However, as we noted earlier, innovation expenditures are for a large part determined by R&D expenditures. Moreover, the R&D sample concerns the largest R&D spenders, so we do not expect that the ranking would change substantially when the sample would be complete. The rankings in average expenditures per company according to the R&D and CIS data also match well.

[8] Turnover or value added in a given year is more sensitive to the business cycle. For a discussion on different measures, see CBS (1999), pp. 270-271.

[9] We assume that the structure of knowledge intensities of domestic and foreign companies did not change a lot between 1996 and 1999, so that we can (tentatively) compare the 1999 CPB data and the 1996 CBS data.

[10] Companies of a number of countries in the R&D database have been left aside, as no data for these countries were available from CBS (1999).

In short, foreign-owned and domestic-owned companies do not differ much in the relative size of their Dutch R&D or innovation activity. Still, there are pronounced differences depending on the country of origin of the foreign-owned firms.

Table 2.4 Relative size of Dutch R&D activity of Dutch-owned and foreign-owned companies

	CPB: R&D activity in 1999				CBS: Innovative activity in 1996			
	Number of comp.	R&D exp. (mrd Dfl)	Average R&D exp. per company (mln Dfl)	R&D exp. per employee (1000 Dfl)	Number of comp.	Innovation exp. (mrd Dfl)	Average innovation exp. per company (mln Dfl)	Innovation exp. per employee (1000 Dfl)
Total	130	8.3	63.5	27.1	2462	10.5	4.3	7.5
Domestic	75	6.4	85.4	27.8	1570	7.7	4.9	7.2
Foreign	55	1.9	33.6	24.8	892	2.8	3.1	8.6

	Number of comp.	Average R&D exp. per company (mln Dfl)	(Rank)	R&D exp. per employee (1000 Dfl)	(Rank)	Number of comp.	Average innovation exp. per company (mln Dfl)	(Rank)	Innovation exp. per employee (1000 Dfl)	(Rank)
Sweden	2	126.0	1	78.2	1	35	13.4	1	35.4	1
Belgium	1	111.0	2	71.0	2	61	4.6	4	13.3	3
Japan	3	18.3	8	64.0	3	59	1.3	11	6.5	8
USA	21	30.6	5	28.3	4	226	3.3	7	7.6	6
Netherl.	71	85.4	3	27.8	5	1570	4.9	3	7.2	7
UK	8	46.4	4	20.7	6	121	1.9	8	4.4	10
Germany	5	27.6	6	18.3	7	121	1.7	9	5.6	9
France	6	25.6	7	16.4	8	57	5.0	2	13.9	2
Switzerl.	3	12.5	10	13.7	9	62	3.8	6	9.5	5
Finland	2	16.5	9	6.1	10	16	4.0	5	13.0	4
Denmark	2	3.1	11	4.4	11	12	1.4	10	2.7	11

Sources: CBS, Kennis en Economie 1999, Appendix E, Tables E.2 and E.3, pp.270-271; CPB company database and internet, November 2001.

Conclusions

In the 1990s,

- 23 Dutch-owned companies and 29 foreign-owned affiliates in the Netherlands account for the lion's share of Dutch business R&D spending in 1999.
- Many top R&D spenders, both Dutch-owned and foreign-owned, operate in chemicals and pharmaceuticals, and in electronics. Food seems to be a Dutch specialisation.
- Dutch business R&D was and is concentrated at a few big companies. The Big Five still account for half the total business R&D in 1999. Océ and ASML in particular now invest in R&D at a scale comparable to the Big Five.
- The share of foreign affiliate R&D spending in the Netherlands increased, partly due to acquisitions of Dutch R&D intensive firms by foreign companies.
- The number of firms devoting substantial amounts of money to R&D grew rapidly.
- Both Dutch-owned and foreign-owned companies increased the absolute level of R&D investments. This joint increase in R&D spending is also reflected by the increase in R&D intensity and the increase in R&D market share at the macro level.
- The R&D intensity of foreign-owned and domestic-owned companies in the Netherlands do not differ strongly.

In sum, the structure of business R&D in the Netherlands did not change strongly during the 1990s. The aggregate level of R&D spending rose considerably.

2.3 Do Dutch-owned companies re-locate R&D to foreign countries?

Do Dutch-owned companies favour the Netherlands as the location for R&D? Or do they move R&D abroad, at the expense of domestic R&D sites? In the current section we study the R&D location decisions of the 'Big Seven': the Big Five multinationals plus ASML and Océ. These firms together account for more than 60% of total business R&D in the Netherlands in 1999 (see Table 2.3).

Table 2.5 presents an overview of the development in the share of Dutch R&D activity in world-wide R&D for the Big Seven companies, and Figure 2.1 reveals the development in the (absolute) level of the Dutch and foreign R&D expenditures of these firms (except for ASML). A comparison between absolute and relative levels of R&D activity gives an indication of the R&D strategy of the companies under consideration. Table 2.5 and Figure 2.1 show that, although the share of Dutch R&D falls for some companies in some years, this is generally due to an expansion of foreign R&D operations rather than a contraction of Dutch R&D activity. We now scrutinize these developments firm by firm.

Table 2.5 Dutch-owned multinationals: share of Dutch R&D in the company's world-wide R&D, 1977-2000

	1977	1980	1985	1990	1995	1999	2000
Philips	50	46	45	46	36	45	38
Akzo Nobel	61	PM	44	52	40	50	50
ASML [a]					100	100	100
Unilever	25	18	21	21	24	22	14
DSM	100	100	100	95	90	77	80
Shell	42	42	27	33	44	36	37
Océ	99	99	98	91	90	67	57

Sources: CPB company database, November 2001. If no data were available for the years under consideration, the nearest years are chosen.
a ASML became independent of Philips in 1991.

Philips

Philips' Dutch and foreign R&D expenditures followed a similar development up till the early 1990s. From that time on, foreign R&D increased while Dutch R&D decreased. Likely explanations are the 'Centurion' overhaul of the Philips organization and the focus of R&D towards a few fields of technology (e.g., semi-conductors), as illustrated by the divestment of R&D intensive subsidiaries such as Signaal and ASML in the Netherlands. However, in the second half of the 1990s, Dutch R&D expenditures caught up with foreign R&D. Foreign R&D activity continued to rise (especically in the USA and Asia), but R&D spending in the Netherlands expanded faster. This recent increase is mainly spurred by the building of a new high tech campus in Eindhoven. In 2000, foreign R&D rose faster than Dutch R&D, but not at the cost of Dutch R&D. Acquisitions of foreign firms with much R&D activity (ADAC, Agilent), and the establishment of new R&D laboratoria in China and Bangalore is responsible for the fast increase in foreign-based R&D. The Dutch campus is still under construction and Dutch R&D grows slower. Recently, the growth in the R&D-intensive chip industry is slowing down. However, as many other firms in the business, Philips continues to invest in R&D on semiconductor and component technologies as long run expectations are more positive.

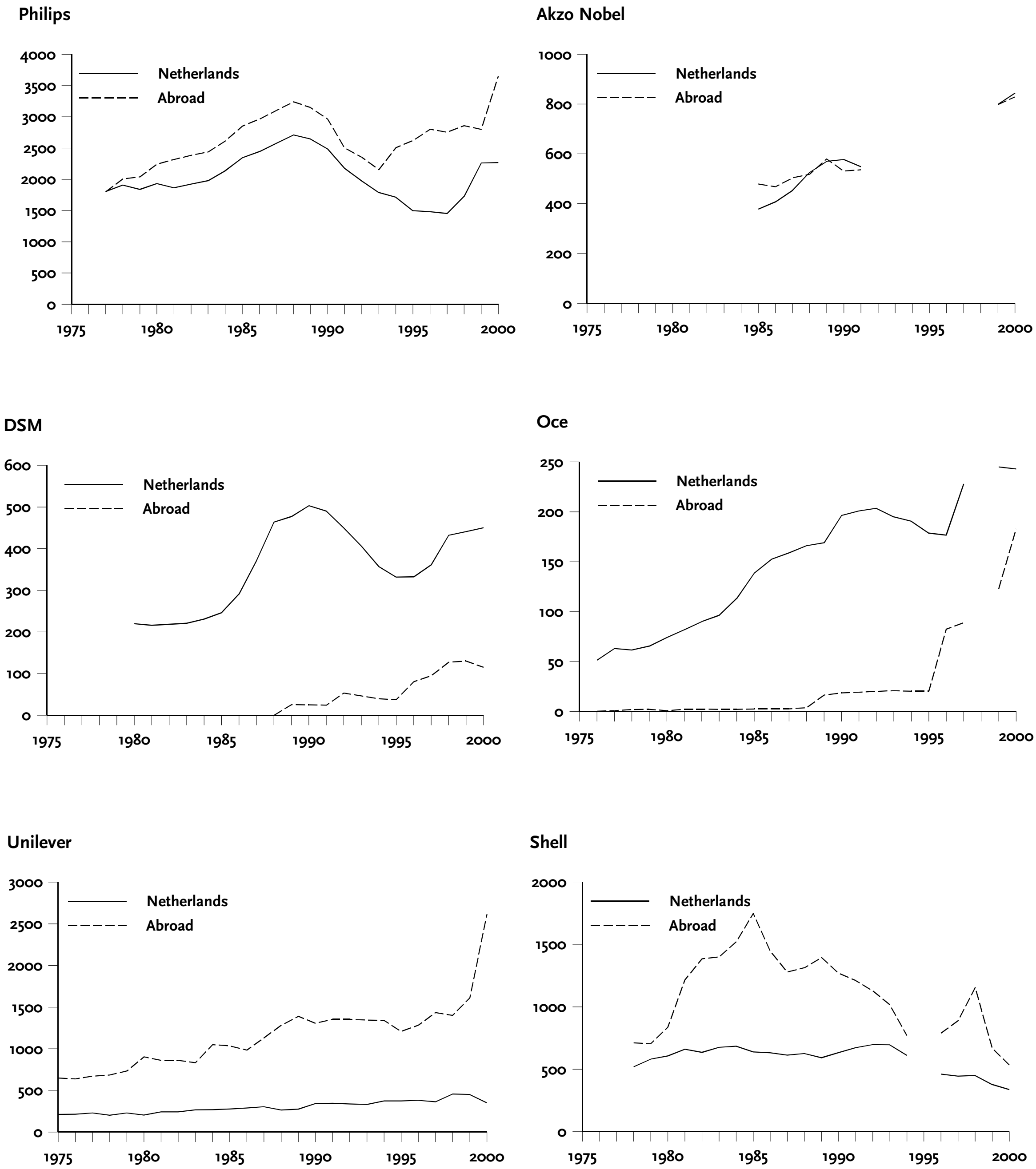
Akzo Nobel

Akzo Nobel publishes few data on R&D expenditures in the Netherlands. The available data suggest that foreign and Dutch R&D expenditures go up together harmonically, although there seems to be a divergence around 1995 (not shown in Figure 2.1). About half of Akzo Nobel's R&D is conducted at Dutch locations. Recently, Intervet, Akzo Nobel's veterinary drugs subsidiary, acquired a number of foreign R&D-intensive companies in order to gain market share. Furthermore, Akzo Nobel divested several business units, e.g. Acordis in 1999, but these firms typically continued their R&D activities in the Netherlands. Hence, any decline in the share of R&D expenditures in the Netherlands can not be attributed to a decline in the level of R&D activity of Akzo Nobel’s (former) business.

DSM

In the mid-1980s, DSM extended the range of fine chemical products in its product portfolio relative to its activities in basic chemicals. This change of strategy resulted in an increase in R&D investments, because the new product portfolio required a larger R&D intensity, i.e. comparable to competitors. The new strategy after 1985 did not consider R&D just as a cost factor, but also as a means of growth and development of the company (Lintsen and Veraart, 2000, p.106-107). The second half of the 1990s showed an upheaval in R&D expenditures, this time including a substantial increase in foreign R&D expenditures. The shift to specialties was intensified, to a portfolio of high-grade chemical and biotechnological products and high-performance materials. DSM is currently trying to increase its knowledge for the new portfolio through acquisitions, in particularly foreign acquisitions. Recently, DSM acquired Catalytica Pharmaceuticals (US). Still, the trend is not at the expense of the level of R&D operations in the Netherlands (see Figure 2.1). Recently, Dutch R&D activity even goes upward, probably due to expansion in pharmaceuticals.

Figure 2.3 Dutch multinationals: R&D expenditures in the Netherlands and abroad, 1975-2000, 1999 prices



Source: CPB company database, November 2001. Price index based on Dutch domestic product in market prices (CPB, 2001).

Océ

Océ expanded its Dutch R&D operations at a high pace throughout the 1970, 80s and 90s. Substantial growth of foreign R&D, in particularly through acquisitions, started in the 1990s. The recent shift in demand from analog to digital copiers forced Océ to acquire essential know-how abroad. The boost in foreign R&D did not restrain the expansion of R&D activity of Océ in the Netherlands. However, in 2000, a fast increase in foreign-based R&D is observable, whereas R&D activity in the Netherlands stagnates.

Unilever

Unilever's Dutch R&D activity decreased from 25% of its world-wide R&D to about 20% during the period under consideration (Table 2.5). Figure 2.1 shows foreign R&D expenditures increase a little faster than Unilever's Dutch R&D, and recently Dutch R&D declined. Nevertheless, it seems as if the Netherlands remain a robust home base for its R&D (together with the UK), as Dutch R&D employment is steady. How the emergence of the Asian markets will change this picture, is not predictable, although it is notable that Hindustan Lever (India) currently runs one of the four core R&D laboratoria of Unilever. The current disposal of a large number of Unilever's brands may also affect the geographical division of R&D.

Shell

Since 1985, Shell focussed its business operation at the start of the production chain: production and processing of basic energy resources. Divestment of a number of R&D intensive chemical divisions reduced the level of Shell's world-wide R&D. The size of the R&D operations in the Netherlands also declined. Shell closed down the Billiton laboratory in Arnhem, for example, and relocated part of its R&D activities to the UK. The reduction of Dutch R&D was relatively smaller and occurred later than the reduction of world-wide R&D spending.

The fall of Dutch R&D spending at Shell stands in marked contrast with the boost at the five Dutch multinationals discussed above. Still, the decline of Shell's Dutch R&D operations did not enhance Shell's foreign R&D.

ASML

Up till now, ASML performed all R&D in the Netherlands. Recently, however, ASML established and acquired several companies in the US. More importantly, the acquisition of the US Silicon Valley Group in 2001 will contribute strongly to an increase in the share of R&D of ASML performed in foreign countries.

Divestments in the Netherlands by the Big Five

In the past 15 years, the Big Five multinationals divested a number of R&D intensive Dutch subsidiaries, such as ASML, Acordis, and Quest. These businesses either continued life as independent companies or as subsidiaries of other, mainly foreign, enterprises. In general, the change of ownership did not affect the location of R&D (see also section 2.4).

Home-based and foreign-based R&D by other Dutch-owned companies

Table 2.1 suggests that only the biggest Dutch-owned R&D spenders have sizeable foreign R&D activities. Still, smaller R&D firms also have foreign R&D operations that, moreover, may be important for the company's performance despite their relatively small size. For example, KPN operates several small 'R&D watchtowers' in Silicon Valley in order to keep in touch with the latest telecom technologies. Another example is Pharming (a biotech company now in financial difficulties) that moved several R&D operations abroad, possibly in response to public anxiety towards biotechnology research and biotech patenting. Note that for many firms listed in table 2.1 we do know that they conduct some R&D in foreign countries, but we do not know the size of these operations. Numico, a firm with sizeable foreign R&D, expanded its R&D operations in the Netherlands in recent years substantially (Minne and Rensman, 2001).

Conclusions

We summarize our findings regarding the location of R&D of large Dutch-owned R&D performing firms:

- For some Big Seven firms the share of R&D located in the Netherlands in total R&D spending falls. Still, the level of R&D expenditures in the Netherlands grows (except for Unilever). For other firms, both the level of R&D expenditures and the share of R&D spending in the Netherlands increases.
- New foreign R&D activities (partially through acquisitions of R&D-intensive foreign firms) by the large Dutch-owned companies generally came on top of the incumbent R&D activities in the Netherlands, rather than being at the expense of those R&D activities.
- Divested R&D subsidiaries typically continued the R&D operations at the same location.
- A few Dutch-owned firms with relatively small R&D expenditures also started or acquired Dutch and foreign R&D labs, the latter typically additional to home-based R&D activities.

In sum, we do not find evidence that Dutch-owned companies relocate R&D to foreign countries. They typically expand their R&D programmes through R&D investments abroad.

2.4 Do the Netherlands attract foreign R&D?

This section analyses foreign-owned R&D investments by the top spenders in the Netherlands (see Table 2.2). The raw data supporting the discussion have been listed in Table 2.9.[11]

Greenfield and non-greenfield R&D

The economic literature defines two types of R&D investments: greenfield and non-greenfield. Greenfield R&D investments are 'newly established stand-alone company facilities mainly active in physical research, design and development of products, while not being a software development centre' (Buck Consultants International, 1999a), i.e. new laboratories build from scratch on. Non-greenfield R&D investments refer to R&D facilities new to the company, but not newly established or stand-alone. Examples includes R&D mergers and acquisitions, expansions of existing R&D facilities, or new R&D facilities co-located to existing non-R&D facilities (e.g. production, sales and distribution).

Usually start by non-greenfield R&D investment

Table 2.6 reveals that most foreign R&D investment by the foreign-owned top R&D spenders which were listed in Table 2.2 is non-greenfield. Foreign firms typically start new R&D operations in the Netherlands through co-location and acquisitions. There seems to be a watershed around 1980, so we divided history into periods before and after 1980. This is also parallel to developments in R&D strategy by multinationals, as described by empirical studies (see for example Research Policy (1999), vol.28(2-3)).

Table 2.6 The 28 foreign-owned top R&D spenders: start of R&D in the Netherlands

Type of R&D investment	Number of companies in period 1900-1980	Number of companies in period 1980-2000	Total number
Greenfield	2	2	4
Co-location	8	1	9
Acquisition	1	12	13
Merger	0	2	2
Total	11	17	28

Source: Table 2.9
Note: Of Q8, which is also listed in Table 2.2, we do not know how it started R&D in the Netherlands, so we left it aside in the current table.

Before 1980

Up till the 1980s, R&D followed production abroad. The internationalization of production required adaption of product characteristics to local preferences, i.e. foreign R&D. Foreign R&D

[11] The data presented in Table 2.9 are subject to uncertainty.

affiliates in the Netherlands adhere to this picture: new R&D facilities were build close to existing production facilities in the Netherlands. Over the years, however, the nature of foreign R&D programme often changed from adaption to creation. The box presents some illustrative examples of foreign firm establishing new R&D facilities in the Netherlands before 1980.

Examples of R&D-related foreign direct investments before 1980: co-location

Ericsson: emergence of a leading consumer market

Ericsson (Sweden) was one of the first foreign companies investing in the Netherlands. In 1920, it established an office in Rijen, because of the abundant supply of wood (in Brabant) for telegraph poles. In a later stage, the company started and gradually extended its R&D programme, starting with applied research. Today, Ericsson Nederland conducts R&D in telecommunication equipment for the world market. Ericsson's European ICT center is located in Enschede. The leading Dutch consumer market for telecommunication is said to have contributed to the size and quality of Ericsson's R&D activities in the Netherlands in recent years.

SKF: concentration of R&D in the Netherlands

SKF (Sweden) is another early foreign starter in the Netherlands. R&D followed sales activities. Today, the company concentrates corporate R&D in the Engineering Research Centre in Nieuwegein. This research is supported by manufacturing technology development centres and product development and testing facilities worldwide. We do not know why SKF decided to concentrate R&D in the Netherlands.

Dow and General Electric Plastics: physical infrastructure and location

General Electric Plastics (US) established its Dutch R&D facility simultaneously with its European headquarter and a production facility. The laboratory is therefore considered to be a greenfield investment. The Dutch R&D activities of General Electric Plastics are important for the European market. Dow Benelux (US) co-located a new R&D facility close to existing production units. This R&D laboratory now hosts Dow's European R&D centre.

Still, the R&D activities of both Dow and General Electric Plastics in the Netherlands fall far short to the size of production and distribution. This suggest that the two companies chose the Netherlands because of the physical infrastructure and its geographical position within the European market rather than because of excellent R&D location factors.

Source: Table 2.9

After 1980

In the period 1980-2000, different strategic motives seem to propel foreign companies to start R&D activities in the Netherlands. Companies all over the world restructured and focussed their businesses at core activities in order to reap 'economies of scale, scope, speed and space' (Granstrand, 1998). Some activities, including associated R&D, were acquired, others divested. Indeed, the main way of entry of foreign R&D in the Netherlands in this period is through acquisition. The data in Table 2.9 suggests that foreign acquisitions of R&D facilities in the Netherlands were often motivated by strategic reasons unrelated to R&D (e.g. production or distribution strategy). The following box enumerates some examples.

Examples of R&D-related foreign direct investments after 1980: mergers and acquisitions

Solvay Pharmaceuticals: physical proximity
Solvay Pharmaceuticals (Belgium) acquired Duphar from Philips. The former Duphar R&D lab is now one of Solvay's main R&D locations. The Duphar lab was located close to Solvay's Belgian R&D centre. This might have been one of Solvay's arguments to acquire Duphar. Distance is not 'dead' because of the ICT as often suggested. Personal contacts are still of importance (for more on 'distance', see the next sections).

Yamanouchi: by coincidence, but extending the acquired Dutch knowledge
Yamanouchi (Japan) acquired Gist's pharmaceutical businesses because it was looking for an access to the European market. Gist was for sale, its R&D operations included. It has been said that Yamanouchi would have chosen for the UK if the R&D investment was of the greenfield type. Since the acquisition of Gist, Yamanouchi extended its R&D operations in Leiderdorp, and, moreover, executes several cooperative research projects with Dutch universities. Appearingly, the Japanese did not want to loose the existing knowledge embodied in the subsidiary's employees.

Corus: strengthening market position and complementarity of knowledge
Corus is the product of a merger between Hoogovens and British Steel in 1999. Both companies conducted about the same amounts of R&D, hence the share of Hoogovens' R&D in Corus' total R&D is high. The main reason for the merger was the need to establish a leading company with a broad portfolio of three metals (plain steel, stainless steel, aluminium) to serve increasingly demanding customers. The technological know-how of Hoogovens on the combination of plain steel and aluminium was an asset fancied by British Steel, which had complementary knowledge on stainless steel.

Medtronic, Thales, Paccar and ICI: acquisition of Dutch know-how
For several acquisitions of formerly Dutch-owned firms, we conjecture that innovative capabilities were the main (although not the only) motivation. Examples include Medtronic, Thales, Paccar and ICI, which have acquired Vitatron, Signaal, DAF Trucks and Quest, respectively. The Dutch subsidiaries of these foreign firms all play a central role in the R&D programme of the company:

- Vitatron develops pacemaker technology. Medtronic acquired Vitatron in 1986. The technology of Vitatron complemented Medtronic's knowledge on cardiovascular products very well. In the same year, Medtronic extended its Dutch R&D through the establishment of Bakken Research in Maastricht. This is near the Academic Hospital of Maastricht, considered as a world-top location for cardiovascular research.
- The former Philips subsidiary Signaal is one of Thales' most important acquisitions around 1990. Recently, it acquired some more divisions of Philips.
- Paccar acquired DAF Trucks in 1996 in order to have access to DAF's knowledge stock on the development and production of medium-heavy to heavy trucks. DAF is now one of the four top brands of Paccar.
- Quest International, headquartered in Naarden, has been acquired by ICI from Unilever in 1997. It is now one of the four core businesses of ICI. Quest has two main divisions, Flagrances and Food. Naarden is the main R&D centre for Food; R&D for Flagrances is located in the UK.

Source: Table 2.9

Is Dutch affiliate R&D important for foreign companies?

The share of Dutch affiliate R&D in the world-wide R&D efforts of a company is an indicator of the importance Dutch R&D plays in the company's innovation process. Table 2.7 provides the (admittedly partial) data. We make three observations.

Table 2.7 Foreign-owned companies: share of Dutch R&D in the company's total R&D, 1983-2000

	1983	1985	1990	1995	1999	2000
Lucent				3.5 ('94)	2.5	2.5 ('01)
Ericsson			2.7	1.5	3.2 ('98)	2.2
Corus						36.0
Solvay	25.4	23.8	26.1	24	13.7	14.0
Medtronic			14.2	11.5 ('94)	10.0	
ICI					13.1	
Dow	2.2	2.6	4.4	4.7	4.1	3.4
Paccar						29.0
Thales						1.0
Yamanouchi			2.4 ('91)	1.8	3.3	4.1
GE Plastics			1.1		0.9	
PetroFina (TFE)			24.7	24.6 ('94)	18.2 ('99/'97)	
J&J			0.8 ('92)	1.2	0.8 ('97)	
Wartsila			17.1 ('92)	30.3	16.6 ('97)	
Sandoz (Novartis)				1.4 ('93)		
SKF			6.9 ('90/'92)			17.3
Glaxo Wellcome				0.7	0.5 ('98)	
Hercules			5.9 ('92)	16.6	8.5	9.0

Main sources: CPB company database and company websites, November 2001

- Low shares of Dutch R&D in foreign company's R&D

  First, the share of Dutch R&D in the foreign companies' world-wide R&D is in general lower than the share of Dutch R&D in Dutch-owned companies' world-wide R&D. Economies of scale and scope in R&D call for a concentration of R&D activities. Multinational firms typically choose to concentrate R&D in the home country (Fors, 1998). Table 2.5 support this claim also for Dutch-owned multinationals. Hence, the share of Dutch R&D in a foreign company's total R&D effort is small in general.

- Very large multinationals have the lowest shares

  Second, the relative importance of Dutch R&D differs considerably between the foreign companies. We find that companies with a share below 5% are generally very large multinationals, active in many countries, such as Ericsson, Dow, GE, J&J and Glaxo Wellcome. If companies choose to spread R&D over all these countries, the small share of Dutch R&D is evident. However, a small size does not imply per se that the Dutch R&D is just 'adaptation' or ‘development' for the Dutch market, as the 2 boxes in this section illustrate. Most of the other foreign companies in Table 2.7 with a Dutch share of more than 5 per cent are more oriented to Europe.

- Changes in shares of Dutch R&D in total R&D?
  Third, we find that for some companies the share of Dutch R&D changes substantially over the years. Examples include Solvay (decreasing), PetroFina (decreasing), Wartsila (fluctuating), SKF (increasing), and Hercules (fluctuating). However, for other companies, the share of Dutch R&D did not seem to change substantially. They neither tend to move away from the Netherlands at favor of foreign-located R&D, nor do they increase Dutch R&D activity relative to foreign R&D. However, the quality of the data does not permit strong conclusions here.

Table 2.8 Foreign-owned companies: R&D expenditure in the Netherlands, 1983-2000 (in mln 1999 Dfl)

	1983	1985	1990	1995	1999	2000	Trend[a]
Lucent			186	153 (‘94)	212	233 (‘01)	~
Ericsson			75	68	203 (‘98)	214	~
Hoogovens (Corus)	71	83	106	90	127 (‘98)	117	~
Solvay	122	135	226	124	104	108	~
Bakken/Vitatron (Medtronic)			24	42 (‘94)	90		+
Quest (ICI)					74		
Dow Benelux	32	47	75	65	72	70	~
DAF (Paccar)			112	132		68	~
Thales Nederland						68	
Yamanouchi Europe			10 (‘91)	12	32	49	+
GE Plastics			37		35	43	~
Sigma (PetroFina)			43	44	32	21	−
Cordis (J&J)			19 (‘92)	34	33 (‘97)	20	~
Stork Wartsila (NSD)			16 (‘92)	28	32 (‘97)		+
Sandoz (Novartis)				35 (‘93)			
SKF			12			31	+
GSK Nederland				22	18 (‘98)		−
Hercules			8 (‘92)	14		17	+

Main sources: CPB company database and company websites, November 2001. Amounts in prices of 1999.
a Trend: + positive; − negative; ~ fluctuating.

Total real expenditures by foreign-owned companies increase

Does the size of Dutch R&D by the foreign companies change over time? Table 2.8 shows real expenditures on R&D in the Netherlands by the foreign companies in the 1980s and 1990s. The table sketches a diverse picture. Some foreign companies have increased the size of their Dutch R&D activities, but others have decreased activities. For some companies the rise or fall is substantial and in a short time. Ericsson, Medtronic, Yamanouchi, Wartsila and SKF multiplied their R&D efforts in the Netherlands during the 1990s. In contrast, Paccar and Solvay halved their Dutch R&D activities in this period. Over-all, the increases outweigh the reductions, and sharp increases outnumber sharp declines. This is consistent with Table 2.3, which showed that aggregate foreign-owned company R&D in the Netherlands is doubled in the period 1993-1999.

Changes at foreign affiliate R&D locations in the Netherlands

Foreign firms generally do not close down Dutch-based R&D laboratories. The exception proves the rule. For example, Genencor (US) decreased the R&D of the acquired industrial enzyme division of Gist Brocades. Hoechst closed down nearly all its businesses in the Netherlands, including its Dutch R&D laboratory. Yamanouchi moved its R&D activities from Delft to Leiden.

Foreign R&D is here to stay

In sum, at the aggregate level we find that the overall size of Dutch R&D activity by foreign companies has increased over the years. At the firm level, we find substantial heterogeneity with respect to the rise and decline of R&D activities, but we still observe that R&D sites are not relocated because of changes in the nationality of the owner.

Other empirical studies confirm this impression. For instance, Cantwell and Janne (1999) argue that the Netherlands became increasingly attractive during the period 1969-1995, in particular in R&D in the branches of 'other organical chemicals', electrical systems and telecommunication technologies.[12] These fields are the specific strengths of the large Dutch multinationals, which extended and strengthened these technological competences at foreign R&D locations, by taking 'advantage of local sources of expertise and innovation'. Cantwell and Janne also note that the above mentioned fields of expertise remain the knowledge basis of the Netherlands, and no drastic changes over time have been observed. Dutch R&D remains strong where it was traditionally strong.

Conclusions

Analysis of R&D spending by foreign affiliates in the Netherlands reveals that:

- Before 1980, new R&D was often co-located close to existing Dutch business activities of the foreign company. After 1980, most foreign companies started R&D through acquisitions of Dutch-owned R&D intensive firms.
- For several foreign multinationals, the Netherlands is not an important location for R&D (measured by the share of Dutch R&D in concern R&D), because they are active around the

[12] They used data on US patents by large Dutch multinationals in the period 1969-1995, and divided the patents into those generated from R&D at non-Dutch locations and those generated from R&D in the Netherlands.

world, or because they concentrate R&D in the home country. For other foreign firms, the Dutch affiliate R&D has strategic importance.

- Once established, foreign affiliate R&D in the Netherlands generally continued. At the aggregate level, foreign R&D in the Netherlands has grown.

In sum, foreign R&D investments in the Netherlands are typically of the non-greenfield type. Once established, they are generally here to stay. The size of foreign affiliate R&D efforts in the Netherlands has grown over the years.

2.5 Conclusions

We summarize the trends in Dutch-owned and foreign-owned R&D in the Netherlands:

- The structure of Dutch aggregate company R&D is relatively stable.
- Dutch-owned companies typically do not move R&D abroad. New foreign R&D is generally additional to the company's R&D effort.
- Usually, foreign companies start R&D activities in the Netherlands by means of non-greenfield investments. In general, they do not tend to move R&D away once located here. On average, foreign companies increased their R&D efforts in the Netherlands.
- The location of R&D in the Netherlands is relatively constant over time. That is, Dutch R&D laboratories are immobile. But ownership, including nationality of ownership, may change.

Table 2.9 Foreign-owned companies' R&D: greenfield, co-location, acquisition or merger?

First year in Netherlands	Company	History of business and R&D activities in Netherlands	R&D in Netherlands started through:
Before the Second World War			
1914	SKF (Swe)	1914: Forms sales subsidiary in Netherlands Today: Concentration Company R&D in Netherlands in Engineering & Research Center (ERC) at Nieuwegein	Co-location
1920	Ericsson (Swe)	1893: First activities in Netherlands 1920: Establishment of Ericsson Telefoon Maatschappij in Netherlands (first subsidiary for parent outside Sweden) Today: Dutch divisions' R&D activities within 'Eurolab Netherlands' important for Company R&D (telecom R&D, and ICT center for Europe)	Co-location
1934	Honeywell (USA)	1934: Opens sales office in Amsterdam, supporting sales in Europe 1963: Building of Combustion Controls Center factory in Emmen with R&D (after discovery gas in Slochteren) 1974: European Distribution Center near Schiphol 1985: Combustion Controls Center becomes 'Center of Excellence' within Honeywell 2000: General Electric announces acquisition of Honeywell	Co-location
1950-1980			
1955	Avery Dennison (USA)	1955: subsidiary in Netherlands (first overseas subsidiary for Avery)	Co-location
1957	Dow Chemical (USA)	1957: Opens sales office in Rotterdam 1960s: Factories in Terneuzen, location becomes Dow Benelux's headquarter (biggest production site outside USA). Values infrastructure highly. 1976: R&D center opens in Terneuzen, now Europe's largest R&D department of Dow	Co-location
1960s	TotalFinaElf (Fra)	1960s: PetroFina (B) establishes Sigma, and a subsidiary in Netherlands. 1972: Extends Dutch subsidiary's activities into Europe in context of diversification 1999: merger PetroFina, Total Oil and Elf into Total Fina Elf Today: Sigma is part of SigmaKalon Group with headquarter and central R&D in Amsterdam	Probably co-location for the former PetroFina; Merger for TotalFinaElf
1967	Medtronic (USA)	1967: Establishes a distribution center near Schiphol. 1968: Establishes production unit in Kerkrade 1986: Acquires Vitatron because of its pacemaker technology, and establishes Bakken Research Institute near Academic Hospital Maastricht, a top location for cardiovascular R&D.	Acquisition

Table 2.9 (*cont. I*)

First year in Netherlands	Company	History of business and R&D activities in Netherlands	R&D in Netherlands started through:
1968	Cap Gemini (Fra)	1968: CAP Europe establishes CAP Nederland in Amsterdam (Moret started activities in Netherlands in 1883) 1992: Cap Gemini Group acquires Volmac BV Today: Increasing role Netherlands in mobile internet R&D. Recently, opening European lab in Utrecht. 2000: Merger Cap Gemini, Gemini Consulting, and Ernst & Young Consulting into CGEY.	Probably through co-location within CAP Nederland and acquisition of Volmac BV
1968	Johnson & Johnson/ Cordis (USA)	1968: Cordis Europa (Roden) is incorporated into Cordis Int. Expands gradually R&D and other activities. 1995: J&J acquire Cordis 1999: J&J acquire Centocor (subsidiary in Leiden since 1985)	Probably greenfield for Cordis; Merger for J&J
1971	GE Plastics (USA)	1971: Opens European headquarter and R&D department in Bergen op Zoom Today: R&D in European headquarter important to GE Plastic's European R&D	Greenfield
1973	Glaxo Wellcome (UK)	1960s: Philips Duphar employees import and distribute drugs of Glaxo 1973: Glaxo opens own sales office in Hoofddorp. 1970s: Starts an own R&D programme (applied clinical research for registration) 1995: Glaxo acquires Wellcome Today: Relatively much of Glaxo Wellcome's registration research takes place in Netherlands 2000: Announcement merger of Glaxo Wellcome and Smith Kline Beecham into GSK	Co-location
1978	Sara Lee/DE (USA)	1978: Alliance DE and Sara Lee (USA) 1988: DE is integrated into Sara Lee Corp. Today: DE carries a number of top brands of Sara Lee; responsible for all SL activities in Asia Pacific region.	Acquisition
1980-2000			
1980	Solvay Pharmaceuticals (Bel)	1980: Acquires Duphar from Philips Today: Netherlands one of main research centers for Solvay	Acquisition
1980	Eli Lilly (USA)	1980: Subsidiary in Netherlands for sales; but own clinical research increases utilizing scientific climate in Netherlands Today: Clinical research in Netherlands is held in high regard by Company, although fundamental R&D drugs takes place in US	Co-location

Table 2.9 (*cont. II*)

First year in Netherlands	Company	History of business and R&D activities in Netherlands	R&D in Netherlands started through:
1980s	Wartsila NSD (Fin)	Early 1980s: Acquires diesel motor division from Stork Today: Zwolle is one of the main engine production locations for Wartsila; increased R&D investments in mid-1990s 2001: announces closure of factory in Zwolle, including the Dutch R&D department, because of overcapacity problems, but is eager to take over Lips (Drunen), which has R&D.	Acquisition
1989	Lucent (USA)	1989: AT&T (with division Lucent) acquires Philips telecom division 1996: Lucent independent from AT&T Today: Has Bell Labs in Netherlands; R&D mainly in communication and internet, recent building of R&D in Enschede	Acquisition
1989	Thales (Fra)	1989: Acquires Signaal from Philips in context of European expansion. Marked an important breakpoint in 's history. 1990s: Signaal broadens range of customers; new systems designed. 2000: Thomson-CSF changes corporate name into Thales.	Acquisition
1991	Yamanouchi (Jap)	1991: Acquires pharmaceutical divisions from Gist Brocades to get access to European market Today: Parent company values current high-quality R&D employment in Leiden, builds further on this force and increases R&D	Acquisition
<1992	Hercules	1992: Centralizes R&D in UK and Netherlands into one new European R&D center in Barneveld (Gld) Tastemaker is a joint venture with Fries&Fries (USA). 1998: Barneveld officially one of the 2 Hercules world-wide research centers 1999: Further extension activities Barneveld (new biotech laboratoria)	Probably greenfield
1994	Suez Lyonnaise (Fra) / Nalco	1994: Nalco (USA) establishes European headquarters and R&D laboratorium in Oegstgeest (ZH) 1999: Suez Lyonnaise (Fra) acquires Nalco, which is integrated with Calgon and Aquazur 2001: Nalco merges with Ondeo, and changes name.	Probably greenfield
1993	Novartis (Swi)	1993: Sandoz AG acquires Zaadunie (later S&G Seeds) 1996: Merger Ciba Geighy and Sandoz AG into Novartis 2000: Merger Novartis Agribusiness with Zeneca Agrochemicals into Syngenta	Acquisition for former Sandoz; merger for Novartis and Syngenta

Table 2.9 *(cont. III)*

First year in Netherlands	Company	History of business and R&D activities in Netherlands	R&D in Netherlands started through:
<1995	Bosch (Ger)	Before 1995: Dutch activities of Bosch (packaging machines, Blaupunkt, and Telenorma) do not amount to anything much to the Bosch Group. Supposedly no Dutch R&D. 1995: Acquires Van Doorne's Transmissie (VDT), which in turn is a result of development activities of DAF. Probably the knowledge of VDT has been interesting to Bosch.	Acquisition
1996	Paccar (USA)	1996: Acquires DAF, being one of the most significant acquisitions in Paccar's history Today: DAF is one of main operations of Paccar. DAF's R&D important to Paccar.	Acquisition
1997	ICI (UK)	1997: Acquires Quest (and some other chemical divisions) from Unilever Today: Quest is one of the four core activities of ICI (which pursues a specialties strategy). Main R&D of Food Division is in Naarden (NL).	Acquisition
1999	Huhtamaki (Fin)	1999: Merger with Van Leer into HVL	Merger
1999	Corus (UK)	1999: Merger Hoogovens and British Steel	Merger
2000	Invensys (UK)	2000: Acquired Baan Company to establish its own position as leading software developer. Baan's R&D proved to be complementary, as well as its sales position and talent pool.	Acquisition
2001	Benteler (GER)	2001: Acquires PD&E from Nedcar (which wanted to dispose PD&E, and continue just production in the Netherlands). To Benteler, PD&E will help to strengthen Benteler's world-wide position as technology-driven developer of automotive components (next to other R&D centers world-wide)	Acquisition
Unknown	Q8 Petroleum (Kuwait)	Today: all corporate R&D of Q8 is located in Europoort (Kuwait Petroleum Research & Technology)	Unknown

Sources: CPB company database, newspapers, and company websites, November 2001

3 Location factors for R&D

3.1 Introduction

What determines the trends in the location of R&D? What are the decisive location factors for R&D? And what is the quality of these factors in the Netherlands compared to other countries?

This section examines these questions. Section 3.2 surveys the factors that have been identified as decisive for the location of R&D in the literature respectively by our interviewees. Section 3.3 offers a benchmark of these location factors in the Netherlands and various other countries competing for the location of R&D. Section 3.4 confronts the benchmark results with the actual R&D location choices of firms. Section 3.5 discusses trends that could change the quality and relevance of R&D location factors. Section 3.6 concludes.

3.2 Decisive location factors for R&D

Greenfield R&D investment

What determines a firm's choice where to locate its R&D activities? Table 3.1 presents the ranking of location factors for greenfield R&D according to Buck Consultants International, a location consultancy firm. Firms choose for locations where highly qualified labour is available at reasonable costs, where universities and technological institutes conduct state-of-the-art research, and where travel to foreign destinations is easy.

Table 3.1 Location factors for greenfield R&D

crucial	very important	important	less important
availability and costs of highly qualified labour	investment and technology grants	quality of local suppliers, customers and competitors	quality and costs of telecommunication and energy
availability and quality of universities and technological institutes	availability of technology/science parks	corporate tax regime, income tax regime	macro-economic profile and political stability
proximity and quality of international airport	quality of life, costs of living, and international schools	regulatory framework	

Source: Buck Consultants International (1999b)

For firms employing specific technologies, however, the picture may look different, and other location factors may turn out to be decisive (Meyer-Krahmer and Reger, 1999). For example, for R&D on the edge of biotechnology and pharmacy the quality of the local science system is vital, and consequently the UK is one of the thriving places to locate this type of R&D. Clinical pharmaceutical R&D, on the other hand, tends to locate in large markets with high standards of drug approval (e.g., the US and Japan). Shaving customs vary with culture, hence Asian markets for electric shaving have to be created through local R&D. The most impressive web sites are said to be build in Amsterdam because of an abundance of artistic but computer-minded people at a major hub in international internet traffic.

Non-greenfield R&D investment

However, most R&D investment decisions do not concern greenfield R&D. Since the 1950s firms typically start new R&D activities through *co-location*, *mergers* and *acquisitions*, or *expansions of existing R&D operations*.[13] Economies of scale and scope in (R&D-)operations and high costs of moving R&D assets may induce firms to adhere to existing locations rather than to move to those places that are most attractive to greenfield R&D (Howells, 1990; Albert, 1999).[14] Consequently, in many cases the location of new R&D is also dependent on previous location decisions, of R&D and non-R&D operations alike, determined by location factors relevant at that time for the type of investment of those days (Gassman and Von Zedtwitz, 1999; Zander, 1999). In other words, R&D location decisions are path-dependent. Ultimately, location decisions may even be determined by chance.[15]

Still, truly multinational firms might decide upon R&D locations as if the project has a greenfield character. These firms can benefit from economies of scale and scope at many locations, since they tend to operate multiple ‘centres of excellence' and many more development centres (Pearce, 1999). Examples important for the Netherlands include Ericsson, IBM, Shell, and Unilever. Although history is a major determinant of the location decision for an incremental R&D project, it need not be important for the decision which one to single out.

[13] See section 2.4 and also Buck Consultants International (1999b), Gassman and Von Zedtwitz (1999), OECD (1999), Niosi and Godin (1999), Ernst & Young (2000), and Wintjes (2001).

[14] For example, PamGene, a bio-tech firm located in ‘s Hertogenbosch, The Netherlands, decided not to relocate to San Francisco because moving its entire team of researchers turned out to be impossible (Het Financieele Dagblad, March 28, 2001).

[15] Philips' NatLab, for example, is located in Eindhoven rather than Breda because in the 1890s the Philips family had tobacco-related business contacts in the Eindhoven area and because the family won the auction of an abandoned Eindhoven buckskin factory (Minne, 1997). DSM Research is located in the Dutch province of Limburg because of the Dutch government's decision to fight unemployment of coal miners in the 1960s and 1970s. Intervet, the animal health subsidiary of Akzo Nobel, is located in Boxmeer because a long time ago a veterinarian of a local cattle feed producer had specialized in chicken health (NRC Handelsblad, April 14, 2001).

Indeed, interviewees from several foreign R&D firms in the Netherlands confirmed that they compete for company-wide R&D projects and company-wide R&D budgets with the firm's establishments in other countries. Locations that do not offer the best facilities for R&D will not be the prime choice of company management. Interviewees from Dutch multinationals asserted that there is some competition with foreign establishments over new R&D projects, but that those overseas facilities generally lack the advantages of scale delivered by the large Dutch R&D lab (see also section 2.3).

Also, one may argue that history does not influence R&D location decisions in brand new fields of technology (e.g., ICT, genomics), since firms simply do not have established R&D labs in these disciplines yet. This argument is not always convincing, however. First, firms have to learn about the new discipline in order to assess its potential before investing in a new R&D site. The firm's establishment that acquires the necessary absorptive capacity for this appraisal will have some advantage over other sites. Second, the firm will focus its R&D in the new discipline on innovations that are adjacent to its current product portfolio and knowledge base in order to benefit from economies of scope.

Apart from reasons of path-dependency, do location factors for non-greenfield R&D differ from those of greenfield R&D? Basically, no. Our interviewees broadly acknowledged the location factors and their classification according to importance as reported in table 3.1. Generally speaking, however, they put relatively more weight on the quality of regional suppliers and customers, including start-ups and spin-offs from universities, and less weight on the size and scope of government incentives. Interestingly, our interviewees often phrased some of the location factors differently and more clearly. Table 3.2 offers a non-ranked overview of the location factors as they put them forward.

Table 3.2 Location factors for R&D according to our interviewees[a]

Class of R&D location factors	R&D location factors
Researchers	• number of graduates and PhDs in S&T, in current time but also in the upcoming decade • quality of PhD candidates in S&T
Knowledge infrastructure	• high-quality public knowledge infrastructure in the appropriate fields (spearheads) of S&T • thriving innovative entrepreneurship, innovative SMEs to supply to and be acquired by MNEs • university researchers have high-quality personal networks throughout the world • entrepreneurial culture in universities, many spin-offs from universities • professional research contract negotiators at universities
Government	• government policy to ensure availability of qualified labour in the future • presence of an important patent office or market approval agency • easily available working permits, in particular for researchers from developing countries • subsidies for joint research of private and public entities • the government is a demanding launching customer • the government establishes an image of dedication towards R&D
Other	• leading demand: customers (final and intermediate) with a love for innovative products and services • children and adults alike consider S&T fun rather than frightening • headquarters of MNEs deciding on procurement of complex, innovative products and systems • no stigma for entrepreneur if start-up ends in failure

a Factors are ranked according to subject, not to importance

The OECD agrees with these selections of R&D location factors, see table 3.3. The Organisation does not rank the factors according to importance.

Table 3.3 Location factors for R&D according to the OECD[a]

Class of R&D location factors	R&D location factors
Skilled labour	• availability of science and engineering professionals • skilled, mobile, flexible and risk-taking workforce, capable of continual learning and training
Public knowledge infrastructure	• high quality basic and applied research • multidisciplinary co-operation • knowledge transfer between public and private sector
Government	• fiscal measures: depreciation allowances, deductability, tax credits • support for venture capital • regulatory and legal issues: intellectual property laws, red tape of starting a business, bankruptcy laws, standard and product safety regulations, competition law • government procurement practices • policy to encourage competitive co-operation

Source: OECD (1999)
a Limited to location factors directly targetable by government policy. Factors are ranked according to subject, not to importance

Note that firms take the quality of some location factors for granted if provided adequately by any country considered to be an eligible location candidate. Examples of such factors include political stability, legal security, and an adequate telecommunication infrastructure. For this reason, this sort of location factors does not show up in the listings.

Conclusion

History is an important determinant of the location of R&D, embedded in the economy. Firms often choose to start new R&D operations through co-location, mergers and acquisitions of existing firms, or expansions of existing R&D operations. For many companies, the advantages of scale and scope offered by the home-based R&D lab is the decisive factor determining the location of a new R&D project. Still, many multinational firms operate multiple R&D sites in multiple countries and they make these sites compete for new, incremental R&D projects. Apart from the strong influence of history on the location of R&D, the decisive location factors for R&D are:

- the supply of qualified researchers in science and technology
- the quality of universities and technological institutes in appropriate fields of science and technology, including the quality of the science-industry knowledge transfer

Costs of use of location factors, for example wages of highly educated researchers, seem to be a less important location factor (although wages may mirror the supply of researchers to some extent).[16]

3.3 Benchmarking the Netherlands as a location for R&D

We compare the Netherlands to competing locations for R&D. We first present an assessment of the R&D labour force and the public knowledge infrastructure, respectively, and then continue with a benchmark of other R&D location factors.

The reader should keep in mind that the indicators used in this benchmark are often imperfect, prone to measurement problems and misinterpretation, and imperfectly comparable among countries. In particular, a highly efficient R&D process could off-set a bad ranking on an input indicator, and the exploitation of comparative advantages could imply that some countries rank high on one indicator while others perform well according to another one. Hence, the conclusions should be handled with care.

3.3.1 Benchmarking the R&D labour force

Education

Test scores on mathematics and science literacy achievement of students in their final year of secondary school reveal that the Netherlands is one of the leading countries with respect to the quality of education of science and technology. This holds both for the average student and for the group of best students (Mullis et al, 1998, tables 1.1 and 1.2). Business executives are less content about the quality of science teaching in Dutch compulsory schools, and they put forward that the Dutch youth has a lack of interest in science and technology (GCR, 2000, table 7.02, and WCY, 2001, tables 4.3.15 and 4.3.16). Our interviewees, however, typically argued that the number of secondary school students taking courses in mathematics and science is satisfying, as is the quality of teaching in these fields.

Graduation

At the graduate level, the share of Dutch students having obtained a degree in science and engineering is relatively low, see figure 3.1. A third of Dutch students in higher education choose to graduate in science and engineering, compared to half of the students in countries like

[16] See also Meyer-Krahmer and Reger (1999), OECD (1999), Pearce (1999), Midelfart-Knarvik et al (2000), and Ernst & Young (2001) for evidence. For anecdotical evidence, consider the statement by Biogen, the second largest US biotech firm, that subsidies do not influence the location decision for the firm's new European production and R&D site (M. Abrahamse, 'Nederland te inflexibel voor Biogen', Het Financieele Dagblad, September 7, 2001).

Germany, Sweden, and in particular Finland.[17] Since a relatively large share of the Dutch youth does complete higher education, the share of the Dutch young population with a science and engineering degree is at the average of the subset of EU member countries (figure 3.2). Our interviewees confirmed the relative lack of interest in studying science and technology at the university level. They typically argued that undergraduates are badly informed about the long-term career opportunities in science and technology, that university curricula are not appealing enough, and that wages for PhD students (a natural next step) are low compared to starting salaries of competing jobs.

Private initiatives to foster the supply of researchers in chemistry

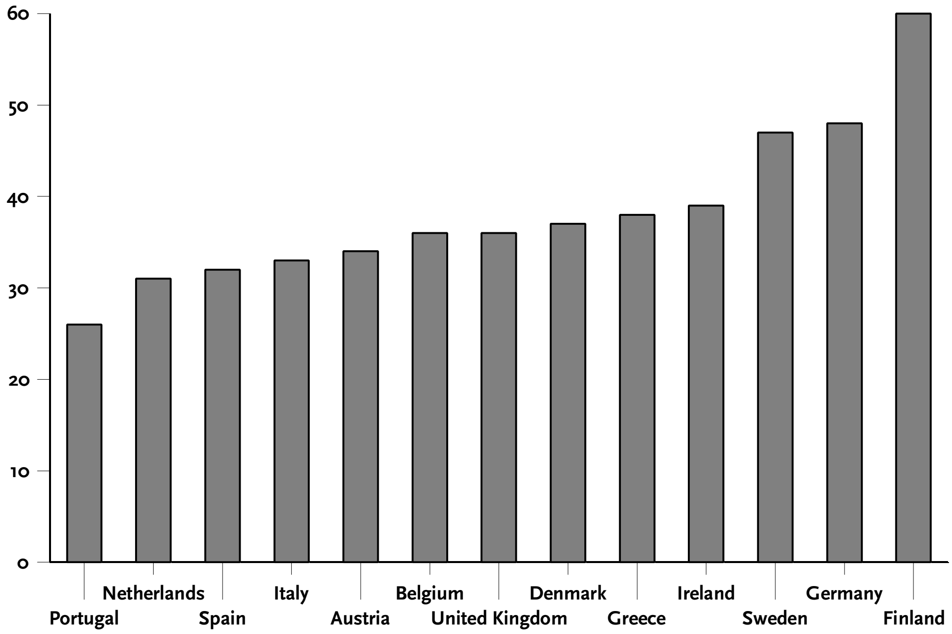
The Dutch chemical industry employs many strategies to invite children and student into a science & technology career. Pandemonia Science Theatre visit primary and secondary schools to perform a science show. Employees of chemical firms lecture at school and universities. Firms welcome visits, donate second-hand equipment, offer scholarships, and sponsor student associations.

Recently, the industry proposed to hire PhD students themselves rather than hiring them once the doctor's degree has been obtained. The industry said to be prepared not to discount PhD student's wage for receiving education. Universities do discount wages by about 25% in the first year of the PhD program, and by 15% in the third year.

Source: Y. Doorduyn, Dansende rozijnen, NRC Handelsblad, July 18, 2001, and O. Porcu, 'Dubbel salaris lost chemieprobleem op', Het Financieele Dagblad, October 5, 2001.

[17] Peculiarities in the classification of curricula explain part of the difference (AWT, 1999).

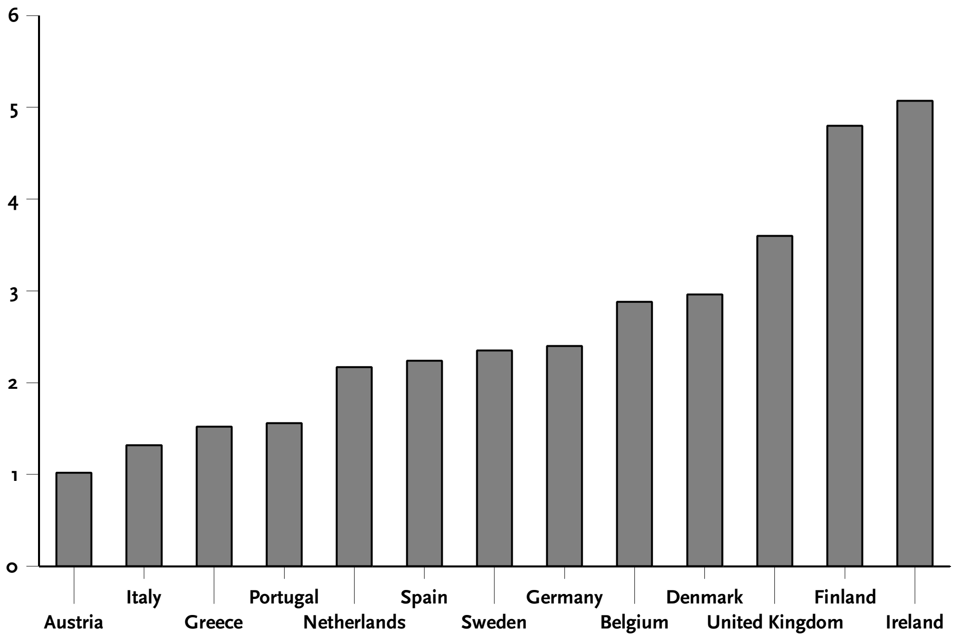
Figure 3.1 Percentages of graduates taking a Science and Engineering degree, 1996



Source: Eurostat, Human Resources in Science and Technology.

Notes: Year of observation is 1994 for Belgium and Greece. No observation available for France and for non-European countries.

Figure 3.2 Percentage of young population (25-29 years) holding a Science and Engineering degree, 1996



Source: Eurostat, Human Resources in Science and Technology.

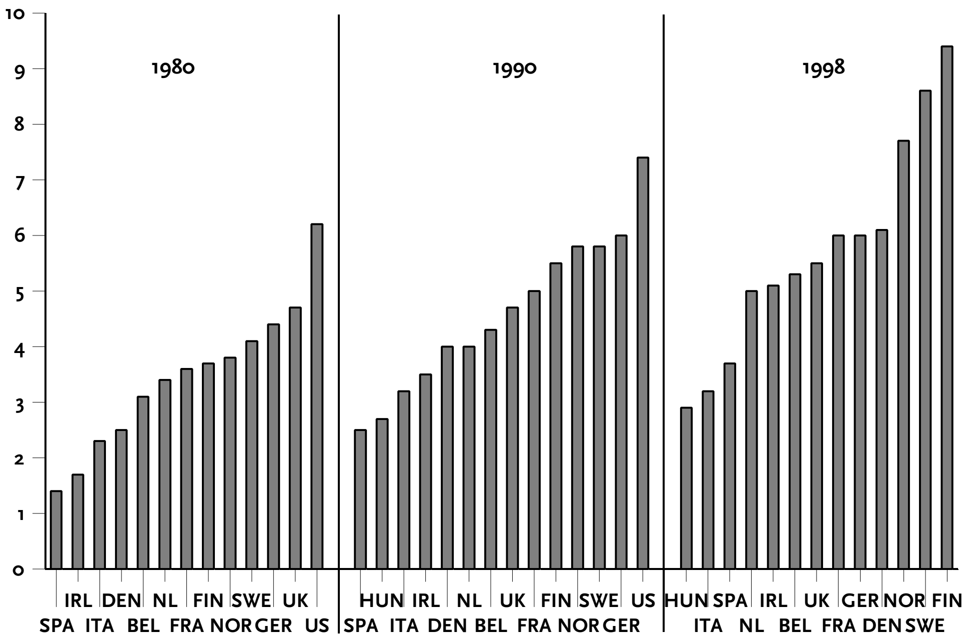
Notes: Year of observation is 1994 for Belgium and Greece. No observation available for France and for non-European countries.

Labour force

Figures 3.3 and 3.4 reveal that the relative size of the Dutch R&D labour force lags behind a group of leading countries (Scandinavia, Germany, France, US). The trend is upwards in most countries, and strongly upwards in the Scandinavian countries. These observations also hold true if restricted to the labour force of the private sector.

Figure 3.3 displays the share of the labour force employed as researchers, i.e. as 'professionals engaged in the conception or creation of new knowledge, products, processes, methods, and systems, and in the management of the projects concerned' (OECD, 1994, p.86), or university graduate. Note that this definition includes professionals in e.g. the social sciences (OECD, 1994, p.162). Figure 3.4 reports on a broader definition of R&D personnel, including technicians and equivalent R&D staff and other R&D supporting personnel.

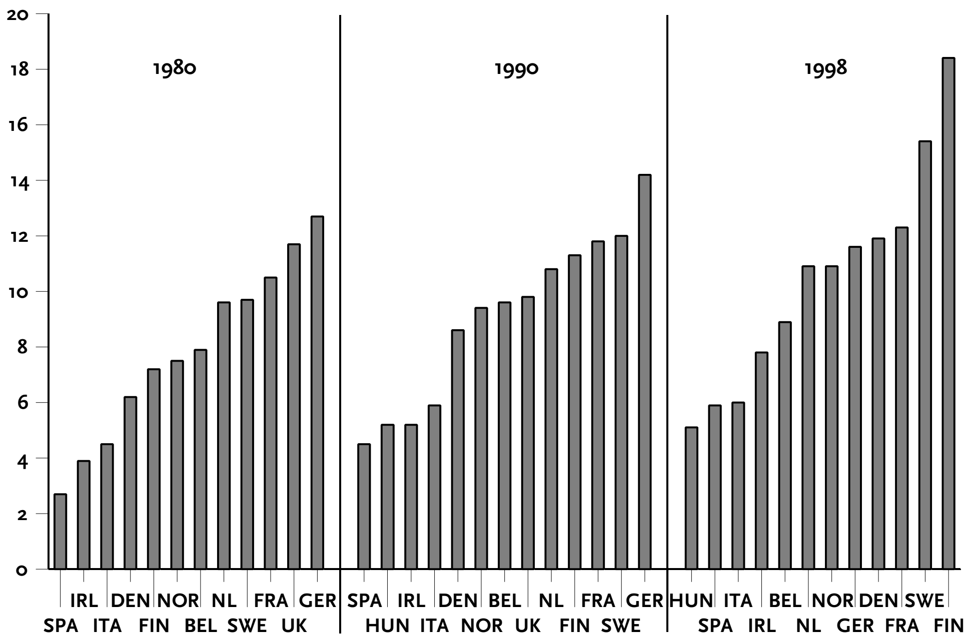
Figure 3.3 Researchers (or university graduates) per thousand labour force



Source: OECD, Main Science and Technology Indicators, table 12.

Notes: Year of observation as indicated, or closest year available. No observation available for Hungary (1980) and the US (1998).

Figure 3.4 R&D personnel per thousand labour force



Source: OECD, Main Science and Technology Indicators, table 9.
Notes: Year of observation as indicated, or closest year available. No observation available for Hungary (1980), the UK (1998) and the US (all years).

Our interviewees put forward that their firms themselves do not face difficulties in hiring suitably qualified researchers. They typically argued that graduates still queue up because of the extraordinary research facilities and interesting research projects their firms offer. The labour shortages are felt by other (i.e., smaller) firms, and, moreover, these shortages are the same in competing R&D locations in the developed world. Nevertheless, they are afraid that inadequate labour supply will also threaten the R&D activities of their firms in the near future.[18]

3.3.2 Benchmarking the public knowledge infrastructure

The performance of the public knowledge infrastructure of the Netherlands stands a comparison with competing locations for private R&D. Researchers at Dutch universities and technological institutes publish 2,3% of the world production of scientific papers at the cost of 2,2% of the OECD expenditures on public R&D (Tijssen et al, 2001, table 3.2, and OECD, Main Science and Technology Indicators). The quality and scientific impact of this research output is relatively high, since scientific publications (co-)authored by Dutch researchers are cited

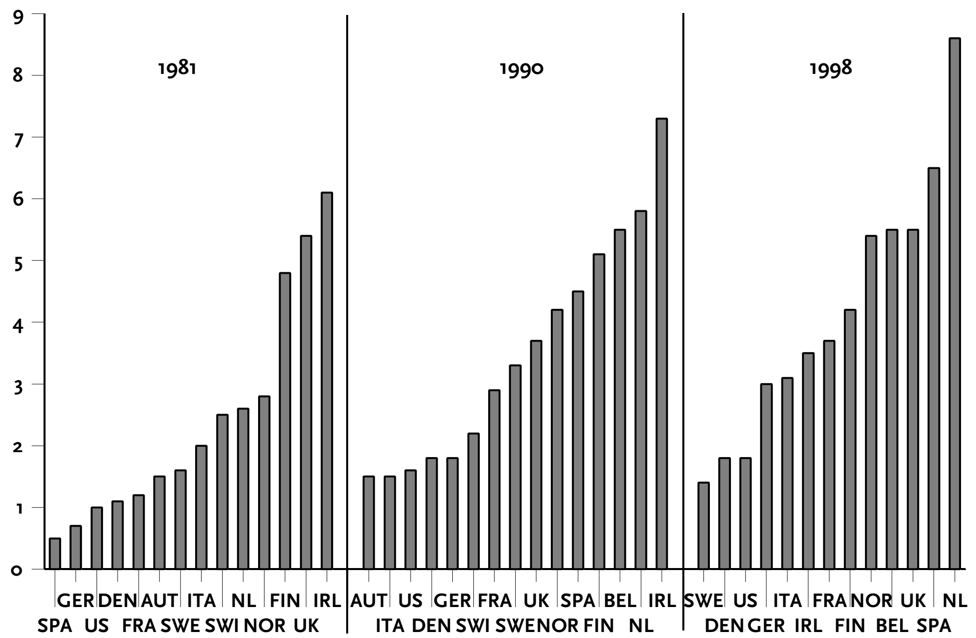
[18] See also "Shortage of chemistry students spoils industry's rosy picture", Het Financieele Dagblad, December 8, 2000.

relatively often (Tijssen et al, 2001, table 3.2). The share of Dutch publications co-authored by a foreign-based researcher is comparable to other medium-sized European countries, suggesting that Dutch researchers neither take more care nor neglect their international personal networks relative to researchers based in competing locations for R&D (Tijssen et al, 2001, chapter 4).[19] However, it has been argued that the Dutch universities may face difficulties in keeping up with large US, UK, Swiss and Scandinavian institutes, because in some disciplines research is scattered across many universities and critical mass for risky or multi-disciplinary research is lacking (AWT, 1999).

Some indicators suggest that Dutch public research is relatively helpful for private firms. Figures 3.5 and 3.6 show that the share of public R&D financed by private firms and the share of firms' R&D performed by the public knowledge infrastructure is relatively large in the Netherlands. The first indicator is particularly interesting, since it reflects the decision of firms to contract out R&D activities to the public knowledge infrastructure. Business executives also observe that companies in the Netherlands collaborate relatively closely with local universities in their R&D activities (GCR, 2000, table 7.06). This positive picture may be flawed, however, by the special position of TNO in the public knowledge infrastructure of the Netherlands. Since TNO is relatively large compared to similar (semi)public knowledge institutes in other countries, TNO might perform R&D-projects by order of private firms that are commissioned to private R&D consultants in other countries. This would introduce a bias in the statistics.

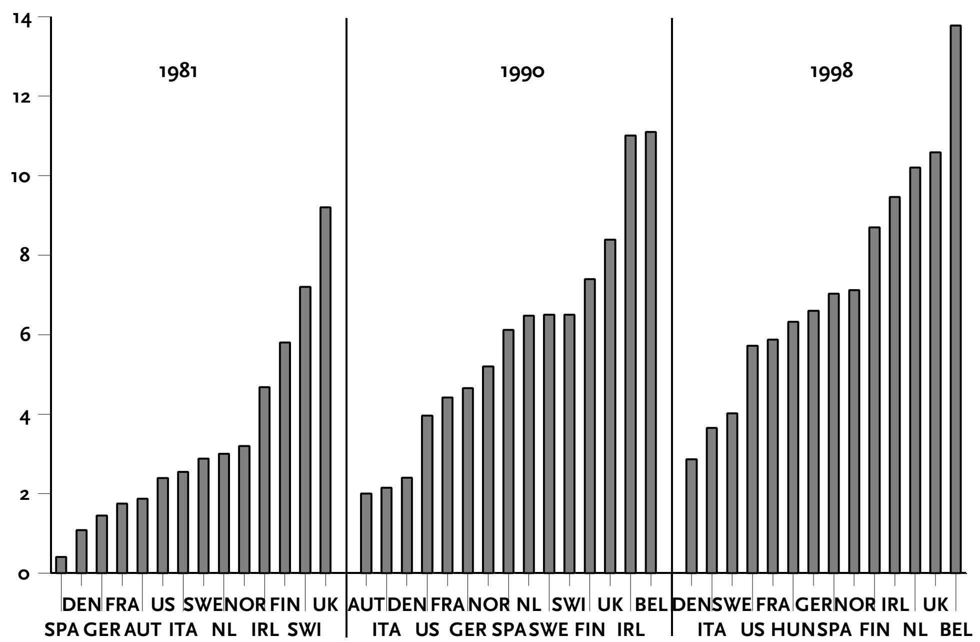
[19] It should be noted that indicators of scientific publications measure the production of the system a few years ago rather than current or expected performance. Indeed, in several scientific disciplines, there is an important delay in publication. Moreover, some time tends to pass by before the value of a scientific papers is recognized through citations in other papers.

Figure 3.5 Percentage of R&D financed by firms that is performed by (semi)public organisations



Source: own calculation using OECD, Main Science and Technology Indicators, tables 2, 13, 17, 22 and 32. Year of observation as indicated, or closest year available. No observation available for AUT (1998), BEL (1981), and SWI (1998).

Figure 3.6 Percentage of R&D performed by (semi)public organisations that is financed by firms



Source: own calculation using OECD, Main Science and Technology Indicators, tables 2, 13, 17, 22 and 32. Year of observation as indicated, or closest year available. No observation available for AUT (1998), BEL (1981), and SWI (1998).

Other indicators contradict such a positive claim about the quality of science-industry knowledge transfer in the Netherlands. The number of Dutch firms cooperating with a public knowledge institute is comparable to the EU-average (Eurostat, Community Innovation Survey, tables c2 and c8), while the Scandinavian countries are leading. In conjunction with the indicator presented in figure 3.5, this might suggest that large R&D intensive corporations have relatively easy access to the public knowledge infrastructure in the Netherlands, while medium and small businesses have not. Moreover, science-industry knowledge transfers are said to be hampered by an inadequate entrepreneurial culture in European universities, including those in the Netherlands, in absolute terms and relative to US universities (AWT, 2001a and 2001b). We were unable to find evidence on the quality of the entrepreneurial culture at Dutch universities relative to other European countries.

Our interviewees acknowledged the high quality of research performed by the Dutch public knowledge infrastructure.[20] But they argued that a large potential for knowledge transfers is still untapped:[21]

- Dutch universities and technological institutes serve established large R&D firms well, but do not optimally cater to the needs of smaller firms and of firms operating in new fields of technology.
- Dutch researchers hesitate to spin-out of the university system, to found a business, and to cooperate with established firms on a commercial base.[22] Dutch universities and technological institutes do not foster their start-ups and lack a intra-mural entrepreneurial culture. Science parks do not offer much value-added compared to standard business parks.
- Dutch universities generally lack the skills and knowledge needed to conclude and manage research contracts with private businesses. In particular, they lack the skills necessary to file and exploit a patent successfully.

Interviewees applauded the recent establishment of four Technological Top Institutes (TTIs) to pursue a scientifically sound research agenda that is tailored towards some of Dutch industry's needs. They argued that the world technology frontier is far too stretched to be completely covered by the public knowledge infrastructure of a small country. Industry fishes the global sea of ideas mainly by itself, with the guiding assistance of researchers at local universities and technological institutes, and their world-wide personal networks in particular.

[20] Tijssen (2000) interviewed Dutch inventors. He found similar evidence.

[21] These arguments hold for many countries. Schmoch et al (2000), for example, extensively discuss the German case.

[22] Not only the number of entrepreneurial university researchers, but also the number of innovative entrepreneurs in general is said to be relatively low in the Netherlands. For example, the rate of entry of new firms in fast-growing industries is low in the Netherlands compared to the UK and the US (EIM, 1999).

3.3.3 Benchmarking other R&D location factors

This section benchmarks the Netherlands on a set of other, less important location factors for R&D.

Entrepreneurship and innovation in SMEs

Dutch SMEs do not lead the rankings of innovators in Europe. The share of Dutch firms that market innovative products and services is above EU-average, in particular in manufacturing, but the Netherlands does not lead (CBS, 1999, table 6.2.1). The share in turnover of new or significantly improved manufacturing products in total turnover of SMEs is close to EU-average (CBS, 1999, table 6.2.2). The share of entrepreneurs in the highly skilled labour force is in the Netherlands comparable to the UK, larger than in Denmark, but lower than in Belgium and Germany.[23]

However, demand for capital by firms at early or expansion stage as a percentage of GDP is large in the Netherlands, comparable to leading countries as Canada and the US, and ahead of the UK, Scandinavia, Germany and France (OECD, 2000a, figure 23). Furthermore, business executives are relatively impressed by the innovative competence of buyers and in particular suppliers in the Netherlands (GCR, 2000, tables 10.09 and 10.11). These latter indicators sketch a more positive picture of entrepreneurship in the Netherlands.

According to our interviewees, the Dutch public knowledge sector lacks an entrepreneurial culture contrary to e.g. Denmark and the UK. Number and quality of spin-offs from universities is relatively low. A big hurdle is the high social price that Dutch entrepreneurs still have to pay in case of failure: a stigma for life. Arthur Andersen and GrowthPlus (2000), however, finds contradictory evidence on this latter issue: the social and legal consequences of bankruptcy are less severe in the US and the Netherlands than in countries such as Belgium, Germany, France, Sweden and the UK.

Demanding consumers

Dutch consumers have a relatively strong predisposition to buy new and different products and brands rather than remain with previous choices and consumption patterns. Table 3.4 ranks consumer innovativeness in the Netherlands third in a set of eleven EU countries. Business executives confirm the relative strong demand of Dutch consumers for the latest products and technologies (GCR, 2000, table 10.13).

[23] This claim is based on computations using figure 1 and table 15 from EIM (1999) and tabel A1.1 from OECD (1998a). See however Cornet (2000) for a discussion of the quality and comparability of international data on the level of educational attainment.

Table 3.4	Ranking of 11 EU countries on consumer innovativeness	
	ranking	country
	1	UK
strong	2	Denmark
	3	The Netherlands
	4	Ireland
	5	France
medium	6	Germany
	7	Italy
	8	Greece
	9	Spain
weak	10	Belgium
	11	Portugal

Source: Steenkamp et al (1999) and information from a private conversation with Steenkamp in January 2001.

Proximity and quality of an international airport

Schiphol Amsterdam Airport is one of Europe's four leading airport hubs, and also one of Europe's airports delivering most passenger satisfaction (IATA, 2000a and 2000b). For the southern and eastern parts of the Netherlands, the international airports of Brussels and Düsseldorf offer additional travel opportunities. Hence, international travel connections are excellent.

Investment and technology grants

The Netherlands, France, Denmark and the US follow a leading group including Spain and Canada in tax payers' generosity for private investments in R&D. Fiscal incentives for R&D are smaller in competing locations such as the Nordic countries, Germany, Belgium, and the UK (OECD, 2000a, table 6.1). Business executive consider Dutch investments incentives for FDI as relatively generous (WCY, 2001, table 2.4.23).

Recently, the Dutch practice of advanced tax ruling for foreign firms considering a greenfield investment in the Netherlands came under attack. This practice, which essentially involves a statement about the definition of its tax base for the next years, has been criticised for being unfair, although many other European countries apply or are going to apply similar procedures.[24]

Some of our interviewees added that the Dutch income tax for expatriates is relatively low. They also brought out that international firms' perception of the Dutch fiscal climate has been changed negatively because of the publicity mentioned above.

[24] See "Holland's advance tax rulings are under fire from all sides", Het Financieele Dagblad, October 20, 2000, and "Fiscus minder geneigd om investeerders tegemoet te komen", Het Financieele Dagblad, October 19, 2000.

3.3.4 Conclusion

The indicators presented in this benchmark suggest that the Netherlands takes an average or higher position in the overall ranking of attractiveness to business R&D. This picture is consistent with two overall rankings of location attractiveness for R&D, featuring the Netherlands as one of the better locations to perform R&D, see table 3.5.[25]

With respect to the two decisive R&D location factors, the benchmark is not unanimously positive for the Netherlands. First, the benchmark reveals that the relative size of the R&D labour force lags behind a group of leading countries. Second, the benchmark is positive on the quality of the public knowledge infrastructure, but inconclusive about the quality of the science-industry knowledge transfer in the Netherlands. On the one hand, the share of private R&D spending sourced out to public knowledge institutes is relatively large; on the other hand, the number of firms cooperating with public knowledge institutes is comparable to the average score of benchmark countries.

Table 3.5 Attractive locations for R&D intensive companies

Ranking	World Competitiveness Yearbook 1999	World Competitiveness Yearbook 2000	World Competitiveness Yearbook 2001	Global Competitiveness Report 2000
1	US	US	US	US
2	Finland	Finland	Finland	Finland
3	Switzerland	Switzerland	Singapore	Singapore
4	Japan	Germany	Switzerland	Luxembourg
5	Germany	*The Netherlands*	Sweden	Sweden
6	*The Netherlands*	Japan	Iceland	Israel
7	Singapore	Sweden	Canada	Ireland
8	Canada	Singapore	Australia	*The Netherlands*
9	Denmark	Canada	*The Netherlands*	UK
10	Sweden	Australia	Ireland	Iceland

Source: WCY (1999, 2000 and 2001) and GCR (2000). The GCR ranking is a ranking of 'economic creativity'.

[25] Rankings that summarize a set of indicators should be handle with much care, since the relative weight given to the indicators often lacks solid ground, and since the indicators themselves are subject to criticism.

3.4 R&D location factors and observed R&D location choices

Do firms' R&D location choices reflect Dutch performance on R&D location factors? Are the actual location decisions consistent with those predicted by the above benchmark? We make four observations:

- According to data obtained from Ernst & Young, a location consultancy firm, The Netherlands attracts its fair share of the foreign direct R&D investment projects, see table 3.6. The share of projects established in the Netherlands is about equal to the relative size of the Dutch economy and the relative size of R&D expenditures. Austria, Hungary, Ireland, and the UK attract relatively many projects. Germany is a relative non-performer. A disaggregation of greenfield and non-greenfield R&D-related FDI reveals that Austria, Belgium, Finland, Ireland, and the UK are relatively attractive to non-greenfield R&D FDI. Denmark, Hungary, and Ireland and the UK (again) attract a relatively large number of greenfield R&D FDI. Germany fails at both indicators. The Netherlands gets its fair share of both greenfield and non-greenfield R&D FDI.
- Analysis by Buck Consultants International, another location consultancy firm, confirms that the Netherlands attracts its fair share of the greenfield foreign direct R&D investment projects, see table 3.7.
- Recent location decisions of the largest Dutch R&D spending firms in the Netherlands do not support an unqualified statement in favour or in disfavour of the competitiveness of the Netherlands as a location for R&D (see section 2.3). Philips, a large multinational enterprise, employs a campus-strategy since the second half of the 1990s, concentrating R&D operations in Eindhoven, the Netherlands. Recent foreign acquisitions however reduced the share of Philips' R&D expenditure in the Netherlands. DSM and Océ only recently started to internationalize their R&D activities through foreign acquisitions, most likely as a consequence of a change in business focus. The share of R&D performed in the Netherlands by Unilever and Shell, both truly multinational companies, fluctuates throughout the years. Apart from Shell, all these companies increased their R&D expenditures in the Netherlands. Shell reduced its R&D spending both in the Netherlands and in other countries.
- R&D operations of foreign firms tend to arrive in the Netherlands through co-location or mergers and acquisitions (see table 2.8). Once established, the size of these R&D operations tends to grow, although there are important exceptions (see table 2.7). However, the evolution of this R&D relative to R&D activities of the firm at facilities in other countries is not clear (see table 2.6). Therefore, this evidence does not imply a strong pro or con.

These observations should be handled with care. First, the number of R&D projects that have to be located each year is small, hence a few projects accidentally landed in a country may have a large impact on its relative performance. Second, there are problems with the quality of the data (as is usual in empirical research).[26] We cautiously conclude that there is no evidence that firms' actual R&D location decisions clearly favour or disfavour the Netherlands relative to its main competitors.

Table 3.6 Allocation of R&D FDI projects across 18 European countries, 1999-2000

	Share in greenfield R&D FDI projects (%)	Share in non-greenfield R&D FDI projects (%)	Share in R&D FDI projects (%)	Share in GDP (%)	Share in total R&D expenditures (%)
Austria	2.4	6.1	4.3	2.2	2.1
Belgium	1.6	5.3	3.5	2.8	2.9
Denmark	3.1	1.5	2.3	1.5	1.7
Finland	1.6	3.1	2.3	1.3	1.9
France	8.7	18.3	13.6	14.6	18.3
Germany	10.2	7.6	8.9	21.7	28.2
Hungary	4.7	0.8	2.7	1.2	0.5
Ireland	9.4	3.1	6.2	0.9	0.7
Italy	5.5	2.3	3.9	14.3	8.1
Netherlands	5.5	4.6	5.0	4.3	5.0
Spain	7.9	8.4	8.1	7.7	3.6
Sweden	6.3	5.3	5.8	2.2	4.6
Switzerland	4.7	1.5	3.1	2.2	3.4
UK	25.2	28.2	26.7	14.7	15.3

Source R&D FDI data: Ernst & Young International Location Advisory Services. Source GDP and R&D expenditure data: OECD.

Notes: Database includes 127 greenfield and 131 non-greenfield R&D FDI projects. Software investment projects are not included. Results for the Czech Republic, Greece, Poland, and Portugal are not reported. Year of observation for share in GDP and share in R&D expenditures is 1997.

[26] Measurement errors cast a cloud upon the quality of the data. First, projects may simply not be detected. Second, a project may be wrongly classified as R&D since the larger part of the project is not R&D but, e.g., marketing, sales and customer support. Small errors could have a serious impact on the relative performance of a country, since the total number of observations is small. It should be kept in mind that location consultancy firms typically collect data for purposes different from those of this study, and that our observations of R&D efforts of foreign firms in the Netherlands (see section 2.4) are imperfect.

Table 3.7 Greenfield R&D FDI projects in the Netherlands relative to six selected European countries, 1991-1998

	Number of projects in six selected European countries	Number of projects in the Netherlands	Share of the Netherlands in number of projects
1991-1992	32	3	9%
1993-1994	13	2	15%
1995-1996	20	0	0%
1997-1998	29	1	3%
1997-1998, announcements	12	4	33%
1991-1998	106	10	9%

Share of the Netherlands in GDP and in total R&D expenditures is about 7%.

Source R&D-FDI data: Buck Consultants International (1995, 1997, 1999b). Source GDP and R&D expenditure data: OECD.
Notes: Projects refer to greenfield R&D-FDI by companies from thirteen selected countries (including North-American, Asian and European countries) into six European countries (UK, Belgium, France, Germany, Ireland and the Netherlands). Projects detected between 1991 and 1994 refer to investments from the US and Japan. Software investment project are not included.

These actual R&D location decisions do not perfectly match with the attractiveness of the Netherlands as suggested by the benchmark exercise of section 3.3, in particular the overall-rankings presented in table 3.5. One might have expected that more firms would have chosen the Netherlands as the best location for their R&D project, or, alternatively, that the benchmark would reveal that the Netherlands is a less-than-averagely attractive R&D location. Several possible explanations cross the mind:

- Measurements problems blur the true R&D attractiveness and the R&D location decisions.
- Since history is also a determinant of the location of R&D, and even an important determinant, location decisions need not to conform to the benchmark (see section 3.2).
- The benchmark may conceal that the Netherlands is a relatively unattractive location for the type of R&D projects that are in the market today.
- What really counts is to be the best. The Netherlands may be an attractive location on average, but for relatively few projects it may be the best location.

We do not know whether one or more of these explanations indeed clears up the imperfect match between the actual R&D location decisions and the outcome of the R&D location benchmark.

In sum, we conclude that it is difficult to gauge whether actual R&D location choices match attractiveness. There is no evidence, however, that the Netherlands clearly underperforms or outperforms in attracting R&D investments relative to its main competitors.

3.5 Trends in R&D location attractiveness

What will become of R&D locations in the future? Previous sections sticked to the current state of affairs. Several trends are said to affect R&D location decisions. We discuss six possible trends put forward in the literature.

Possible trend 1: The location of R&D becomes less dependent on history
History is currently an important determinant of the location of R&D, since R&D is subject to important economies of scale and scope, with respect to own activities and with respect to activities of other firms and of public knowledge organisations (section 3.2). History becomes a less important determinant if:

- new information and communication technologies reduce the need to concentrate a portfolio of (R&D) activities geographically (Howells, 1990; Pearce, 1999). But it is unlikely that such a reduction would be large, since many types of knowledge needed for successful R&D remain highly tacit (Venables, 2001).
- the share of R&D performed by multinational enterprises increases and intra firm R&D re-location is less expensive than inter firm re-location. Table 2.3 does not provide strong evidence for the first part of this condition.

Possible trend 2: History becomes irrelevant to the location of R&D in new technologies
The arrival of new general purpose technologies such as ICT and biotechnology supports the emergence of new R&D intensive industries. It could be argued that such new industries still have to find a place to settle down to realise economies of scale and scope. Then, countries should hurry and attract a substantial share of these new R&D activities under penalty of missing this boat. However, it could also be argued that these new technologies do not arrive like manna from heaven, but instead evolve out of existing stocks of knowledge. Then, the localization of R&D in 'new' industries is as path dependent as the localization of R&D in traditional industries.

Possible trend 3: Researchers become more mobile
The international mobility of R&D activity increases if researchers become more mobile. Migration of highly skilled workers from Asia towards North America is increasing, although small in comparison with overall migration (OECD, 2001). We do not know of direct evidence that the mobility of highly educated researchers from other continents has gone up. Evidence put forward by our interviewees is inconclusive. There is evidence that intra European mobility of EU residents in general increased substantially over the past five years (OECD, 2000b, part III) after being roughly constant over the period 1985-1995 (Krueger, 2000). In addition, the growing expats service industry in the Netherlands provide circumstantial evidence of an

increase in high-skilled labour mobility.[27] Still, the level of intra EU mobility seems to be invariably low (Krueger, 2000): for example, the share of non-Dutch EU residents in Dutch salaried employment is small (1.6%) and fairly constant over the past decade.[28]

Possible trend 4: Emerging R&D activity in emerging markets

Emerging markets, in particular in Asia and Latin-America, demand tailor-made products and services, which implies a demand for tailor-made R&D to be performed nearby consumers. This trend suggests a decrease in the relative size of the world's R&D performed in developed countries, but not an absolute decline. Several of our interviewees confirmed that their firms increased R&D activity in emerging economies, however not only to cope with local demand for innovations, but also to serve world markets. The competitiveness of several R&D locations in developing countries such as Brazil and India is said to be increasing (Albert, 1999).

Possible trend 5: What matters for an R&D location is to be the best location

The global technology-market race induces multinational enterprises to seek out the unique centers of excellence (Gassman and Von Zedtwitz, 1999; Meyer-Krahmer and Reger, 1999). Locations that 'just keep up' are not good enough anymore; locations have to be best rather than good. Quality of R&D location factors is more important than the costs (Meyer-Krahmer and Reger, 1999; Pearce, 1999; Midelfart-Knarvik et al, 2000). However, the trend is unlikely to lead to one or two hot R&D spots on the globe and a desert everywhere else, since agglomeration of R&D is bounded by congestion (Fujita et al., 1999; Albert, 1999). A trend of increased geographical specialization is more likely: a region attracts R&D in a specific field of science and technology, focussed on a specific type of customer, etcetera. Technology networks (intra firm and inter firm), alliances and partnering will coordinate geographically dispersed technological developments (Mytelka, 1993; Gerybadze and Reger, 1999; Albert, 1999; OECD, 1999).

Possible trend 6: Students turn away from science and technology educations and careers

A relatively small share of Dutch students aspires to an R&D job (section 3.3.1). According to representatives of several established Dutch R&D intensive firms, the inflow expected in the near future is alarmingly low. Still, they also argued that many competing R&D locations face a similar problem, suggesting that the relative attractiveness of the Netherlands does not change. Moreover, AWT (1999) argues that students trade in an education in traditional S&T (e.g., chemistry) for a training in new and booming technologies (e.g., life sciences and computer sciences): the overall demand for S&T training relative to non-technical education is 'remarkably' constant.

[27] De Volkskrant, 'Verhuizing expats bloeiende markt', August 24, 2001.

[28] Source: Statistics Netherlands, Buitenlandse werknemers in Nederland.

What do these possible trends tell?

If the trends 1 to 5 hold true, then competition for the location of R&D activities will increase. Trends 1 to 4 suggest that firms face an expanding set of conceivable locations for an R&D activity, because path dependency of the location of R&D diminishes, because mobility of researchers increases, and because new location options in emerging economies spring up. Moreover, if trend 5 holds true, then not only the set of location options expands, but also the competition between locations grows.

A consequence of increased competition between R&D locations is that the relative importance of R&D location factors that remain immobile increases (e.g., the quality of universities and technological institutes and the size and quality of the labour supply of supposedly less mobile technicians). Moreover, theory argues that such an increase in competition induces regions to specialise in specific technologies, specific types of R&D, and so on. Specialization in the wrong type could trap a region into a low-income equilibrium.

Possible trend 6 - substantial shortages of research personnel - will reduce the absolute quality of the Netherlands as an R&D location. Since many competing locations face a similar trend, it is not likely that the relative position of the Netherlands will be affected.

3.6 Conclusions

The conclusions from the analysis read as follows:

- History is an important determinant of the location of R&D, since firms choose to start new R&D operations through co-location, merges and acquisitions, and expansions of existing R&D facilities. Two other decisive R&D location factors are the supply of qualified researchers in science and technology and the quality of the public knowledge infrastructure including the quality of the knowledge transfer channels between science and industry. Location choices are less driven by costs (e.g., wage costs of R&D personnel).
- A benchmark reveals that the Netherlands takes an average or higher position in a ranking of OECD countries according to attractiveness to business R&D. The indicators for the size of the R&D labour force show that the Netherlands lags behind a group of leading countries. The benchmark is relatively positive on the quality of the Dutch public knowledge infrastructure, but inconclusive about the quality of the science-industry knowledge transfer.
- It is difficult to gauge whether actual R&D location choices match attractiveness. In any case, there is no evidence that firms' R&D location decisions are strongly in favour or disfavour to the Netherlands.

- Several trends have been put forward that suggest that competition for the location of R&D activities will increase. However, the pervasiveness (if not the existence) of the trends is open to debate.

4 R&D location and government policy

4.1 Introduction

There is convincing evidence that R&D is a main engine of long-term productivity growth.[29] Market failures, however, hamper the incentives to perform R&D and suggest a role for the government to select and implement policies that make a country a more attractive location for R&D. Yet, the opportunity costs of such policy initiatives may be large.

This section presents a general discussion of the social costs and benefits of R&D location policy rather than an extensive overview and analysis of specific policy instruments.[30] Section 4.2. explores the rationale for government policy in this field, in particular the interaction between R&D location and knowledge spillovers. Section 4.3 discusses the sorts of social costs R&D location policies may involve. Section 4.4 concludes.

4.2 The social benefits of R&D location policy

R&D market failure

Market failure drives a wedge between private and social returns to R&D. A firm does not take into account all the benefits and costs that society faces because of its R&D investments. On the one hand, private incentives to invest in R&D fall short of the social needs for R&D for two reasons:

- Part of the return to R&D investment accrues to consumers and other firms through knowledge spillovers, rent spillovers, and network spillovers.[31]

[29] See Cameron (1998) and Canton (2001) for surveys of this evidence, and see Atella and Quintieri (2001) for some critical remarks.

[30] CPB (forthcoming) analyses several policy options that may foster the location of R&D in detail.

[31] Knowledge spillovers: knowledge transfers for which the recipient does not pay, e.g. transfers through labour mobility, wining-and-dining, re-invention and imitation of products, and disclosure of information through patenting. Rent spillovers: inventors do not capture all value their customers derive from the innovation, since prices are less than customers' willingness to pay. Network spillovers: a firm's innovation is complementary to another firm's innovation, so both firms may wait for each other's innovations till the cows come home, e.g. hardware and software in telecommunication. The classic reference for an exposition of different sorts of R&D spillovers is Griliches (1979).

- R&D is risky, hence risk adverse firms with few opportunities to diversify risks invest less in R&D.[32] Moreover, R&D requires up-front payments, hence credit- or liquidity constrained firms face difficulties to invest in R&D.

  On the other hand, there are reasons for private incentives to exceed the social incentives:
- New knowledge makes existing markets of other firms dead wood. This is the so-called business stealing or creative destruction effect.
- Innovation races mean duplication of R&D efforts.[33]

  The empirical literature shows that, all-in-all, the social returns to R&D exceed the private returns, even at the current level of public support for innovation (Griliches, 1992; Mohnen, 1996).

Spillovers and geography

R&D spillovers are not evenly spread around the globe. Geography matters. Physical, cultural, jurisdictional and organizational borders limit the scope for knowledge spillovers. Spillovers need linkages, and those linkages tend to be more dense when distances are short (see e.g., Marshall, 1920; Storper, 1992; Markusen, 1996). Case studies show that physical proximity plays a key role in the innovative success of regions such as Third Italy, Silicon Valley, and Baden-Württemberg (Storper, 1993; Saxenian, 1994; Sternberg, 1999). Indeed, the general finding of the literature is that spillovers become less important as geographical distance increases (see e.g., Jaffe et al., 1993; Audretsch and Feldman, 1996; Keller, 1997, 2001; Jacobs et al., 1999; Branstetter, 2001; Tijssen, 2001; but see also Verspagen, 1997).[34] So we conclude that R&D spillovers that are bounded by distance motivate national policies that foster R&D in the domestic economy.

Even though the evidence shows that spillovers are bounded by distance in general, this need not hold true for specific cases. Some long-distance R&D linkages may be welfare-enhancing relative to short-distance connections, for example because they are relatively dense or because they connect the domestic economy with relatively valuable foreign knowledge stocks. Hence, in some cases, the domestic economy may even benefit from a relocation of domestic R&D activity to a foreign country.

[32] An obvious risk is the risk of technical failure of the R&D project. But there are also market related risks. A competitor may independently produce a superior innovation and capture the market. A competitor may learn from your (marketing, distribution, technological) mistakes, learn better, and capture the market.

[33] In addition, Cooper et al. (2001) argue that if income growth implies a shift in relative preferences from normal goods towards status goods, then business R&D will be focused on status goods, hence will have a negative impact on utility growth though a positive impact on economic growth.

[34] Beugelsdijk and Cornet (2001) did not find evidence that distance reduces knowledge spillovers within the Netherlands.

Spillovers of foreign versus domestic R&D

The next question is: does society benefit more or less from foreign direct R&D investments than from domestic R&D? Differences in social returns between foreign and domestic direct R&D investments could imply a different policy agenda for foreign R&D. The arguments include the following:

- Foreign direct R&D opens a linkage between the domestic economy and the knowledge base of the foreign firm. Domestic firms can benefit from knowledge spillovers, for example through labour mobility of researchers (Fosfuri et al., 2001). Branstetter (2000), for example, finds evidence that Japanese FDI in the US has had a positive impact on local US productivity through knowledge spillovers. Barrell and Pain (1997) find similar evidence for FDI in Germany and the UK. Keller (2001) finds corresponding evidence for FDI in the G-7 countries. The evidence is likely to hold for R&D FDI all the more. Knowledge spillovers are unlikely to materialize, however, if domestic firms lack absorptive capacity or if linkages between domestic firms and the foreign firms are weak (Blomström and Kokko, 1998).
- New R&D operations and new innovative producers force incumbent, domestic innovators to enhance their competitiveness. Increased competition presses incumbents to reduce x-inefficiencies. Increased competition in domestic output markets compel incumbents to be innovative too. Both effects benefit the domestic economy (Porter, 1990; McKinsey Global Institute, 1993; Blomström and Kokko, 1998).
- Some innovations beg for complementary innovations that have to be produced in close interaction with each other. An innovation of a foreign firm tailor-made to local demand may create a demand for complementary innovations of local, domestic firms. Empirical evidence, either pro or con, is non-existent (Fosfuri et al., 2001).
- Foreign R&D facilities may crowd out domestic R&D inputs, and compete with innovations of domestic firms in domestic and foreign markets. This competition reduces the rents domestic firms enjoy from their innovations. Shareholders of the foreign firm benefit at the expense of domestic firms. There is evidence that multinationals perform R&D abroad to exploit and strengthen their knowledge base (Pearce, 1999; Patel and Vega, 1999; Lipsey, 2000), but we are not aware of evidence that multinationals enter in markets of domestic firms thanks to their foreign R&D activities.

We are not aware of studies that weigh up the relative pros and cons. We therefore conclude that we do not know whether foreign direct R&D investments benefit society more or less than domestic R&D investments.

Spillovers and re-location of R&D

The following box illustrates the case for short and long-distance R&D spillovers with a hypothetical story of a firm that re-locates an R&D activity to a foreign location. The story first tells that the loss of short-distance spillovers may be offset by new spillovers that the researchers who were formerly engaged in the re-located activity now generate in their alternative research jobs. Second, it is argued that the re-location changes the set of long-distance linkages between the Dutch knowledge infrastructure and those of foreign countries, and that it is difficult to tell a priori whether this affects Dutch welfare positively or negatively.

Conclusions

There is strong evidence that the social returns to R&D exceed the private returns (even in the current presence of public support for R&D), and that R&D spillover effects are bounded by distance. Hence, policies that foster R&D in the domestic economy are legitimate. There is no evidence that social returns to foreign direct R&D investments are larger or smaller than those to domestic R&D investments. Hence, there is no evidence that supports R&D policy measures that discriminate between domestic and foreign direct R&D investment.

The impact of the re-location of R&D activity on R&D spillovers

Suppose a Dutch multinational firm X decides to move several R&D activities to foreign locations. What will be the welfare effects for the Dutch economy?

The story starts as follows. Since R&D (knowledge) spillovers are bounded by distance, the social returns of firm X's relocated R&D activities will not benefit the Dutch economy anymore. However, this loss will be compensated by the new activities of former R&D employees of firm X. Indeed, these workers tend to stay in their home country, and they are likely to look for a similar type of job in order to benefit from their specific stock of human capital (that includes a set of business friends and university contacts). Since R&D personnel is in short supply these days, it is highly likely that displaced R&D workers will find such a similar job. These jobs will yield spillovers as well. Hence, the real issue is whether the spillovers associated with the employment alternatives are smaller or larger than those of the relocated jobs. If relocation of R&D activities implies a shift of the Dutch economy (or the Dutch branch of multinational X) to R&D activities with even higher social returns, then the Netherlands clearly benefit. If not, productivity slows down.

But there is more to the story: relocation of R&D affects the set of R&D spillover channels. Indeed, relocation of some of firm X's R&D activities is likely to open new linkages between the Dutch and the foreign innovation system or improve upon existing ones. Hence, R&D spillovers previously inhibited by distance now reach the Dutch economy. Conversely, the foreign country also benefits from better access to the Dutch innovation system. This could imply more foreign innovations that compete with those of Dutch firms, including firm X, and reduce their market power. But it also could imply complementary innovations that spur demand for Dutch innovations. Or it could press firm X and other Dutch firms to be more competitive and innovative to their own benefit.

Hence, we cannot a priori conclude that relocation of some of firm X's R&D activities is good or bad for the Dutch economy.

Now suppose that a Dutch firm X decides to close its R&D site and to relocate all its R&D activities to a foreign country. Again, the welfare loss will be compensated by the social returns of the alternative jobs of firm X's former R&D personnel (partly, fully, or possibly even more than fully). It is unlikely, however, that the Dutch economy will benefit from firm X's foreign R&D, since firm X now lacks a Dutch R&D site to absorb the R&D spillovers. Moreover, since new R&D sites tend to pop up infrequently (see section 2), loss of an R&D site is not easily offset by the arrival of a new one. Hence, closure of an R&D site could decrease the diversity and scope of the Dutch innovation system.

4.3 The social costs of R&D location policy

The previous section set out the potential benefits of R&D location policy. This section sketches the sorts of (opportunity) costs of some policy options aimed to make the Netherlands more attractive to R&D. We restrict ourselves to a discussion of policy options that address two important R&D location factors (see section 3.2): the size and quality of the R&D labour force and the quality of the knowledge transfer between science and industry.

First, however, we take a small step aside. We did not observe that location factors decisive for foreign direct R&D investment are not decisive for domestic R&D investments and vice versa (section 3.2). What is good for foreign direct R&D investments is what is good for domestic R&D. Hence, policies that improve upon decisive R&D location factors do not discriminate between foreign and domestic R&D investments. Even if there is a case for differential policy (and there is no such evidence, see section 4.2), then it would still be impossible to design such policy as far as the decisive R&D location factors are concerned.

Policies addressing the R&D labour force

Labour supply of the R&D work force may be quite inelastic in the short run but also in the longer run. There is evidence that it is difficult to induce R&D personnel to work more hours, to induce workers in non-R&D jobs to switch to an R&D career, and to induce students to favour a science and engineering education (even though there is a substantial number of female non-tech students that is technically talented).[35] It might be less difficult to reduce the drop out rate of students in science and technology (Berkhout and Van Leeuwen, 2000). Furthermore, a switch towards an R&D education/job involves opportunity costs if the student/worker would have created positive spillovers in her alternative career in, for example, finance, logistics, marketing and sales, or (public) management. We are not aware of evidence on the size of those alternative spillovers. In sum, the effectiveness of policies intended to increase the R&D labour supply is hampered if the R&D labour supply is inelastic, and the efficiency of such policies is reduced if additional R&D labour would have creates large social returns in its alternative employment.

An alternative for 'more R&D workers' is 'better R&D workers'. Policies that enhance the productivity (e.g., absorptive capacity, creativity, entrepreneurship) of scientists and engineers also raise the effective R&D labour supply. The policy options typically address the educational sector at all levels (e.g., undergraduate, graduate and post-graduate), but could also aim at 'life-long learning' activities within business organisations. The benefits of such policies should

[35] Marey and Borghans (2000) estimate that, in the short run, wage increases capture about 30% of additional R&D expenditures in the Netherlands. In the long run, the wage gain for incumbent researchers is about 20% of additional R&D spending. Goolsbee (1998) find similar evidence for the US. Groot et al (1999) find that about 30% of Dutch high-skilled technical workers favour a non-technical job. AWT (1999) observes that the share of Dutch students choosing to graduate in science and engineering has been 'remarkably' stable over the past 30 year. Berkhout and Van Leeuwen (2000) find that the share of Dutch students (high school and undergraduate level) that chooses a non-technical education while considering a technical education a (serious) alternative is very small. Romer (2000) points at institutional bottlenecks in the US system of higher education that hinder students to choose the field of study that fits their preferences best. Oosterbeek and Webbink (1997) show that a subtantial share of female non-tech students is technically talented.

be offset against the costs, which include the opportunity costs of foregone productivity while learning.

Policies addressing the public-private knowledge transfer

Improving the transfer of knowledge from universities and technological institutes to the business sector ranks high on the policy agenda (Schmoch et al, 2000; OECD, 2000a; AWT, 2001a and 2001b; Venniker and Jongbloed, 2001). The policy measures under discussion push or allow public knowledge organizations to enter the private market for knowledge, foster scientists to set up new firms, induce public research organisation to claim and exploit intellectual property rights, and gear the pure science agenda towards the long-term needs of industry, among others. The possible adverse effect of such initiatives is that a too strong focus on industry's needs could crowd out the main missions of the public knowledge sector, in particular the production and broad diffusion of pure and basic science. Hence, policy initiatives need to balance these pros and cons of stronger incentives to science-industry knowledge transfer.

Conclusions

The strong rationale for R&D location policy does not necessarily imply that such policy initiatives are always effective and efficient: the elasticities and the social (opportunity) costs should be taken into account. For example, increasing the supply of R&D labour could be difficult, and the opportunity costs of such policy measures are large if the alternative jobs of additional R&D workers would have generated large social returns. Policy initiatives that raise the quality of the R&D labour force through learning and education may face opportunity costs of foregone productivity. Policies that enhance industry-science relationships could divert public knowledge organisations from their main mission: production and broad dissemination of pure and basic science.

4.4 Conclusions

Policy that fosters the location of R&D activities in the domestic economy is well-grounded, since R&D spillover effects are substantial and, moreover, bounded by distance. There is no evidence that supports policies that differentiate between foreign and domestic direct R&D investments. The strong rationale for R&D location policy does not necessarily imply that such policy initiatives are always effective and efficient: policy makers should take into account the elasticities and the social (opportunity) costs.

5 Summary and conclusions

Motivation

Research and development (R&D) is a main engine for productivity growth. Since the social benefits of R&D tend to be localized, a country's growth engine runs at a higher speed if a given R&D activity is performed at home instead of abroad, all other things equal. Moreover, since the social benefits of R&D outweigh the private rewards, the rationale for government policy that fosters the location of R&D is strong. (Section 4.2)

Setting the stage: the location of R&D in the Netherlands

A handful of large Dutch-based multinational enterprises (MNEs) performs the lion's share of Dutch business R&D. The remainder is carried out by a small group of mostly multinational companies, and a substantial number of them is headquartered in foreign countries. Recent years have seen an increase in R&D activity in the Netherlands, by Dutch and foreign firms alike. (Section 2.2)

R&D locations do not arrive out of the blue in the Netherlands: greenfield R&D investments are rare. Generally, new R&D activities are located at established sites close to current activities, i.e. they are labelled co-location and expansion projects. Once established in the Netherlands, R&D facilities tend to stay, although the scale of the operations may change over time. This holds both for Dutch-owned and for foreign-owned firms. Hence, the location of R&D is path-dependent. (Section 2)

Since the 1980s, a number of Dutch R&D-intensive firms have merged or have been acquired by foreign enterprises. We did not find evidence that in general new, foreign ownership brought a considerable change in scale of R&D activity, neither positive nor negative. (Section 2.4)

Some Dutch firms have increased their foreign R&D activities, in relative and absolute terms. In general, these incremental activities did not affect the size of the R&D operations in the Netherlands negatively. Other Dutch firms strengthened the role of Dutch R&D sites in the company's R&D. For example, Philips (by far the largest R&D investor in the Netherlands) recently started to build a new high tech campus, expanding its main research centre. (Section 2.3)

R&D location factors

The major determinants of the choice of site and size of R&D operations are:

- history
- the supply of qualified researchers in science and technology

- the quality of the public knowledge infrastructure including the quality of the science-industry knowledge transfer channels

  R&D location decisions seem to be less driven by the costs of R&D inputs. (Section 3.2)

A benchmark study of R&D location factors (apart from history) shows that the Netherlands takes an average or higher position in a ranking of OECD countries according to attractiveness for business R&D. The size of the R&D labour force in the Netherlands lags behind those in a group of leading countries. The quality of the Dutch public knowledge infrastructure is relatively high. Indicators are inconclusive about the quality of the science-industry knowledge transfer. (Section 3.3)

Firms' R&D location decisions are neither very favourable nor very unfavourable to the Netherlands. (Section 3.4)

Several trends have been put forward that suggest that competition for the location of R&D activities will increase. Still, the pervasiveness of the trends is open to debate. (Section 3.5)

Policy options

The empirical rationale for government policy that fosters the location of R&D is strong. There is no evidence that supports differentiated policies towards foreign and domestic direct R&D investments. (Section 4.2)

However, the strong policy rationale does not necessarily imply that such policy initiatives are always effective and efficient: the elasticities and the social (opportunity) costs should be taken into account. For example, increasing the supply of R&D labour could be difficult, at least in the short run, and the opportunity costs are large if the alternative jobs of the additional R&D workers would have generated large social returns. Policy initiatives that raise the quality of the R&D labour force through learning and education may face opportunity costs of foregone productivity. Policies that enhance industry-science relationships could divert public knowledge organisations from their main mission: production and broad dissemination of pure and basic science. (Section 4.3)

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Abstract

Many factors determine the location of business R&D projects, the most important being history, the supply of R&D labour, and the quality of the public knowledge infrastructure (including the science-industry knowledge transfer). The set of R&D locations in the Netherlands changes little over time. But two things do change regularly: the size of the R&D activities at a particular site and the name and nationality of the owner of an R&D site. The Netherlands takes an average or higher position in a ranking of OECD countries according to attractiveness to the location of business R&D. Since domestic R&D is an important engine for domestic economic growth and since the market fails to provide optimal incentives for R&D, there is scope for government policy that improves upon the R&D location climate. Yet, this policy rationale does not necessarily imply that R&D policy initiatives are always effective and efficient: elasticities and social (opportunity) costs should be taken into account.

JEL codes: O32, O38, R30
Key words: business R&D, R&D location, R&D policy