Chapter 4

Innovation actors in the Netherlands

This chapter describes the main actors in the Dutch innovation system – business enterprises, higher education institutes and public research institutes – highlighting their respective roles in the development of the innovation system in recent years. It reviews scientific, technological and related functions carried out by the main actors within the system and their contributions to innovation.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

4.1. Business sector

Overall industry profile

The Dutch business sector is very diverse. By some measures, the Netherlands' exports are among the four most diversified in the world (Hausmann and Hidalgo, 2013, p. 21). This is impressive for a country of its size but reflects, of course, the Netherlands role as a gateway to Europe and the large volume of re-exports. Alongside good export performance in high-technology sectors such as electronics and pharmaceuticals (see Chapter 2), the Dutch business sector exports strongly in sectors that are traditionally not considered knowledge-intensive or high-technology, notably in niches of agriculture and food products. These strengths undoubtedly reflect historical patterns of specialisation, but also ability to add value by way of innovation and strategic positioning in global value chains and to build on the country's location at the heart of large European markets.

Since the 1970s, the Netherlands has also developed a sizeable services sector. The shift towards services, both via the development of new services firms and the "servitisation" of traditional industry, reflects to some extent the Dutch economy's diminishing cost competitiveness. Although the services sector overall is afflicted by lagging productivity performance (see Chapter 2), parts of it are internationally very competitive. While these strong points are difficult to capture with traditional export statistics, the performance of the Netherlands on various measures of licensing of intellectual property provides some direct indications of strengths in internationally traded services. Naturally, the contribution of the services sector to the Dutch economy cannot be ascertained simply from measures of its own performance in terms of value added or exports. Transport, logistics, information technology (IT) and not least, finance, provide services that are crucial for the performance of other sectors, including manufacturing.

Table 4.1. Firm demographics in the Netherlands, 2012

	Number of enterprises			Number of employees				Value added			
	Netherlands		EU27	Netherlands		EU27	Comparator group	Netherlands		EU27	Comparator group
	Number	Share	Share	Number	Share	Share	Share	EUR billions	Share	Share	Share
Micro	602 149	91.6%	92.1%	1 438 484	26.8%	28.7%	24.5%	62	20.9	21.1%	23.1%
Small	45 079	6.9%	6.6%	1 102 544	20.6%	20.4%	21.8%	60	20.3	18.3%	18%
Medium	8 497	1.3%	1.1%	1 012 041	18.9%	17.3%	17.8%	67	22.6	18.3%	18%
SMEs	655 724	99.8%	99.8%	3 553 069	66.3%	66.5%	64.1%	189	63.8%	57.6%	59%
Large	1 514	0.2%	0.2%	1 804 649	33.7%	33.5%	35.9%	107	36.2%	42.4%	40.8%
Total	657 238	100.0%	100.0%	5 357 718	100.0%	100.0%	100.0%	297	100.0%	100.0%	100.0%

Note: The comparator group includes Austria, Belgium, Denmark, Finland, France, Germany, Norway, Sweden, United Kingdom (United States excluded owing to lack of data).

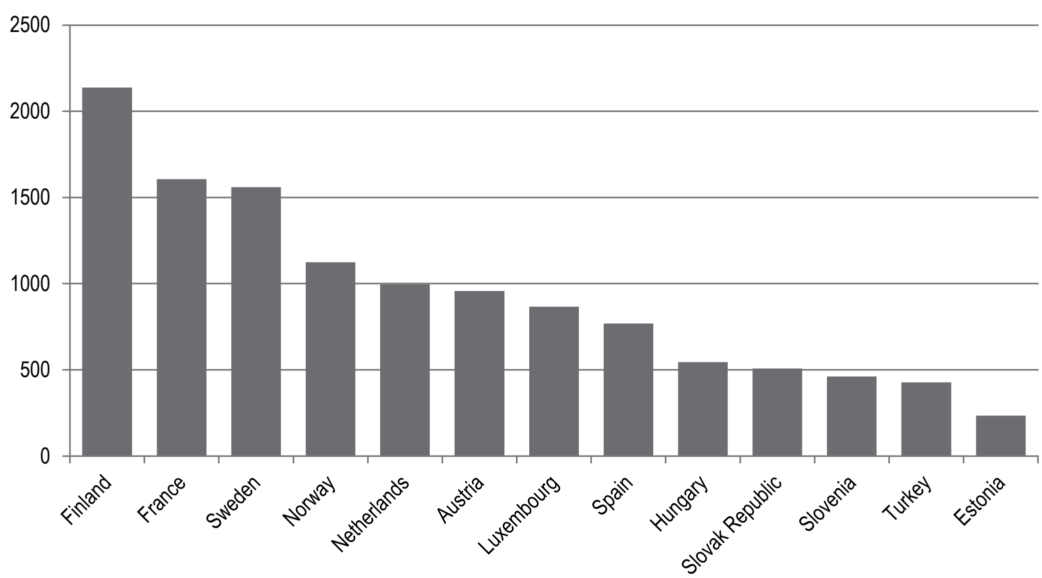
Source: European Commission (2013a), "2013 SBA Fact Sheet The Netherlands", Directorate-General Enterprise and Industry, http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/performance-review/files/countries-sheets/2013/netherlands_en.pdf; European Commission (2013b), "Database for the Annual Report on European SMEs", Directorate-General Enterprise and Industry, http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/performance-review/index_en.htm.

The share of the workforce employed in small and medium-sized enterprises (SMEs) is comparable to the EU average, but higher than in the comparator group of countries with advanced innovation systems (Table 4.1). Dutch SMEs, and medium-sized companies in particular, are more productive than the EU and even the comparator group averages, accounting for 64% of value added, as opposed to 57% for the EU. Relative to the EU average, Dutch SMEs are oriented more towards services than manufacturing: manufacturing accounts for about a third less of SME employment than the EU average. Among Dutch services SMEs, 43% are engaged in knowledge-intensive services and 8% in high technology activities, as opposed to 30% and 5%, respectively, in the EU (EC, 2013a; EC, 2013b).

Innovation and R&D performance

The average innovation expenditure of firms (Figure 4.1) can provide useful insight into the scale of innovative effort, not only for R&D but also for the purchase and integration of the latest capital goods, implementation of new processes, training, and additions to the firm's stock of accessible knowledge such as licences. In contrast to expenditure per worker or per some unit of economic output, it is a measure of the scale of expenditure deployed within the firm's boundaries. As such it may better correspond to the size of its R&D projects and of the extent to which innovative effort can overcome the "indivisibilities" often associated with innovation activity. According to the 2008-10 Community Innovation Survey (CIS), the average Dutch innovating firm spent about a million euros on innovation. This puts it ahead of many European countries but at about half of the spending of Finnish firms and about two-thirds that of French and Swedish firms.

Figure 4.1. Average innovation expenditure per innovating company, 2008-10



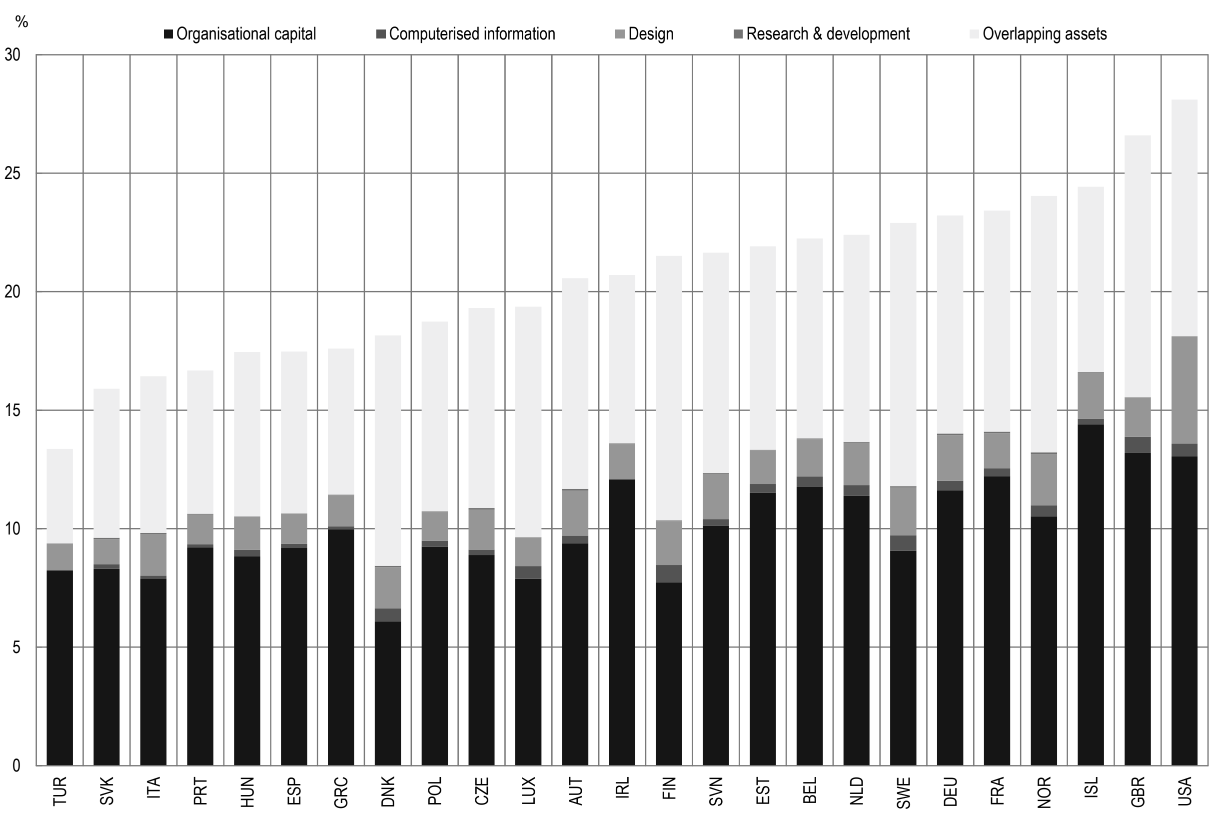
Note: Germany and some non-EU members missing due to lack of data.

Source: OECD, based on Eurostat (2014), "Statistics Database", http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database.

Companies across the OECD use a much larger share of employment and investment for knowledge-intensive activities, such as design and various aspects of engineering, than for R&D. The Netherlands has a relatively high 22% of employment in occupations contributing to R&D, design, software and database activities and to firms' organisational know-how (Figure 4.2). It is ahead of Finland, Austria and Denmark but behind most other countries with advanced innovation systems. Eurostat (2014) figures on the share of employment in industries classified as knowledge-intensive (on the basis of their average propensity to employ tertiary graduates) show a relatively high 36.4%, for the Netherlands, a share that is in keeping with the levels of Finland, Norway and Germany. These employment figures show that the Netherlands possesses the human capital and the production structure that underpin strong innovation systems. They also allow for the possibility that Dutch companies engage in more knowledge-intensive activity than is suggested by the relatively low level of business R&D expenditure. What is relatively certain (as observed in Chapter 3) is that the Netherlands is among the global leaders in terms of its human resources and well positioned to close any gaps in aspects of its current innovation performance.

Figure 4.2. Knowledge-based capital related workers, 2012

As a percentage of total employed persons



Notes: Workers contributing to R&D, design, software and database activities and to firms' organisational know-how account for between 13% and 28% of total employment in many OECD economies (total length of the bar). Of these workers, between 30% and 54% contribute to more than one type of KBC asset (bar "overlapping assets"). R&D is difficult to discern in this graph as it accounts for less than 1% in all countries.

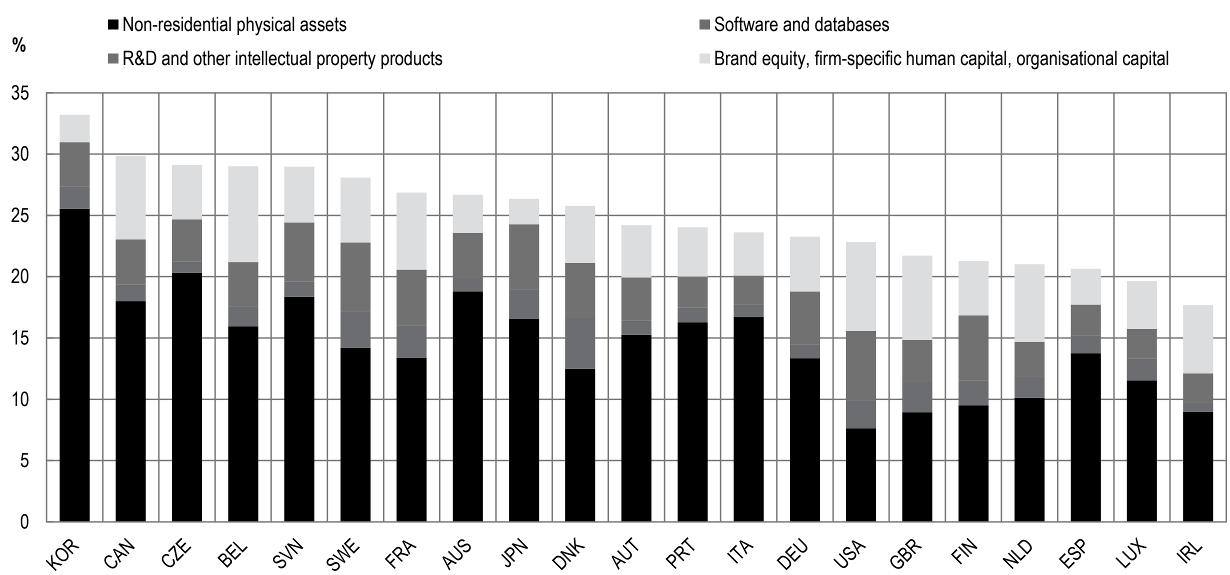
Source: OECD (2013a), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing. doi: 10.1787/sti_scoreboard-2013-en.

Firms' innovation efforts are largely dependent upon a variety of investments in knowledge assets. These investments enable them to remain successful in their respective markets, without necessarily pushing the global knowledge frontier. Whereas employment figures are suggestive of the current degree of knowledge-intensity, investments can be seen as indicative of firms' preparations for the future.

Figure 4.3 shows investments in knowledge-based capital (KBC), including software and databases, brand equity, firm-specific human capital, organisational capital as well as R&D and other intellectual property, in the Netherlands and other OECD countries. In 2010 the Netherlands had a relatively low level of investment in assets of all types, including non-residential physical capital, partly owing to the pressures of the global economic crisis. In terms of KBC, the Netherlands is better positioned relative to the OECD area, but with 11% of business sector value added, it still trails the United States (15%), Sweden (14%), France, Belgium, Denmark and the United Kingdom (13%). Most of the difference with leading countries is due to relatively weak investments in R&D and other intellectual property assets, followed by software and databases. Dutch firms' investment in brand equity, firm-specific human capital and organisational capital appears on par with other advanced systems.

Figure 4.3. Investment in physical and knowledge-based capital, 2010

As a percentage of value added in the business sector



Notes: For Canada, Japan and Korea estimates refer to 2008. Estimates refer to the business sector for all countries except Korea, for which estimates refer to the total economy. Value added in the business sector is adjusted to include knowledge-based investments. Data on KBC for Australia provided by L. Talbott; all data for Canada provided by J. Baldwin, W. Gu and R. Macdonald; data on KBC and physical assets for members of the European Union, Norway and the United States provided by the INTAN-Invest consortium led by C. Corrado, J. Haskel, C. Jona-Lasinio and M. Iommi; all data for Japan provided by K. Fukao and T. Miyagawa; data on KBC for Korea provided by H. Chun. Data on tangible investment for Australia, Austria, Denmark, Finland, France, Ireland, Italy, Korea, Luxembourg, the Netherlands, Spain and Sweden and data on adjusted value added for Australia, Korea, Luxembourg and Portugal are OECD calculations based on OECD and Annual National Accounts Databases, May 2013.

Source: OECD (2013a), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing. doi: 10.1787/sti_scoreboard-2013-en.

The Dutch business sector's reaction to the global economic crisis can indicate how it responds to threats and can, symmetrically, be suggestive of its overall evaluation of future opportunities. In particular, changes in firms' investments in different types of assets may reveal the priority accorded to different types of investments as a source of profitability. In 2008-10 business investment contracted, but the contraction varied considerably across countries and for different types of assets. Whereas investment in physical non-residential assets fell across the OECD, some countries increased their investments in KBC assets. In the Netherlands all types of knowledge-based capital investments decreased, in contrast to Belgium and Denmark, and to some extent, Finland, France and Germany[1] (OECD, 2013a, p. 39).

In absolute terms, businesses in the Netherlands spend significantly on R&D. Expressed in constant 2005 USD PPP, Dutch business R&D expenditure (BERD) stood at USD 7.5 billion in 2012, a level comparable to Sweden (USD 7.7 billion), and higher than Switzerland (USD 6.8 billion), Austria (USD 6 billion), Belgium (USD 5.5 billion) and Finland (USD 4.1 billion) (OECD, 2014). However, as shown in Chapter 2, the Netherlands is less R&D-intensive than comparable countries. BERD as a share of GDP in particular is low compared to other countries with advanced innovation systems (Table 4.2). For much of the past decade (and the two preceding decades), BERD intensity has stagnated, declining slightly from just over 1% in 2000 to 0.9% in 2010. It has since increased, but, because important changes in the measurement of BERD were introduced in 2011 (see Chapter 3) at least part of the increase (by EUR 1.6 billion in 2011 in real terms) corresponds to improvements in the measurement of BERD.

Table 4.2. BERD as a share of GDP, 2000 and 2005-12

	2000	…	2005	2006	2007	2008	2009	2010	2011	2012
Austria	..		1.72	1.72	1.77	1.85	1.84	1.91	1.90	1.95
Belgium	1.42		1.24	1.29	1.32	1.34	1.34	1.41	1.52	1.52
Denmark	..		1.68	1.66	1.80	1.99	2.21	2.01	1.96	1.96
Finland	2.37		2.46	2.48	2.51	2.75	2.81	2.72	2.68	2.44
France	1.34		1.31	1.33	1.31	1.33	1.40	1.42	1.44	1.45
Germany	1.74		1.74	1.78	1.77	1.86	1.91	1.88	1.96	1.95
Netherlands	1.07		1.01	1.01	0.96	0.89	0.85	0.89	1.14	1.22
Norway	..		0.81	0.79	0.84	0.84	0.91	0.86	0.86	0.87
Spain	0.49		0.60	0.67	0.71	0.74	0.72	0.72	0.71	0.69
Sweden	..		2.59	2.75	2.51	2.74	2.55	2.33	2.33	2.31
Switzerland	1.82		..	..	..	2.11	..	..	..	2.17
United Kingdom	1.17		1.04	1.06	1.09	1.09	1.10	1.08	1.13	1.09
United States	1.94		1.73	1.79	1.86	1.97	1.96	1.87	1.89	1.95
Total OECD	1.51		1.48	1.52	1.56	1.61	1.59	1.56	1.59	1.62
EU28 (OECD estimates)	1.11		1.08	1.10	1.11	1.14	1.16	1.17	1.22	1.22

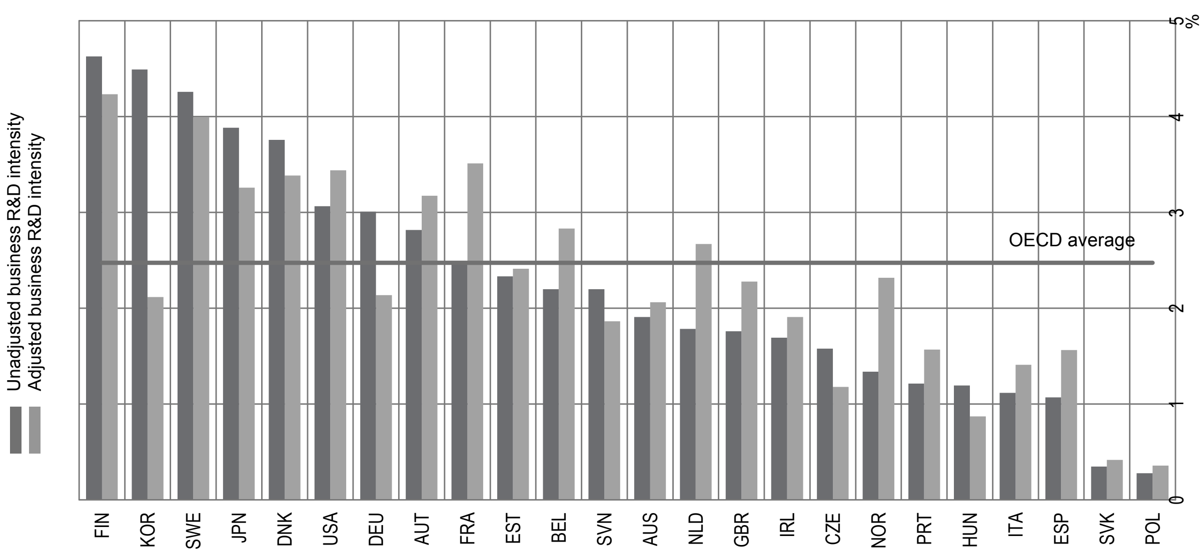
Source: OECD (2014), *Main Science and Technology Indicators*, Vol. 2013/2, OECD Publishing, doi: 10.1787/msti-v2013-2-en.

The reasons for the low level of business R&D are the subject of some debate. The literature has attempted to explain it in terms of industrial structure, insufficient collaboration between business and public research institutes, and the internationalisation of R&D (Erken and Gilsing, 2005).

The prevalence of sectors that typically invest little in R&D is certainly an important part of the explanation. Some question the appropriateness of R&D as a measure of innovation for a country with the Netherlands' industrial structure. Clearly, not all sectors are equally prone to engage in R&D. R&D tends to capture innovation activity better in manufacturing, whereas firms in services can innovate without much R&D. At the same time it is important to recall that relatively low levels of R&D intensity may be not only a consequence but also a *cause* of the types of prevalent economic activity.

Irrespective of the sector, however, for a system operating, and competing, at the global frontier, the *scope* of innovation activity – whether new-to-the-world or less ambitious – is of utmost importance. To remain at the global frontier, a sector must sustain or develop its capacity potentially to shift that frontier.[2] Doing so requires a range of innovation capabilities of which R&D is only a part. Nevertheless, R&D is an indicator of innovation input with a reasonable expectation of producing knowledge that is new-to-the-world.[3] Until more holistic indicators of innovation input with a global frontier orientation can be developed (e.g. in the CIS), a critical appreciation of R&D statistics (by e.g. statistically correcting for the varying propensity to perform R&D across sectors) seems a reasonable way of ascertaining proximity to the frontier at the side of inputs.

Figure 4.4. Business R&D intensity adjusted for industrial structure, 2011

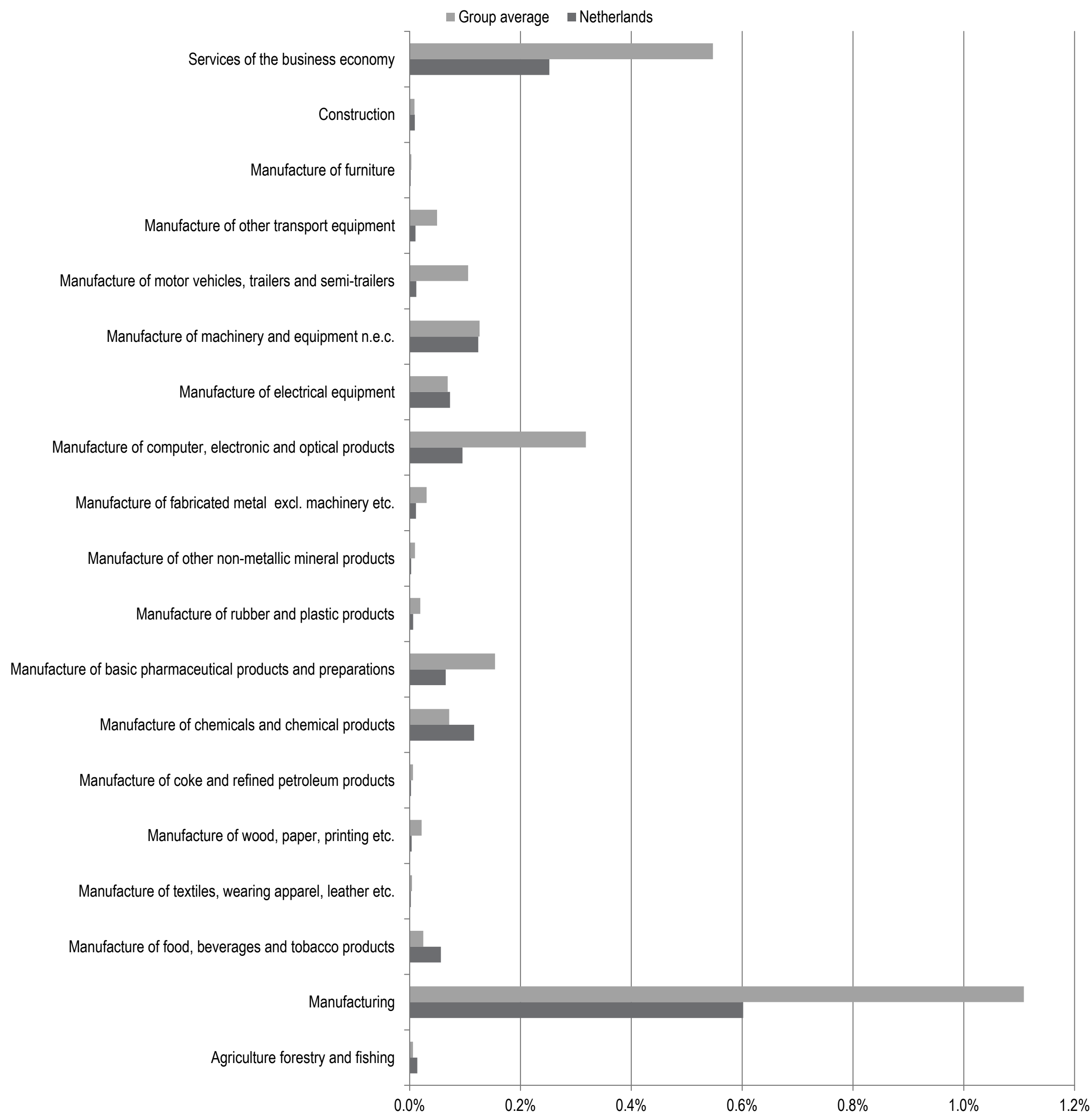


Note: R&D intensity adjusted for industry structure is a weighted average of the R&D intensities of a country's industrial sectors, using the OECD industrial structure's sector value added shares as weights instead of the actual shares used in the unadjusted measure of R&D intensity.

Source: OECD (2013a), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, doi: 10.1787/sti_scoreboard-2013-en.

Figure 4.5. R&D intensity across industrial sectors, 2010 or latest years

Expenditure on R&D in the sector as a share of GDP

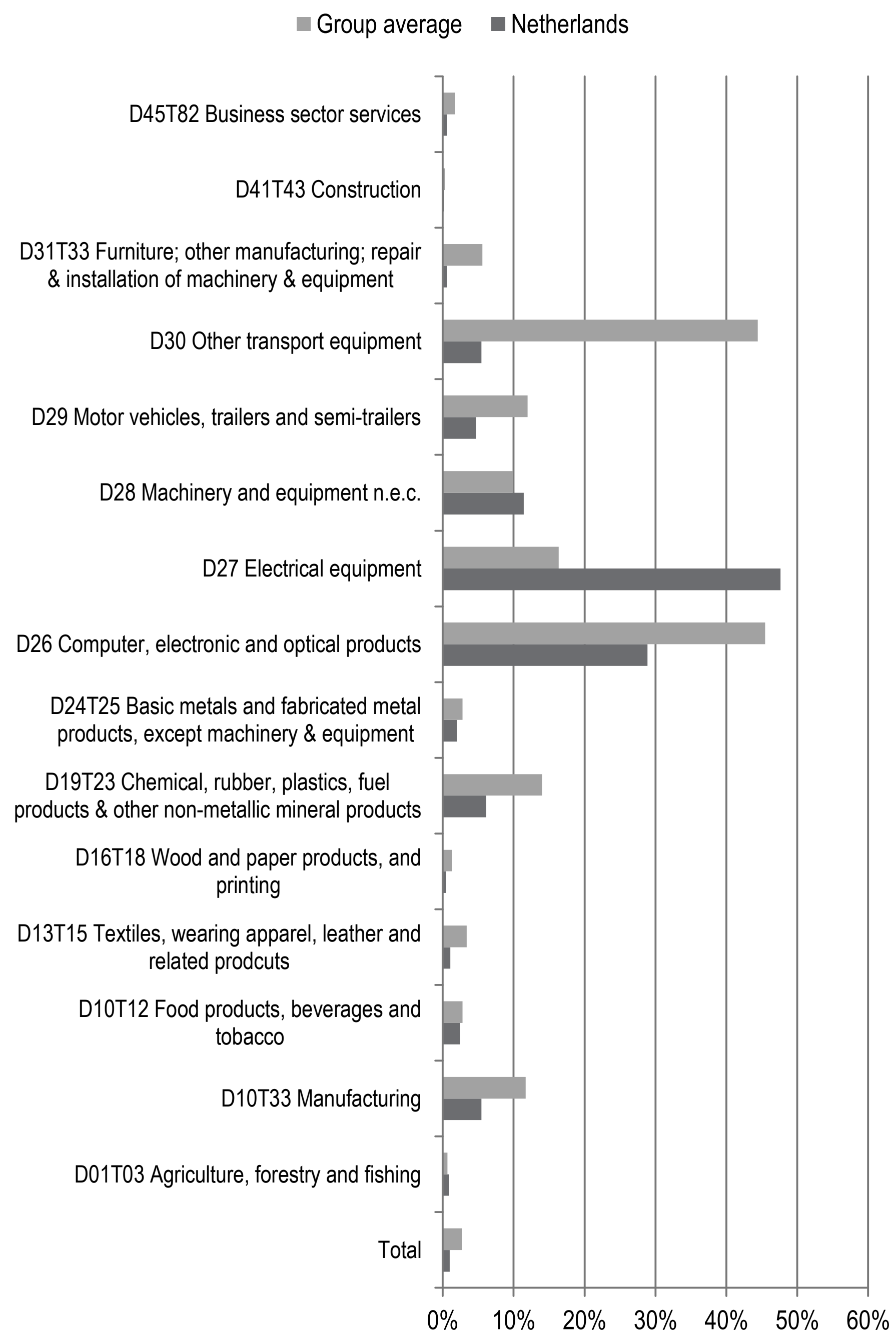


Note: The comparator group includes Austria, Belgium, Denmark, Finland, France, Germany, Netherlands, Norway, Sweden, United Kingdom, United States. Latest figures are from 2009 for Austria, Belgium, Sweden, United States.

Source: OECD Research and Development Statistics.

Figure 4.6. R&D intensity across industrial sectors, 2010

Expenditure on R&D in the sector as a share of sectoral value added



Note: Provisional figures. The comparator group includes Austria, Belgium, Denmark, Finland, France, Germany, Netherlands, Norway, United States.

Source: OECD Structural Analysis (STAN) Database.

Figure 4.4 presents an attempt to estimate the R&D intensity of countries if they all had the average OECD production structure. In fact, once sectoral structure is taken into account, the Netherlands' share of BERD in GDP increases to just above the OECD average. Nevertheless, it is still behind many comparator countries: Finland, Sweden, France, the United States, Denmark and Belgium.

To evaluate the R&D performance of specific sectors, Figure 4.5[4] compares the R&D intensity of the Netherlands to that of the comparator group average for the same sectors. It is striking that Dutch businesses appear to invest less than their counterparts in countries with advanced systems in all but four manufacturing sectors: food, beverages and tobacco products; chemicals and chemical products, manufacture of electrical equipment; and manufacture of machinery and equipment n.e.c. The gap is particularly pronounced for services of the business economy, and within manufacturing for motor vehicles; transport equipment; computer, electronic and optical products; and basic pharmaceutical products.

The production structure of the Netherlands differs in important ways from that of the comparator group, notably its stronger specialisation in services (see Chapter 1). In the case of services, differences in the production structure may overstate the sectoral R&D deficit observed in Figure 4.5. An alternative indicator of R&D intensity based on R&D expenditures as a share of sectoral value added (comparator group excludes Sweden and the United Kingdom due to lack of data) confirms the main patterns (Figure 4.6).

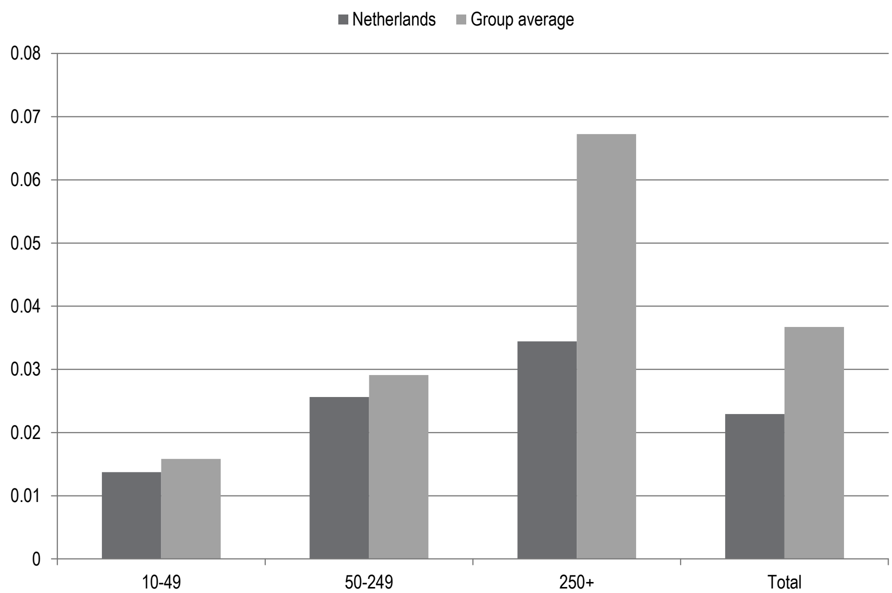
In the Netherlands, SMEs account for about 6% more of total BERD than they do in comparator countries. Aside from that, the distribution of expenditures across firm-size bands does not differ significantly to the reference group of advanced innovation systems. It is however striking that for the R&D intensity of the various size bands (Figure 4.7), the deficit in R&D spending with respect to the reference group is greatest for firms with 250 employees or more.[5] At this level of aggregation it is difficult to say whether the prevalence of the R&D deficit in large firms is a distinct phenomenon or a corollary of the sectoral R&D deficit.[6]

For R&D personnel as a share of industrial employment, the Netherlands is near the comparator group median (Table 4.4). With around 12 R&D workers per thousand, it leads Norway and the United Kingdom, is on par with Belgium and Germany but lags Denmark's 19 workers per thousand. The Dutch business sector displays some distinctive patterns with respect to the employment of R&D workers. Some of these patterns suggest that its R&D activity may be a poorer predictor of efforts dedicated to new-to-the-world (or other ambitious forms of) innovation than in other advanced systems.

First, labour costs account for the lion's share of BERD in the Netherlands, ahead of all countries in the comparator group (Figure 4.8). This appears to be a relatively recent development as in 2005 the Netherlands' share was not much above the comparator group average (Table 4.3). As there are no strong indications of a scarcity of R&D personnel (see OECD, 2012a), this likely reflects an unintended effect of the R&D tax credits, which have traditionally focused on labour costs. One of the evaluations of the effects of the WBSO R&D tax credit over 1997-2004 found that the real effect of the WBSO on R&D expenditure could be 25% higher if there was no effect of the R&D wage level (Lokshin and Mohnen, 2013). This may be due to substitution effects (between R&D workers and other R&D inputs), or alternatively, the extensive expansion of the WBSO tax credit over the past decade may have contributed to the rising costs. It would be important to see whether the introduction of complementary tax incentives for non-labour costs (i.e. capital and exploitation R&D expenditure, as promoted by the RDA scheme, discussed in Chapter 5) has compensated for this.

Figure 4.7. Business enterprise R&D intensity by size class, 2010

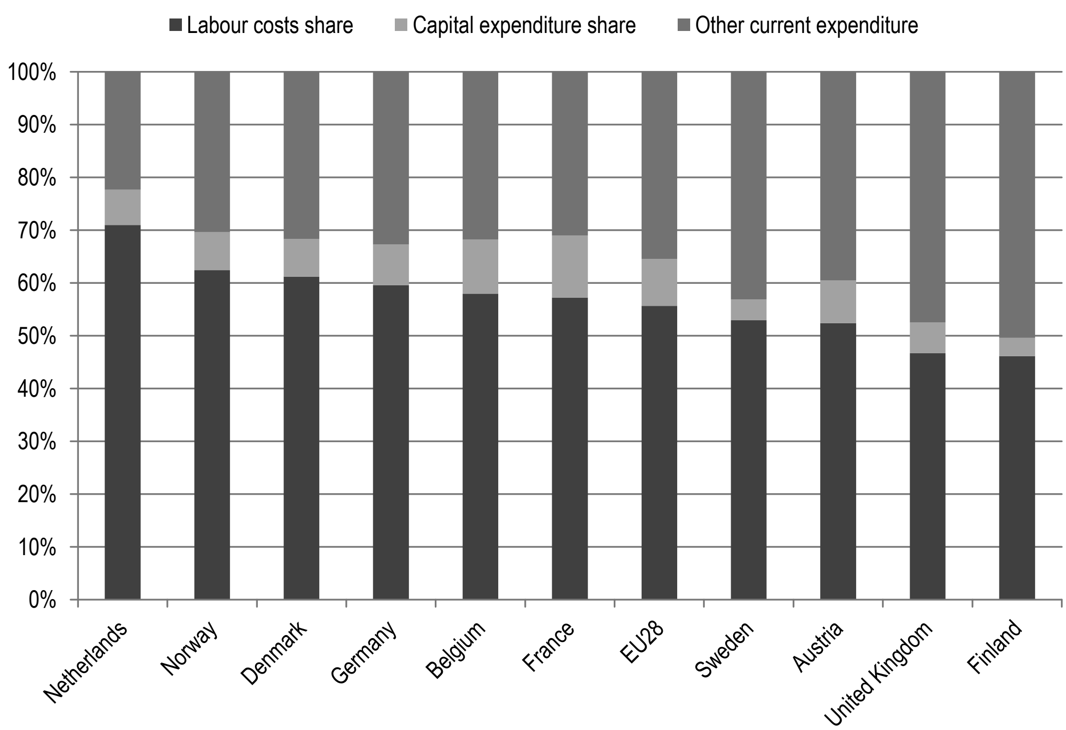
R&D expenditure in the size class as a share of size class value added.



Note: Comparator countries include Belgium, Denmark, Germany, France, Austria, Finland, Sweden, United Kingdom, Norway.

Source: Eurostat (2014), Statistics Database, http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database; and European Commission (2013b), "Database for the Annual Report on European SMEs", Directorate-General Enterprise and Industry, http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/performance-review/index_en.htm.

Figure 4.8. Shares of BERD spent on labour costs and capital, 2011



Source: Eurostat (2014), Statistics Database, http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database.

Table 4.3. Share of labour costs in BERD, 2005-11

	2005	2007	2009	2011
Netherlands	58%	61%	67%	71%
Comparator group	56%	55%	57%	55%

Source: Eurostat (2014), Statistics Database, http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database.

Nevertheless, and despite the increase, estimates of the cost per full-time equivalent (FTE) R&D worker (adjusted for the share of researchers) indicate that labour costs remain low relative to the comparator group[7] (Table 4.4). If there are indeed shortages in the supply of R&D personnel, the relative cost of this type of labour suggests that they are no more pronounced than elsewhere.

Table 4.4. Business R&D personnel in the Netherlands and the comparator group

	R&D personnel in industry	Share of researchers in total R&D personnel, 2009-12 average	Cost per FTE R&D personnel, adjusted estimate*, 2011
	Per thousand employment	%	EUR in 2005 prices PPS
Austria	13.7	57	34 779
Belgium	12.0	61	50 146
Denmark	18.9	61	32 119
Finland	17.5	73	42,957
France	13.1	63	35,499
Germany	11.7	55	43,767
Netherlands	12.2	51	32,616
Norway	10.9	71	41,589
Sweden	18.0	54	33,385
Switzerland	13.4	..	..
United Kingdom	7.0	56	33,165
EU28	8.3	56	..

Note: *Estimates based on aggregate R&D statistics. Costs adjusted to account for the fact that researchers are better paid than other R&D personnel. Cost per FTE personnel is estimated as [L*(RD/RP)]/RP, where L is business R&D labour costs expressed in purchasing power standard (PPS)at 2005 prices, RD is FTE researchers and RP is total R&D personnel.

Source: OECD, based on Eurostat (2014), "Statistics Database", http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database; and OECD (2014), *Main Science and Technology Indicators*, Volume 2013, Issue 2, OECD, Paris, http://dx.doi.org/10.1787/msti-v2013-2-en

Second, researchers account for only 51% of total R&D personnel, behind all comparator countries and the group average of 61%. The Netherlands has historically had a smaller share of researchers in its R&D workforce than countries in the comparator group (and most OECD countries). This likely reflects a strategic specialisation on development rather than research.[8] Moreover, in 2011 the share dropped abruptly to 42%. The gap between numbers of researchers and numbers of R&D personnel grew fastest in 2010-11 (see Figure 3.14 and accompanying note in Chapter 3). In other words, the increase in business R&D intensity in that year coincided with the largest expansion in numbers of non-researchers over the previous decade.

In sum, the business sector has only a moderate R&D workforce for its size. It is largely comprised of non-researchers and has become more expensive over time, which may have reduced the real amount of expenditures devoted to R&D. It nevertheless still enjoys low (adjusted) R&D labour costs in comparison with other advanced innovation systems.

Patterns of innovation output

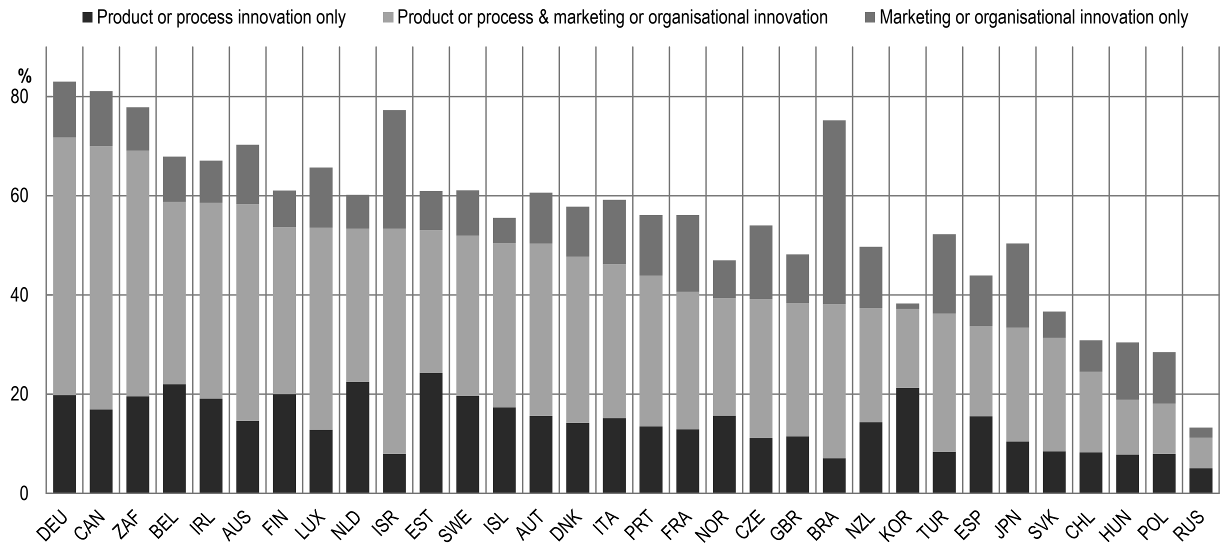
A majority of Dutch firms operating in manufacturing (60%) (Figure 4.9) and services (55%) (Figure 4.10) reported innovation activity in the 2008-10 EU CIS. Aside from Germany's exceptionally high shares of innovating firms (83% in manufacturing and 77% in services), the performance of the Dutch business sector is similar to that of comparable countries. Also as in other countries, the share of innovating firms is somewhat larger in the manufacturing sector. The manufacturing sector has a larger share of product and process innovators (23%) than the services sector (17%). In spite of the services sector's lagging productivity performance (see Chapter 2), it does not appear to innovate less than services sectors in comparable countries. This observation appears in keeping with the dominant explanation for the low productivity of the Dutch services sector: the fact that it is composed of many very small firms. Nevertheless, as over 40% of Dutch services firms do not innovate, innovation would probably make an important contribution to productivity performance.

In manufacturing, 31% of Dutch firms engage in various modes of innovation (product/process as well as marketing/organisational innovation). With the exception of Germany (52%), this is somewhat below countries in the comparator group. In services the difference between the Netherlands and comparable countries is a bit more pronounced, as 27% of Dutch firms engage in various modes of innovation (product/process and marketing/organisational), compared to 32% of Swedish and Belgian firms. If one considers the firms engaging in both product/process and marketing/organisational innovations as a share of total innovators, the Netherlands lags most countries of the comparator group in both manufacturing[9] and services[10].

Empirical analysis has shown that the impact on productivity of different modes of innovation varies across countries and that no single innovation mode is superior (Frenz and Lambert, 2012). On the whole, different modes of innovation can be complementary, so firms that engage in a greater variety of modes can be expected to reap the greatest benefits. In an analysis of firm-level innovation and productivity performance, Polder et al. (2009) find that, in the Netherlands, organisational innovation has the greatest productivity benefits. Importantly, product and process innovation is reported to have had positive productivity effects only when combined with organisational innovation. These results, combined with the somewhat narrower focus on innovation modes relative to peer countries, would suggest that there are potential gains from encouraging firms that are already innovating to engage in a greater variety of innovation modes.

Figure 4.9. Innovation in the manufacturing sector 2008-10

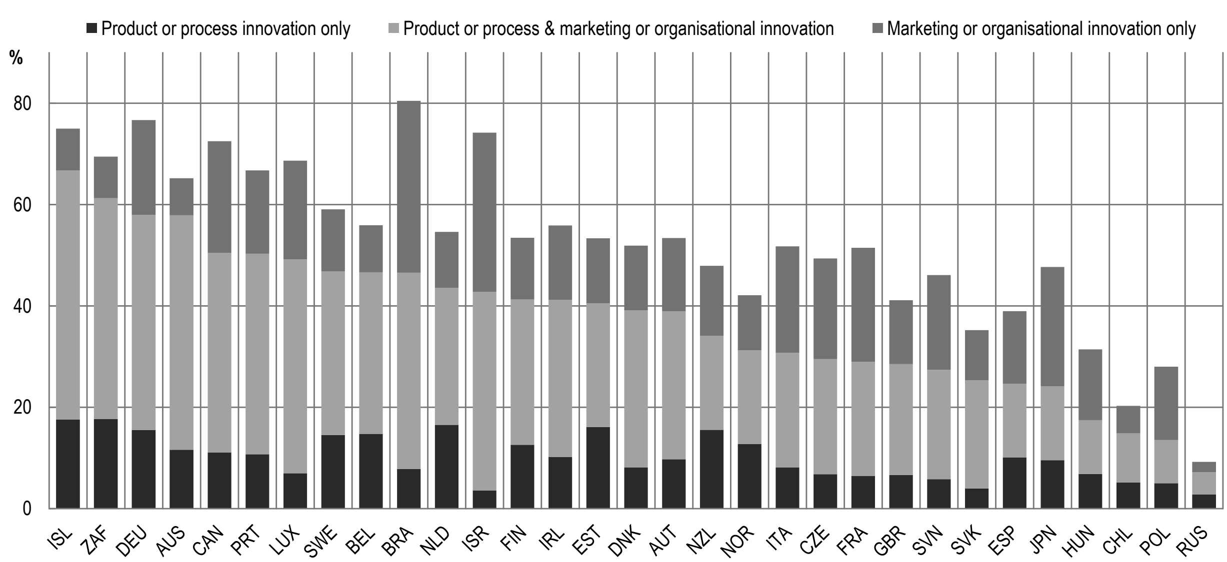
As a percentage of all manufacturing firms



Source: OECD (2013a), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, doi: 10.1787/sti_scoreboard-2013-en.

Figure 4.10. Innovation in the services sector 2008-10

As a percentage of all services firms



Source: OECD (2013a), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, doi: 10.1787/sti_scoreboard-2013-en.

Despite the low expenditure by business on R&D, the Netherlands is typically among the world's leaders in patenting activity (see Chapter 3), a testament to the presence of some large, globally networked and probably highly efficient R&D spenders. In particular, the Netherlands leads the group in terms of the rate of patenting output obtained per unit of input (Table 4.5). Dutch patenting productivity, measured in either Patent Cooperation Treaty (PCT) applications or triadic patent families, not only leads the group, but considerably outdistances Germany, the second most productive country in this regard. The explanation for this outstanding performance likely has two components. One is scale effects on inventive productivity due to concentration and the ability to overcome "indivisibilities[11]" in R&D. The second is differences in the share of technological output that is patented, owing to patterns of specialisation that favour patenting (e.g. in electronics) over alternative forms of appropriation and/or due to corporate strategies that emphasise generation of intellectual property.

Table 4.5. Patents per business expenditure on R&D, 2008-10 average

	PCT patents per USD 100 million of BERD	Triadic patent families per USD 100 million of BERD
Austria	22.7	5.08
Belgium	23.3	6.22
Denmark	31.6	6.45
Finland	31.3	5.61
France	25.3	6.95
Germany	33.1	9.65
Netherlands	51.1	12.70
Norway	32.2	3.78
Sweden	31.6	7.20
Switzerland	30.0	8.84
United Kingdom	24.3	5.77
United States	16.4	4.66
OECD	22.4	6.38
EU28	28.1	6.93

Note: Owing to lack of continuous BERD data, the figures for Switzerland refer to 2010 only.

Source: OECD (2014), *Main Science and Technology Indicators*, Vol. 2013/2, OECD Publishing, doi: 10.1787/msti-v2013-2-en.

With respect to the first likely explanation for high patenting productivity, it appears that patenting activity is highly concentrated in large firms in the Netherlands, with firms employing over 200 employees accounting for 75% of patent applications to the European Patent Office (EPO) (Table 4.6). In addition, the concentration of PCT patents in the top ten companies is the highest for the comparator group (Table 4.7). The Netherlands is unique among the countries examined in terms of concentration in the top patenting company; Philips accounts for about 37% of Dutch PCT patents. Even excluding Philips, the share for the second to tenth firms (36%) is ahead of other countries, with only Switzerland (34%) coming close.[12]

Available evidence on firm-level R&D expenditures is partial and fragmented, but on the whole seems to corroborate the assessment of high concentration. According to a non-comprehensive[13] list of the top 30 R&D spenders in the Netherlands published by *Technisch Weekblad*, the R&D spending (both domestic and abroad) of the top eight companies (Philips, ASML, Shell, Royal DSM, NXP Semiconductors, Unilever, Océ Technologies and KPN/Gentronics) represents 76% of Dutch BERD (de Heide et al., 2013). According to Dialogic (2014) domestic R&D spending by the top five firms in this list (Philips, ASML, KPN, Shell and DSM) amounted to EUR 2.37 billion in 2012, which is equivalent to 32% of BERD. The share of the top five has not changed much over the past decade.

Table 4.6. Concentration of patents in large firms

	Share of EPO patent applications by companies with 200 or more employees	Share of EPO patent applications by companies with 500 or more employees
2000	70%	67%
2005	78%	75%
2010	75%*	66%*

*Provisional figures.

Source: OECD, based on Statistics Netherlands (2014), StatLine, http://statline.cbs.nl

Table 4.7. Concentration of patents and R&D, selected countries

	Share of top 10 firms	Share of top 9 (excluding first firm)	Share of top 10 firms	Share of ICT patents over total PCT patents	Share of top 10 R&D investors in BERD
	(Patents with priority date 2011)		(sum of patents with priority dates 2000-11)	(2009-11 average)	(2010; 2008 for Switzerland)
Austria	25%	19%	16%	20%	12%
Belgium	31%	27%	36%	23%	33%
Switzerland	41%	34%	29%	21%	205%
Germany	30%	20%	26%	22%	69%
Denmark	29%	25%	31%	19%	65%
Finland	67%	30%	65%	40%	115%
France	32%	29%	31%	28%	58%
United Kingdom	25%	19%	20%	29%	72%
Netherlands	73%	36%	79%	31%	106% (excl. EADS)
Sweden	59%	18%	51%	32%	76%
United States	14%	11%	11%	36%	24%

Note: For the first three columns, top firms were identified according to the number of PCT patents filed over 2009-10. Patent applicant names in the OECD HAN database were harmonised using a series of automated cleaning and string matching algorithms. The number of patents may be underestimated for some companies.

Source: OECD, Calculations based on the Worldwide Patent Statistical Database (PATSTAT), EPO, October 2013 and HAN Database, OECD, January 2014; OECD (2014), *Main Science and Technology Indicators*, Volume 2013, Issue 2, OECD, Paris, http://dx.doi.org/10.1787/msti-v2013-2-en; and European Commission (2011), *The 2011 EU Industrial R&D Investment Scoreboard,* http://iri.jrc.ec.europa.eu/scoreboard11.html.

The EU Corporate R&D Investment Scoreboard (EC, 2011) potentially allows for a cross-country view, with the important caveat that companies' nationalities are assigned according to the location of their headquarters. Although the Netherlands does not lead the comparator group, concentration by the top firms (excluding EADS for the Netherlands) is on the high end (last column of Table 4.7). Account should be taken not only of the effect of the location of headquarters but also of the fact that that in the Netherlands SMEs account for a slightly larger share of total BERD than in comparator countries. Therefore, if the concentration of R&D in the top ten firms is not entirely due to the headquarters effect, it is likely an indication of partial concentration at the upper end of the distribution, which is counterbalanced by partial concentration in the lower end.

The concentration of patenting and R&D expenditures by the top firms suggests that, despite its small size, the Netherlands is well positioned to exploit scale economies in R&D, particularly in the case of patented technological innovations. It has also managed largely to sustain the R&D commitments of large firms in the Netherlands over a period of considerable internationalisation of R&D (discussed below).[14]

With respect to the second likely explanation for high patenting productivity, one may examine the concentration of patenting in fields considered to have a higher propensity to patent, such as information and communication technologies (ICT). With the notable exception of software (which is not patentable in Europe), companies active in the ICT sector are prone to use patents and do so as part of their corporate strategy, as suggested by a number of well-publicised litigation cases. The second-to-last column of Table 4.6 gives the share of ICT patents in total PCT patent filings, and it too positions the Netherlands at the high end of the comparator group. In fact, looking at its global share of ICT patents (not included Table 4.6), the Netherlands ranks eighth, ahead of Sweden, Finland and Switzerland (OECD, 2012b).

The Netherlands performs well on other measures of intellectual property that can be used as proxies for innovation, such as trademarks. As seen in Chapter 3 it is at the upper end of the comparator group in terms of international trademarks per capita, though it lags countries with smaller services sectors such as Sweden and Switzerland. The pattern of trademarks is also suggestive of the types of service innovation most prevalent in the Netherlands. The top two trademark application fields were advertising and business services and leisure and education, while ICT and audio-visual led in France, Finland and the United States and health, pharmaceuticals and cosmetics in Denmark and Switzerland (OECD, 2013a, p. 187). Other intellectual property instruments such as designs suggest a Dutch specialisation in electricity and lighting and in furniture and household goods (OECD, 2013a, p. 187).

Globalisation and its impact on business innovation

Historically R&D was rarely outsourced, but this changed in the 1990s (Mol, 2005). An apparent intensification of outsourcing of R&D activities by Dutch firms and a parallel inability to attract much internationally mobile R&D investment prompted policy concern and intense debate, particularly at the beginning of the past decade (e.g. Erken and Gilising, 2005).

Unfortunately, national statistics on the R&D activities of Dutch firms abroad were not available at the time of the review. A partial view of the situation may be obtained from other sources. The OECD's Technology Balance of Payments Database tracks R&D carried out abroad, most of it by businesses. In 2011 Dutch actors had commitments of USD 1.98 billion, but in relative terms these were no greater than in comparable countries (Table 4.8). In that year Dutch actors, largely Dutch multinational enterprises, performed the equivalent of 28% of BERD abroad, down from 65% in 2003. Philips maintains R&D laboratories abroad, in both advanced (Germany, United Kingdom, United States) and emerging (China, India) markets. About a quarter of its R&D workforce in 2012 was located outside the Netherlands (see Box 4.1).

Table 4.8. R&D carried out abroad as a share of BERD

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Netherlands	65%	58%	62%	42%	37%	35%	33%	32%	28%
United Kingdom	9%	14%	15%	15%	14%	23%	24%	26%	23%
United States	2%	3%	3%	4%	5%	6%	6%	8%	9%
Sweden	38%	37%	38%	39%	45%	46%	46%	44%	39%
Norway	5%	6%	10%	11%	11%	11%	11%	11%	0%
Germany	11%	11%	12%	12%	13%	12%	15%	16%	15%
Finland	0%	0%	46%	46%	41%	70%	64%	66%	60%
Denmark	0%	0%	13%	14%	15%	14%	12%	15%	20%
Belgium	20%	28%	28%	24%	21%	43%	51%	48%	31%
Austria		5%	5%	6%	6%	7%	8%	6%	7%

Source: OECD Technology Balance of Payments Database and Main Science and Technology Indicators.

Box 4.1. Large, R&D-intensive multinationals in the Netherlands

Philips

Royal Philips (commonly known as Philips) is one of the world's largest electronics companies, employing around 115 000 people in over 100 countries. In 2013 recorded sales amounted to EUR 23.3 billion. Philips has three main thematic divisions: Healthcare; Consumer Lifestyle; and Lighting, as well as an Innovation, Group and Service division, employing 32%, 16%, 42% and 12%, respectively, of its personnel.

According to its 2012 Annual Report, emerging economies accounted for 10% of sales growth. Mature economies accounted for only 1% of sales growth between 2011 and 2012. In 2012, emerging economies represented 35% of total sales (33% in 2011).

R&D expenditures increased from EUR 1.6 billion in 2011 to EUR 1.8 billion in 2012 (i.e. above the 2008 pre-crisis level of EUR 1.7 billion). As a percentage of sales, R&D expenditures increased from 7.1% in 2011 to 7.3% in 2012. In Healthcare, R&D investments increased mainly in Imaging Systems and Home Healthcare Solutions (an increase of EUR 63 million from 2011 to 2012). In Lighting, R&D expenditures increased by EUR 44 million from 2011 to 2012. In Consumer Lifestyle, however, R&D spending decreased by EUR 12 million. Additional R&D investments by the Innovation, Group and Services divisions created new value spaces and launched innovation and design initiatives.

Philips R&D centres are located throughout the world (two in Asia-Pacific, five in Europe, Africa and the Middle East and one in North America). Most Philips research personnel are located on the campus in Eindhoven, the Netherlands (1 500), followed by Briarcliff, United States (125), Shanghai, China (110), Hamburg, Germany (100), Aachen, Germany) (70), Cambridge, United Kingdom (35), Bangalore, India (30).

Source: Philips.com, Philips Annual Report 2012.

ASML

Since 2002, ASML is a producer of lithography systems for the global semiconductor industry. Its headquarters are in Veldhoven, the Netherlands. ASML was created in 1984 as a joint venture between Philips and Advanced Semiconductor Materials International (ASMI). Philips pulled out of the venture in 1994. In 2013, ASML employed 10 360 people and is present in more than 70 locations in 16 countries.

In 2013, the company invested EUR 882 million in R&D (net of credits, EUR 589 million in 2012 and EUR 590 million in 2011). Its R&D budget is extensively used to sponsor joint developments with suppliers and technological partners. ASML manufacturing and R&D centres are located in Connecticut and California in the United States, in the Netherlands in Europe and in Chinese Taipei in Asia. Technology development and training centres are located in Japan, Korea, the Netherlands, Chinese Taipei and the United States.

Source: ASML website and Annual Report 2013.

.../…

Box 4.1. Large, R&D-intensive multinationals in the Netherlands *(continued)*

DSM

Royal DSM is an international company active in the health, nutrition and materials sectors. Its products include food and dietary supplements, personal care devices, pharmaceuticals, medical devices, alternative energy and bio-based materials. In 2012, DSM had net income of EUR 437 million and employed more than 23 000 people on five continents. In 2012, 38% of sales were in emerging economies, 20% in North America and 36% in western Europe.

R&D expenditures in 2012 amounted to EUR 490 million. The DSM Innovation Centre was created in 2006 to integrate innovation in the company's strategic orientation and has been expanding. It employed 668 people in 2012 (383 in 2011) and its R&D investments were EUR 61 million in 2012 (EUR 42 million in 2011). Open innovation approaches are considered an essential part of its efforts. DSM also invested in the development of new R&D facilities: a biotechnology centre in Delft, two centres on material sciences in Geleen (the Netherlands) and in Singapore. The company is also active in venture capital investments in different countries.

Source: www.dsm.com; DSM (2013) At a Glance Factbook,
www.dsm.com/content/dam/dsm/cworld/en_US/documents/company-presentation.pdf;
www.dsm.com/content/dam/dsm/cworld/en_US/documents/factbook-2013.pdf.

Shell

Shell is a global energy and petrochemical company employing around 87 000 people in more than 70 countries. In 2005 Royal Dutch Shell and Shell Transport and Trading were reorganised into a single company. The headquarters of the resulting company (Royal Dutch Shell plc.) is in The Hague. In 2012, Shell's income was USD 26.8 billion and the company invested USD 1.3 billion in R&D.

Shell has three main technology centres located in the Netherlands, India and the United States. These were chosen as strategic locations for the company's business, with access to world-class researchers and scientists. The first laboratory was created in Amsterdam in 1914 and now hosts around 1 300 people. The US centre is located in Houston, Texas, and employs over 2 000 scientists and engineers. A third large R&D centre is under construction in Bangalore, India, to replace two existing sites, with 1 500 researchers. In addition, smaller-scale technology centres are located in Germany, Canada, Norway, China, Oman and Qatar.

Source: www.shell.com.

NXP Semiconductors

NXP Semiconductors is one of the world's leading companies in semiconductor manufacturing. It was created in 1953 as a division of Philips (Philips Semiconductors) in Nijmegen, the Netherlands. Philips sold the company in 2006. It was renamed NXP and is now headquartered in Eindhoven. NXP employs approximately 24 000 people (of whom 8 000 based in China) and operates in more than 25 countries. NXP produces semiconductor components used in smart devices such as wireless infrastructure, cyber-security, automotive, lighting, mobile and computing applications. The company's strategic orientations include energy efficiency, connected devices, security and health. NXP revenue in 2013 amounted to USD 4.82 billion. Identification devices accounted for 28% of revenue, automotive components 22%, portable and computing components 10%, infrastructure and industrial solutions 16%, other standard products 24%.

NXP invested USD 639 million in R&D in 2013 and employs 3 300 R&D staff. R&D is performed in Asia, Europe and the United States (manufacturing takes place in Asia and Europe). There are design and engineering teams in 21 locations. The company is active in joint ventures and/or participation in companies in various countries.

Source: NXP.com.

UNILEVER

Unilever was established in 1929 as a merger. Today it has more than 400 brands in the fields of food and nutrition, soap and shampoo, and everyday household-care products. Unilever employs around 173 000 people and has 252 manufacturing sites across the world. Unilever products are sold in more than 190 countries and generated a sales volume of EUR 51 billion in 2012, with emerging markets accounting for 55% of the company's business.

…/…

Box 4.1. Large, R&D-intensive multinationals in the Netherlands *(continued)*

UNILEVER ***(continued)***

Over 2003-12 the company invested approximately EUR 1 billion a year in R&D, or about 2% of turnover. Over 6 000 people are employed in R&D in 20 countries. Unilever has six research centres: in Trumbull, United States (400 people), in Colworth and Port Sunlight, United Kingdom (600 and 750, respectively), in Vlaardingen, the Netherlands (1 000), in Bangalore, India (300) and in Shanghai, China (450). R&D project teams increasingly collaborate with academic partners. Unilever researchers have a background in various fields: bioscience, structured materials, advanced measurement and data modelling, consumer perception and behaviour, nutrition and health. Unilever tightly links its marketing, R&D and product development efforts, tailoring them as far as possible to the demands of national markets.

Source: www.unilever.com/innovation/innovationinunilever/; www.unilever.com/images/ir_Charts-2012_tcm13-348370.pdf.

Océ Technologies

Océ develops and produces printing and copying machines, ink-jet technologies and related software. The company's origins date back to 1857 when the two founding families created a pharmacy in Venlo, where the company's headquarters are still located today. In 1930 it brought chemical innovations to the market and the Océ brand was created. Océ is now active in more than 100 countries and employs more than 20 000 people globally. In 2010, Océ was acquired by the Canon Group. The two companies have combined their printing activities in order to create the largest digital printing consortium.

In 2011 Océ invested EUR 174 million in R&D (EUR 183 million in 2010 and EUR 225 million in 2009). Océ has research centres in nine countries, which employ more than 1 500 professionals. The Dutch research centres are located in Venlo and Eindhoven. Other centres are located in Belgium, Canada, France, Germany, Romania, the United States and Singapore. Océ is part of the PrintValley consortium together with 22 other companies and Dutch knowledge institutions.

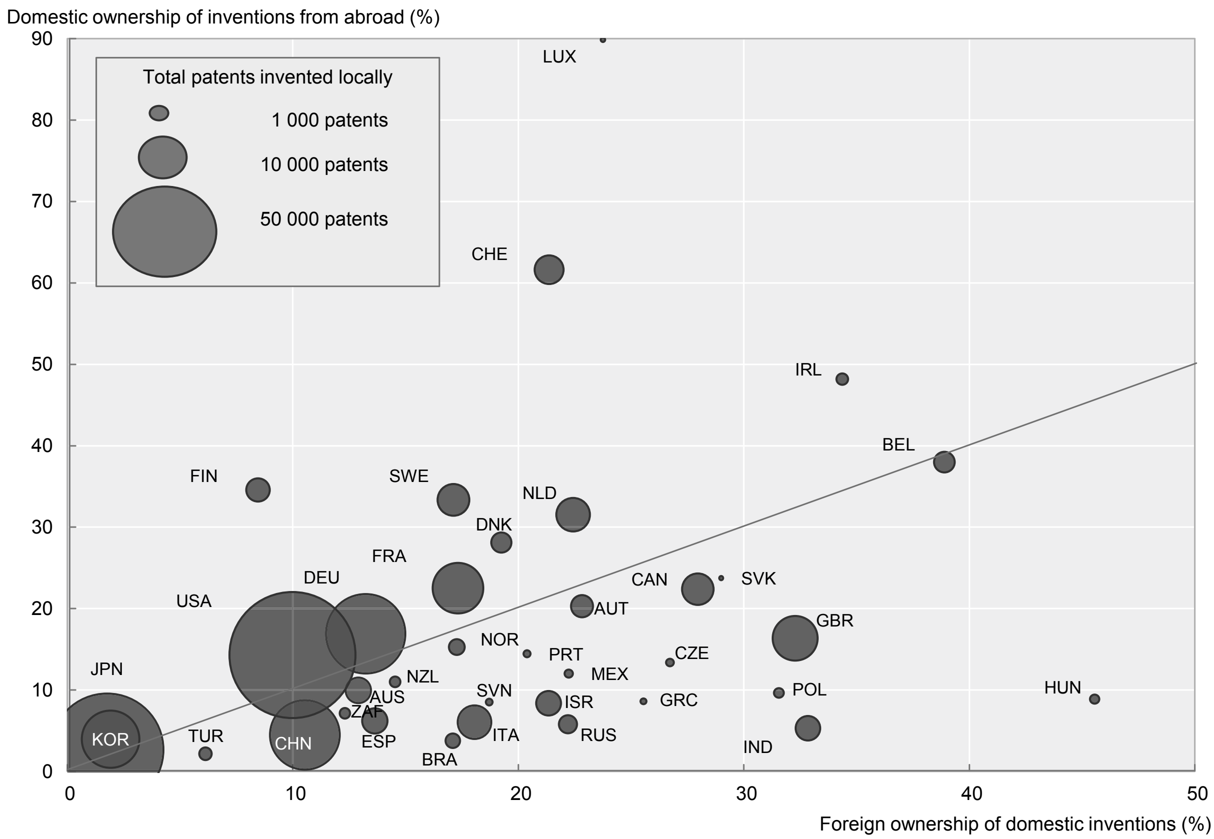
Source: http://global.oce.com/.

Additional indirect evidence can be gleaned from patenting. Differences in the owner's and the inventor's country of residence may be due to the activities of multinationals: the owner is an international conglomerate and the invention is that of a foreign subsidiary (OECD, 2013a). However, multinationals may also choose to assign ownership of intellectual property to a part of the company registered in a location with preferential tax treatment for the licensing and/or use of knowledge capital. At 32%, the share of domestically owned but foreign-invented patents (vertical axis in Figure 4.11) places the international R&D activities of Dutch companies at a level similar to that of Sweden and Finland. As both Sweden and Finland have substantially higher financial commitments abroad than the Netherlands (Table 4.8), their equal position on this dimension may point to the importance of the Netherlands as a preferential location for headquarters and/or to the attractiveness of the Dutch tax regime.

With respect to the foreign ownership of domestic inventions (horizontal axis in Figure 4.11), at 22% the Netherlands occupies a position similar to that of Switzerland, Austria and Israel. This can be partly seen as an indirect indication of the attractiveness of the Dutch innovation system for foreign R&D investment. However, a non-negligible part (by some estimates close to a third[15]) may reflect the complicated ownership structure of companies that ultimately remain under Dutch control.

Figure 4.11. Cross-border ownership of patents, 2009-11

As a percentage of countries' total patents

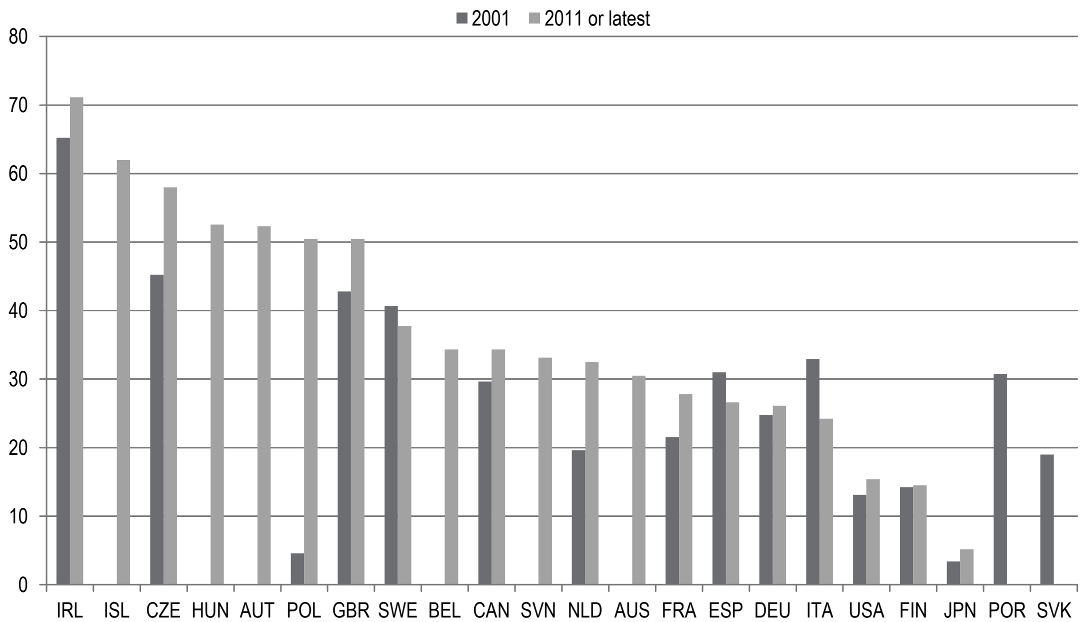


Source: OECD (2013a), *OECD Science, Technology and Industry Scoreboard 2013*, OECD Publishing. doi: 10.1787/sti_scoreboard-2013-en.

The share of Dutch BERD funded from abroad has remained stable for the past decade at around 15%, just above that of Sweden but somewhat below that of Austria and the United Kingdom (OECD, 2014). A substantial part is funded by the European Commission for participation in the Framework Programme (den Hertog et al., 2012).

Foreign-majority-owned affiliates now account for about a third of BERD, a greater share than a decade ago (Figure 4.12). This suggests that the R&D activities of foreign businesses have increased. However, according to Statistics Netherlands (2012) the shift was the result of a small number of acquisitions of large Dutch-controlled firms by foreign-controlled entities. As such, the increase may reflect important shifts in ownership structure and potentially in decisions about the location of higher-value adding activities such as R&D. Nevertheless, irrespective of ownership, R&D location decisions are subject to global corporate strategies and guided in part by the rise of new markets and of global centres of R&D. Provided it does not lead to substantial diversion of R&D from home, expansion of business sector R&D abroad should not be seen as a national loss. Far from supporting competitiveness, excessive preoccupation with keeping R&D within national borders may ultimately constrain the business sector's ability to enter new markets and shift to new technologies.

Figure 4.12. R&D expenditure of foreign affiliates as a percentage of R&D expenditures of enterprises



Note: The data come from the OECD Foreign Affiliates Database and in some cases are not directly comparable with standard BERD. They are based on the concept of controlling interest, and the statistical test for data is a majority interest (over 50% of shares that carry voting rights on a company's board of management).

Source: OECD (2014), *Main Science and Technology Indicatiors*, Volume 2013/2, OECD, Publishing, doi: 10.1787/msti-v2013-2-en.

The scope of business innovation activity

There are a number of indications that, despite the high overall propensity of Dutch firms to innovate, a smaller share of innovating firms engages in new-to-the-world innovation than in comparator countries. These indications go beyond the low R&D intensity and low share of researchers in R&D personnel observed earlier. They include patterns of collaboration on innovation between firms and other knowledge-producing institutions and between Dutch firms and partners abroad, as well as the types of innovation activity undertaken within Dutch firms and their impact on turnover.

One indication comes from the CIS in the form of the low share of innovating firms that report co-operation with higher education institutions (HEIs) and public research institutes (PRIs) relative to countries with advanced innovation systems (Table 4.9). As the Netherlands scores high on other indicators of university-industry co-operation (the share of university R&D funded by business and co-publications between Dutch universities and industry *abroad*; see below) this suggests the presence of a sizeable group of companies whose innovation activities have a somewhat narrow market scope and may thus derive little benefit from cutting-edge science. Strikingly, it is the larger firms that account for most of the deficit relative to the comparator group. This is in line with the R&D deficit among non-SMEs identified in Figure 4.7. As the R&D and patenting activities of the top ten firms appear very strong in international comparison, the deficit may be due to the performance of a substantial layer of intermediate-sized firms.

Table 4.9. Collaboration between companies and HEIs and companies and PRIs by firm size, 2010

Share of innovative companies, %

	Collaboration with universities or other HEIs				Collaboration with government or public research institutes			
	Firm size bands (numbers of employees)			Total	Firm size bands (numbers of employees)			Total
	10 to 49	*50 to 249*	*250 or more*		*10 to 49*	*50 to 249*	*250 or more*	
Belgium	13%	22%	42%	17%	6%	13%	25%	9%
Denmark	9%	17%	38%	13%	8%	11%	30%	10%
Germany	10%	18%	40%	14%	4%	7%	21%	6%
France	9%	16%	32%	13%	7%	12%	24%	10%
Netherlands	6%	11%	26%	8%	5%	8%	17%	7%
Austria	15%	30%	55%	22%	6%	12%	25%	9%
Finland	23%	40%	68%	30%	17%	30%	60%	23%
Sweden	9%	20%	48%	14%	5%	9%	26%	7%
United Kingdom	3%	4%	5%	3%	2%	2%	2%	2%
Norway	9%	18%	37%	13%	10%	20%	36%	14%
Comparator group average	10%	20%	39%	15%	7%	13%	27%	10%
Netherlands' difference from comparator average	-5%	-8%	-13%	-6%	-2%	-4%	-10%	-3%

Source: OECD, based on Eurostat (2014), Statistics Database, http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database.

A breakdown of companies' collaboration with HEIs and PRIs by industrial sector may shed additional light on the types of firms concerned (Table 4.10). The table shows that the propensity to collaborate on innovation is already at, or above, the comparator group average in Mining and quarrying and in Water supply; sewerage, waste management and remediation activities. However, Dutch enterprises in Agriculture, forestry and fishing, Electricity, gas, steam and air conditioning supply, and in the services sector (particularly Professional, scientific and technical activities; Real estate; and Administrative and support services) were less likely to collaborate with HEIs and PRIs than enterprises in the comparator group. For agriculture in particular this may be due to average firm size and the possibility that the sector has a larger number of firms than in the comparator countries.

Table 4.10. Collaboration between companies and HEIs and companies and PRIs by industrial sector, 2010

Share of innovative companies, %

NACE sector	Collaboration with universities or other HEIs			Collaboration with government or public research institutes		
	Netherlands	Comparator group average	Netherlands' difference from comparator average	Netherlands	Comparator group average	Netherlands' difference from comparator average
Agriculture, forestry and fishing	12%	32%	-19%	5%	23%	-17%
Mining and quarrying	31%	21%	11%	37%	17%	21%
Manufacturing	11%	17%	-6%	8%	11%	-4%
Electricity, gas, steam and air conditioning supply	27%	46%	-19%	12%	24%	-12%
Water supply; sewerage, waste management and remediation activities	25%	22%	3%	18%	18%	0%
Construction	5%	7%	-2%	3%	6%	-3%
Wholesale and retail trade; repair of motor vehicles and motorcycles	4%	8%	-5%	3%	4%	-1%
Transportation and storage	5%	7%	-2%	4%	6%	-2%
Accommodation and food service activities	6%	8%	-2%	0%	2%	-1%
Information and communication	4%	11%	-7%	5%	8%	-3%
Financial and insurance activities	7%	9%	-2%	6%	7%	-1%
Real estate activities	5%	16%	-12%	3%	16%	-13%
Professional, scientific and technical activities	10%	24%	-15%	6%	20%	-14%
Administrative and support service activities	5%	12%	-7%	7%	13%	-6%
All Core NACE activities related to innovation activities (B, C, D, E, G46, H, J58, J61, J62, J63, K and M71)	8%	15%	-6%	7%	10%	-3%

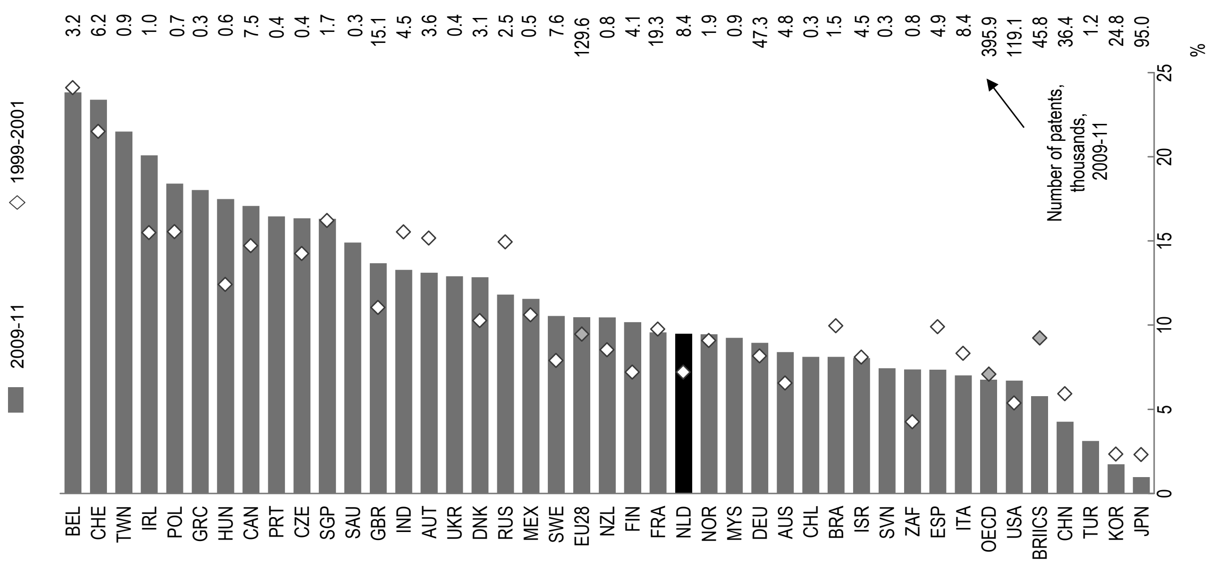
Source: OECD, based on Eurostat (2014), Statistics Database, http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database.

Dutch firms' international collaboration activities provide additional indications. Although the Dutch economy is very internationalised, a smaller share of Dutch innovating firms engage in innovation with international partners than in other advanced countries. The CIS results indicate that a relatively small 22% of innovating Dutch firms collaborate with partners abroad in the course of their innovation activities (compared to 31% for France, 38% for Belgium and 46% for Sweden). This relatively low position is common for both large firms and SMEs (Eurostat, 2014). The incidence of co-inventions, as indicated by patent data, provides a similar pattern, with only moderate performance and a smaller (though increasing) share of internationally co-invented patents than Switzerland, the United Kingdom, Austria, Denmark, Sweden, Finland and France

(Figure 4.13). In addition, the participation of Dutch SMEs in the European Framework Programme is at the EU average, in terms both of the share of SMEs participating and of funds obtained by SMEs (EC, 2013c, pp. 16-17). These findings are at odds with the openness of the Dutch economy and the level of international collaboration of Dutch science in terms of co-publications and participation in the European Framework Programmes. The small share of the business sector that engages in new-to-the-world innovation also contrasts with the strong international patenting performance of the Netherlands (which is *de facto* new-to-the-world). This inconsistency is likely due to the concentration of R&D and patenting among the top companies and to their specialisations. The fact that Dutch patent applications have gone to fewer international patent offices over time may also suggest a focus on specific markets (den Hertog et al., 2012, p. 95).

Figure 4.13. International co-inventions in PCT patents, 1999-2001 and 2009-11

As percentage of the economy's total patents



Source: OECD (2013a), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing. doi: 10.1787/sti_scoreboard-2013-en.

Finally, there are some indications that new-to-the-firm innovations are more prevalent in the Netherlands than in the comparator countries. This matters because this type of innovation is dominant in developing rather than advanced systems, where most innovating firms introduce not only innovations that are new-to-the-firm but have accumulated enough capabilities to transition to new-to-the-market innovations.

According to the 2010 CIS, the turnover from innovation is low, at only 73% of the EU average (EC, 2014). This relatively low ranking was also observed in previous CIS (2004, 2006 and 2008), which showed the Netherlands positioned near the median of a slightly different group of countries with advanced innovation systems (OECD, 2013b, p. 133). As noted above, a relatively high share of knowledge-based capital investments goes for the acquisition of machinery and other external knowledge. In the 2008-10 CIS, 37% of innovation expenditure in Dutch firms was devoted to activities other than R&D, compared to 23% in France and around 20% or less in Sweden, Austria, Finland, Norway and Denmark (Eurostat, 2014). Moreover, about 70% of product innovators conduct R&D, a share ahead of France and Germany and similar to Sweden but lower than Finland, Norway and Belgium (where it is closer to or above 80%) (OECD, 2013a, p. 183).

Taken together, these observations suggest a contrast between generally large, R&D-driven and highly internationalised firms and parts of the business sector (primarily intermediate-sized firms with activities in parts of agriculture, utilities, manufacturing and the large services sector), whose innovation activities tend not to extend much beyond the firm or national borders. Even if this reflects the strategic positioning of these Dutch firms in specific economic activities at present, the long-term sustainability of the system would be well served by efforts to extend the scope and ambition of a greater share of business innovators, as is already the case in other countries with advanced systems.

Indeed, the link between R&D and collaboration on innovation, on the one hand, and the greater scope or higher impact of innovations, on the other, has been established empirically in various firm-level studies in the Netherlands using both the CIS and other surveys. Jong and Hulsink (2010) found that small Dutch firms that engaged in more complex types of networking with HEIs, PRIs or government agencies were more likely to have innovation strategies and to employ specialised innovation workers. They were also more likely to introduce innovations that were new-to-the-market (as opposed to new-to-the-firm) and that required new competences. Zhou et al. (2011) found that firms that spent more on R&D, employed highly educated workers and invested in training obtained innovations of greater scope of applicability (new-to-the-market as opposed to new-to-the-firm) and impact (in terms of sales). Uhlaner et al. (2013) found that the sourcing of external knowledge and collaboration with other companies or institutions have direct and cumulative benefits for firm innovation performance and indirectly influence sales growth. Finally, in a study of small firms operating in Dutch high-technology sectors, de Jong and Freel (2010) found that most collaborations were among local firms, though the likelihood of collaborating with more distant organisations increased with the level of R&D expenditures. An econometric analysis by Statistics Netherlands (2010) found that, controlling for other factors, companies performing R&D were more likely to be trading with BRICs (Brazil, the Russian Federation, India, China).

These results should not be interpreted simply as supporting calls for “more R&D”. They do however paint a consistent picture of the need to improve enterprises’ ability to collaborate with universities and research institutes, to strengthen their abilities to collaborate internationally, and to extend the scope of their innovation activities. This will entail more investments in knowledge capital and more intensive innovation efforts, including R&D, and engagement in a greater variety of modes of innovation. These are worthy goals because they can improve the economic impact of a firm’s innovation efforts, improve productivity in the lagging services sector, support an export orientation in emerging markets, and strengthen resilience by bringing about a more balanced portfolio of strong innovators than the current reliance on few large firms.

4.2. Higher education institutions

Higher education is an essential component of the Dutch innovation system, equipping the future labour force with advanced and specialised knowledge and the skills and ability to learn and adopt new skills. Dutch higher education institutions (HEIs) also account for around one-third of all Dutch R&D expenditures, second only to the business sector. The Netherlands' higher education system is composed of academic universities and universities of applied sciences.

There are 13 publicly funded academic universities (Wetenschappelijk Onderwijs, WO) and the Open University.[16] They have a three-fold task: to conduct scientific research, to provide science and research-based teaching, and to disseminate knowledge (which also encompasses valorisation of research). The oldest research university, Leiden University, was founded in 1575, and three more (Groningen, Amsterdam and Utrecht) were founded in the seventeenth century. The rest were founded in the nineteenth and twentieth centuries. Six of the universities are comprehensive (Leiden, Utrecht, Groningen, Nijmegen, and the two universities in Amsterdam) and teach and conduct research in subject fields across the academic spectrum; seven focus on certain areas. Three are universities of technology (Delft, Eindhoven and Twente). A further eight university medical centres treat patients and conduct research, innovation and teaching.

There are 37 universities of applied sciences (UAS, in Dutch, Hogescholen), which offer more practical and professional higher education. The UAS are mainly oriented to teaching that is based on professional practice. Their research capacity is limited but has increased in recent years. In contrast to most OECD countries with binary tertiary education systems, the Netherlands has far more students in the universities of applied sciences (around 65% of tertiary enrolments), compared to a range between 5% in France and 46% in Finland (Weert and Soo (2009), cited in the 2010 Veerman Committee report).

Both types of university obtain direct block grant funding from the Dutch government according to a funding model that includes parameters for teaching and research activities. In the WO, the block grant is divided into a teaching component (41%), a research component (44%) and a component for medical education and research (15%).[17] Of the teaching component, 65% is divided among the WO in proportion to the number of students enrolled and the number of degrees earned, with most of the remainder distributed in the form of a teaching supplement set out in the Higher Education Funding Scheme. Of the research component, 35% is allotted in proportion to the number of PhDs and degrees earned. The remainder is dispensed in the form of an amount for research schools, fixed amounts for each institution, and an amount that is distributed according to the percentages given in the aforementioned scheme (see below for details). In the UAS, 80% of the block grant is distributed in proportion to the number of students enrolled and the number of degrees earned, with the rest allocated on the basis of percentages per institution and for specific policy objectives (Ministry of Education, Culture and Science, 2013). Block grants are paid as lump sums and an institution may spend its allocation at its discretion for the performance of its statutory tasks. In addition to block grants, HEIs receive tuition fees, separate resources for research and revenue from work performed for third parties.[18]

Education activities

University education is of great importance for a country's innovation performance. Over the last few decades, the Dutch tertiary education system has expanded rapidly. The number of first-year students increased by more than half in the last 15 years, reaching 120 000 in 2011. In 2008, nearly 383 000 students were enrolled in UAS and more than 219 000 in WO. In 2012, the numbers rose to 421 000 and nearly 240 000, respectively (Ministry of Education, Culture and Science, 2013). Female students outnumber their male peers in both UAS and WO. However, men far outnumber women in science and engineering: in the UAS, four times as many men as women were newly enrolled in engineering and technology courses in 2011; in the WO, twice as many men as women were newly enrolled in similar courses. Still, the percentage of students enrolled in science, engineering and technology courses in Dutch universities remains relatively low (see Table 3.2).

Since 2002 and the Bologna Declaration guidelines, Dutch tertiary education has been divided into three phases: bachelor's, master's, and doctorate. The minimum course duration for a master's degree is four years, including the three-year bachelor's phase. An academic master's degree programme takes either one, two or three years. The four-year UAS programme leads to a bachelor's degree. Students are free to apply to any university or programme, although many programmes require a specific combination of examination subjects. Some disciplines, e.g. dentistry and medicine, have an admissions quota (Ministry of Education, Culture and Science, 2013).

An international comparison of either UAS or WO study programmes is difficult or impossible because so few have been internationally accredited (Veerman Committee Report (2010), p. 72). The Veerman Report attempted to compare figures on Dutch performance with those of a number of other countries in terms of student selection and/or dropout and success rates. Owing to a wide variation in these respects and in the nature and quality of the data, it is difficult to judge Dutch performance with confidence. However, when compared with the United Kingdom and Germany, student success rates are lower in the Netherlands: 65% in UAS and 68% in WO in 2012, while the rate was 77% in Germany and 82% in the United Kingdom. In engineering and technology courses, success rates were even lower at 58% in both WO and UAS. For science courses in the WO, success rates were just 48% in 2012 (Ministry of Education, Culture and Science, 2013).

A number of reasons can be put forward to explain these comparatively low student success rates. First, student admission systems likely play a role: the Dutch system is by and large open, while many other systems select students and this can influence success rates. Second, the duration of study has traditionally been longer than in some comparator countries, which increases the likelihood of dropout along the way. Finally, there may be issues of teaching quality. Section 5.5 discusses recent government policy changes aimed at improving teaching, particularly in the UAS, an indication that their teaching level is generally regarded as insufficient.

On a more positive note, the number of foreign students studying in Dutch HEIs rose by 82% between 2005 and 2011 (OECD, 2013c), though foreign students still constitute a lower share of total tertiary enrolments (4.9%) than the OECD average (6.9%). Most of the increase occurred in the WO, which have the more internationalised student body. The majority of foreign students in the Netherlands come from Germany, followed by China, Belgium, Bulgaria and Greece (Ministry of Education, Culture and Science, 2013). The number of foreign students has been rising since the early 1990s, a phenomenon that is not unique to the Netherlands. The share of foreign students is in fact increasing in all EU countries that there is increased competition for students at the international level.

Research activities

The higher education sector performed 33% of Dutch R&D in 2011. This is a relatively high share compared with the average for the EU28 (24%) and the OECD (18%). As a percentage of GDP, Dutch expenditure on R&D in HEIs was 0.67% in 2011, compared to an average of 0.46% for the EU28 and of 0.44% for the OECD. The WO perform virtually all of this R&D. The UAS remain minor R&D performers, despite marked increases in R&D spending over recent years (see below).

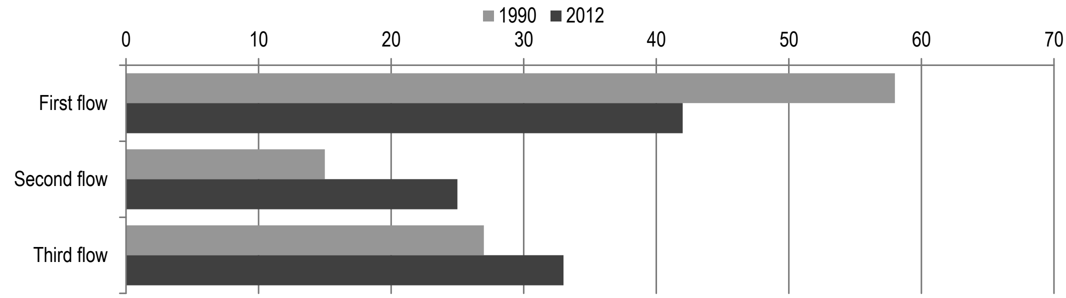
The funding of research in the WO has three mechanisms or "flows". The first flow is the previously described basic funding provided as a block grant (a lump sum) for teaching and research directly by the government. There is no precise financial data for funding flows to Dutch universities; instead, the share of the various funding flows is estimated by the number of scientific personnel they fund. By this measure, the share of first flow funding for university research was on average 42% in 2012, although there is a great deal of variation, with Delft University of Technology having 31% and Tilburg University having 68% of its scientific personnel funded from this source in 2012. The size of the grant is formula-based and, before the reform of the universities' funding system in 2011, it was largely based on student enrolments, number of diplomas and a fixed share. After 2011, as part of the new profiling and valorisation policy, the teaching allocation to academic and professional higher education includes a quality and profile allocation amounting to 7% of the education part of the block grant.[19]

The second flow consists of indirect government funding provided by the Netherlands Organisation for Scientific Research (NWO) and the Royal Netherlands Academy of Arts and Sciences (KNAW). NWO distributes most of this funding; the KNAW's much smaller share is mainly intended for university professors. NWO funding is allocated on the basis of evaluation of excellence and competition and is granted to projects, programmes and researcher posts. The average share of this flow was 25% in 2012, with variation ranging from 15% at Delft University of Technology to 37% at Leiden University.

The third flow consists of additional funding for research and education from public and private sources, including government departments, industry, charities, and European and other sources abroad. The share of this source was on average 33% in 2012 and varied among universities, ranging from 53% at Delft University of Technology to 11% at Erasmus University Rotterdam.

The balance between the three funding flows has evolved over time. Figure 4.14 shows that the first flow, i.e. block grant funding, while still the largest funding flow for research in the WO, was previously greater than it is today. It accounted on average for funding 58% of research personnel in the WO in 1990 but only 42% in 2012. The second flow from NWO and KNAW has seen the largest growth, up from 15% of research personnel funding on average in 1990 to 25% in 2012. This signifies a shift towards more competitive project-based funding, a trend in most OECD countries over the last two decades. Over the same period, the third funding flow has increased from an average of 27% of research personnel funding to 33%. Increases in private funding and in funding from EU programmes have been important drivers of this growth.

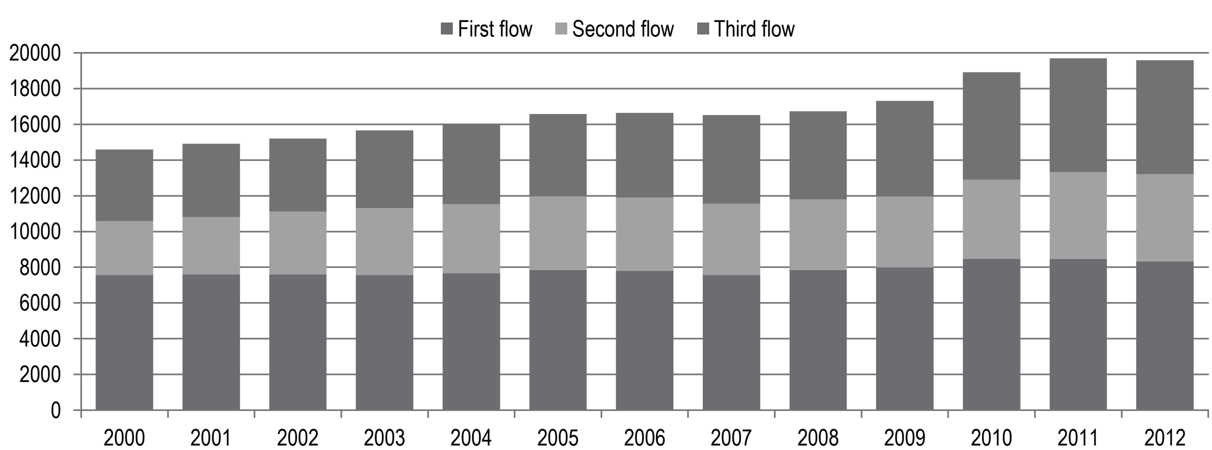
Figure 4.14. Trends in university research funding flows (percentage total)



Source: Ministry of Education, Culture and Science (2013), *Key Figures 2008-2012*, The Hague.

Figure 4.15 shows the implications of these changes for the funding of research personnel in the WO. Most of the increase in research personnel over the past decade – from 14 600 in 2000 to 19 600 in 2012 – has been funded by research council and contract research project funding, while the number of research personnel funded by the block grant has remained relatively stable. At the same time, the ways in which research is organised in the WO has been changing, with a shift towards a range of institutional forms, such as university institutes, research schools, graduate schools and centres of excellence. The Netherlands now has over 100 accredited research schools in which the majority of university research takes place (Chiong Meza, 2012).

Figure 4.15. Research personnel (full-time equivalents) in research universities, by funding flow, 2000-12

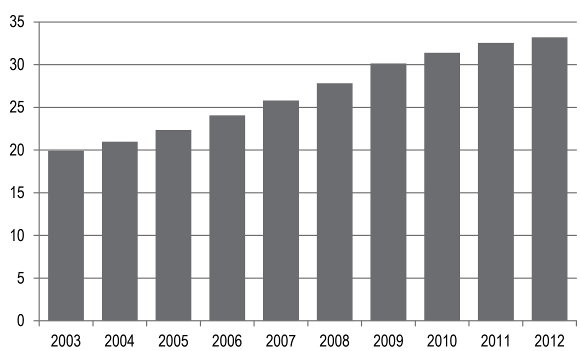


Source: VSNU.

In international comparison, Dutch university research is of very high quality. This is evident from a variety of indicators, including the relative citation rate of Dutch scientific publication output, the citation levels of individual universities, or the citation rates of different scientific fields. As shown in Chapter 3, the Netherlands has the second largest share (after Switzerland) of publications with a high citation impact among domestic publications. Since research universities (including university medical centres) account for close to 90% of Dutch scientific publications, it can be concluded that they perform extraordinarily well as a whole in an international comparison.

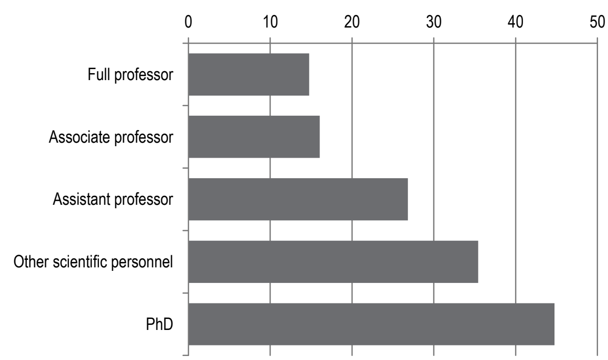
Research in the Netherlands is performed with a high degree of international collaboration. This is attributable both to the scientific excellence of Dutch universities and to the country's relatively small size. Some 48% of Dutch scientific articles were published with an international co-author over the period 2003-11, higher than the OECD+BRIICS[20] average of 42%. Furthermore, 58% of Dutch top-cited articles were co-published with international research institutes, a significantly higher share than the 12% of top-cited articles co-published with domestic institutes (OECD, 2013a). With respect to the international mobility of Dutch researchers from 1996 to 2011, the largest flows are between the Netherlands and the United States, followed by Germany and the United Kingdom. As the net flows between these countries and the Netherlands are positive, the latter is able to attract or attract back researchers at the international level. Figure 4.16 shows the growth in share of foreign scientific personnel in the WO – up from one in five in 2003 to one in three in 2012, or more than 8 000 personnel (in full-time equivalents). Around one-third of these are PhD students and account for around 45% of all PhD students in the Netherlands (Figure 4.17). These figures attest to the openness and high quality of Dutch research universities.

Figure 4.16. Foreign scientific personnel (FTE) in Dutch academic universities as a percentage of total



Source: Rathenau Institute.

Figure 4.17. Foreign scientific personnel (FTE) in Dutch academic universities, by category, and as a percentage of total



Source: Rathenau Institute.

The UAS have a limited research capacity and conduct a very small share of the R&D performed in the HEI sector. It was not part of their original mandate to conduct research and the teachers' education did not provide them with the appropriate capabilities. This started to change in 2001 with the appointment of "lectors", each of whom leads a group of researchers (including lecturers) who carry out research on a particular theme. By 2010, there were around 450 lectors in the system, mostly half-time (HBO-raad, 2010). The task of the UAS is to meet the smaller-scale research and knowledge needs of SMEs, particularly at the regional level. Table 4.11 shows that the necessary resources – both government funds and contract research – have increased in recent years.

Table 4.11. Sources of research funding in the UAS, 2010-12

EUR millions and percentage

	2010		2011		2012	
Government	91.9	73%	107.1	74%	118	71%
Contract research international	4.8	4%	4.1	3%	5.9	4%
Contract research national	29.4	23%	34.4	24%	41.6	25%
Total	126.1	100%	145.6	100%	165.5	100%

Note: The government contribution contains also direct funding from the national research programme on applied research for UAS (NWO-Raak) (roughly 20 %).

The quality of UAS applied research cannot be evaluated in the same way as the more fundamental research of the WO and it is difficult to make international comparisons. Moreover, the system is quite new and still developing. A few national reviews and evaluations of UAS research activities have taken place. They show the importance of this type of research, which has beneficial links to student training and professional practice, and the challenges it faces: the need to upgrade staff qualifications, which are low by international standards[21] and insufficient for significant research activities; the need to increase the number of research staff, which, despite the appointment of lectors, remains very low; the need to invest in research facilities, which are weak, and to facilitate the use of existing facilities in the WO and PRIs; the need to introduce more "focus and mass" in the research activities of each UAS, for example, through profiling and specialisation; and the need to introduce more stable and substantial funding streams in support of UAS research activities (HBO-raad, 2010). Chapter 4 outlines some of the policy measures introduced to tackle these challenges. Still, the impression is that UAS research activities are sub-critical and require further investment if they are to realise their ambition.

Valorisation activities

A third mission of Dutch universities is "valorisation", which has attracted growing attention over the last decade or so. In comparison to other European countries, a "valorisation infrastructure" was established relatively early (Leisyte, 2011). Its existence is not, of course, a guarantee of effective technology transfer and spin-off activities. It has been shown that the existence of formal technology transfer mechanisms is generally positively related with commercialisation but not with academic engagement with industry (Perkmann et al., 2013).

Valorisation has been defined as "the process of creating value from knowledge by making knowledge suitable and/or available for economic and/or societal use and translating that knowledge into competitive products, services, processes and entrepreneurial activity" (Rathenau Institute and STW, 2011). As such, it can have a wide range of manifestations, which can generally be grouped into two categories, i.e. commercialisation and academic engagement. Commercialisation involves the patenting and licensing of inventions and academic entrepreneurship; academic engagement with industry involves multi-directional knowledge-related collaboration via such formal activities as collaborative research, contract research and consulting, and via informal activities such as networking and exchanges at conferences and other forums (Perkmann et al., 2013; Luukkonen and Thomas, 2013). Both activities are important for knowledge transfer and utilisation, but it is harder to obtain information on the many, often informal forms of interaction. Valorisation is therefore difficult to measure and benchmark and valorisation indicators are weakly developed at an international level.[22] Proxy indicators used here are limited to industry funding of university research, university-industry co-publication, and patenting by universities. These are complemented by a qualitative description of organisational arrangements for supporting research commercialisation in universities.

Table 4.12 shows the share of industrial funding of university research in recent years for the Netherlands and some comparator countries. The Netherlands' share increased from 5.2% in 2001 to 8.2% in 2011, and only Belgium and Germany had higher shares among the comparator group. This suggests that university-industry interaction in the Netherlands is relatively strong.

Table 4.12. Share of industry funding of university research, 2000-11

Percentages

	2001	2003	2005	2007	2009	2011
Germany	12.2	12.6	14.1	15.5	14.2	14.0
Belgium	12.7	11.6	10.9	11.1	11.0	10.7
Netherlands	**5.2**	**5.7**	**7.8**	**7.5**	**8.2**	**8.2**
EU28	6.4	6.2	6.4	6.9	6.4	6.6
Total OECD	6.3	5.9	6.1	6.6	6.3	5.9
Finland	6.7	5.8	6.5	7.0	6.4	5.5
Austria				5.7	5.2	5.2
United States	6.5	5.2	5.0	5.5	5.6	4.5
Sweden	5.4	5.3	5.1	4.9	4.5	4.0
Norway	5.8	5.0	4.7	4.0	3.8	4.0
United Kingdom	6.0	5.2	4.6	4.5	3.9	4.0
Denmark	3.0	2.7	2.4	2.1	3.6	3.4
France	3.1	2.7	1.6	1.6	1.8	2.6

Source: OECD (2014), *Main Science and Technology Indicators*, Volume 2013, Issue 2, OECD, Paris, doi: 10.1787/msti-v2013-2-en.

Only a part of knowledge transfers from universities to industry take place through formal contracts involving money transfers. A lot of R&D collaboration takes place in publicly funded research programmes, which may or may not involve direct payment of university research by industry. Other important channels for knowledge transfer are informal interaction at conferences, partnering events and fairs, and training events or through supervision of theses, joint publication, and common research or other facilities. These interactions are not captured by indicators of industry funding of university research.

With this in mind, an internationally comparable indicator that may provide insight on the levels of interaction between universities and firms is the level of university-industry co-publications (expressed as a percentage of the publications linked to a specific university within the country where at least one address referred to is a firm). While there is some bias in this indicator,[23] there is some evidence (e.g. Wong and Singh, 2013) that university-industry co-publications are positively related to universities' technology commercialisation, including patenting, spin-offs, and technology licensing. Table 4.13 compares the share of university-industry collaborative papers across countries using Web of Science-indexed research publications for 2008-11. It shows that 7.2% of Dutch university papers over this period were co-authored with industry, a level surpassed only by Sweden and Denmark. Furthermore, less than half (44%) of these publications were co-authored with domestic firms, a level that is lower than in comparator countries. This could signal a relatively low capacity to perform world-class/new-to-the-world research (as the universities *have* to do) in Dutch industry.[24] However, as universities in the open and advanced Nordic economies have only slightly higher levels of co-authorship with domestic firms than their counterparts in the Netherlands, country size and openness are likely to be important. Moreover, industry co-authored papers of the top 500 universities in the Leiden Ranking 2013 have an average co-authorship with domestic firms of 44%, the same level as Dutch universities (Tijssen, 2013). The relatively low share of co-publications with domestic firms therefore probably signals the high research quality of Dutch research universities and their attractiveness as partners to international firms.

Table 4.13. Share of university-industry* co-publications, by country (2008-11)

Country	Papers co-authored with industry, %	Share of domestic industry,** %
Sweden	8.0	46
Denmark	7.7	52
Netherlands	**7.2**	**44**
Austria	6.8	-
Finland	6.4	51
Norway	6.1	52
United Kingdom	5.2	-
Belgium	5.1	-
United States	5.0	84
Germany	4.9	-
Switzerland	4.9	-
France	4.6	-

Table 4.14. Share of university-industry* co-publications, by university (2008-11)

University***	Papers co-authored with industry %
Utrecht University	7.1
Leiden University	7.3
University of Groningen	6.9
Radboud University Nijmegen	6.1
University of Amsterdam	6.1
University of Wageningen	10.1
VU University Amsterdam	6.5
Erasmus University	7.4
Delft University of Technology	14.0
University of Maastricht	7.2
Eindhoven University of Technology	15.6
University of Twente	9.8

Notes:

*Industry is defined as for-profit business companies and excludes organisations primarily active in the clinical health-care sector and the education sector (i.e. hospitals, clinics, private colleges, etc.) (Tijssen, 2012).

**Refers to the share of research publications with a university author's address in a given country and a co-author from industry in the same country (and possibly also in another country) as a percentage of all publications with a university author's address in the given country.

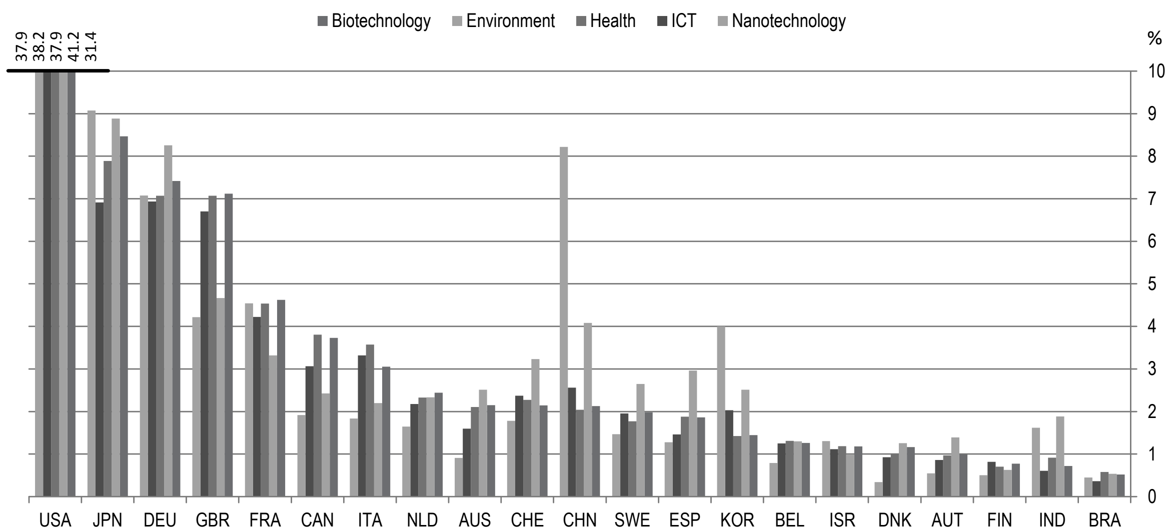
***University of Tilberg is not included, since the data in the table is based on CWTS Leiden Ranking 2013, which includes only the 500 universities worldwide with the largest publication output in the Web of Science database.

Source: R.J.W. Tijssen (2013), "Measuring University-Industry Research Connectivity within and across National Systems of Higher Education", U21 Symposium "National Systems of Higher Education: Criteria for Evaluation", Shanghai, China, 7 November.

In a comparison of individual universities (Table 4.14), the universities of technology and the University of Wageningen (which focuses on food, nutrition and environmental fields) have the highest shares of industry co-authored papers. This is hardly surprising given the nature of their industry-relevant activities, but even the comprehensive universities have quite high shares when compared with the countries in Table 4.13. Furthermore, three universities (Eindhoven, Delft and Wageningen) have a higher share of industry co-authored papers than MIT (8.9%), Stanford (10.0%) or Imperial College London (8.8%) (CWTS Leiden Ranking, 2013). Again, this would seem to suggest that Dutch research universities have comparatively strong links with industry.

As a possible further sign of high research quality and commercial relevance, Figure 4.18 shows that the Netherlands occupies one of the leading positions in the OECD in terms of international patent citations to national non-patent literature (i.e. scientific publications).

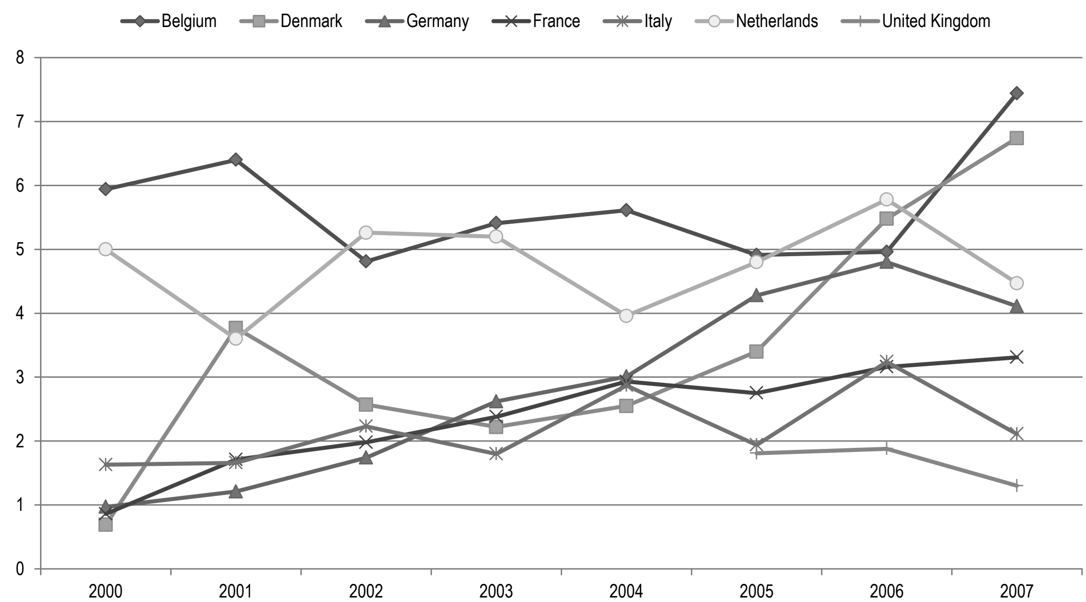
Figure 4.18. Main sources of scientific documents cited in patents, selected technology areas, 2001-11



Source: OECD (2013a), *OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth*, OECD Publishing, doi: 10.1787/sti_scoreboard-2013-en.

Besides academic engagement with industry, commercialisation of research findings (through patenting, licensing and spin-offs) is considered another important valorisation route. Figure 4.19 shows that Dutch universities' patenting performance is good by international standards. Such data should, however, be treated with caution. Patents do not equate to valorisation; they must be exploited, e.g. through licensing or spin-offs, to realise their value. Furthermore, even when they are exploited, patents and other ways to monetise university research capture only (a very small) part of the economic value and social impact of universities. As the direct economic benefits derived by patents (with very few exceptions) are modest, university patents are arguably most useful as steering devices (to align the range of university research that is not patented) and as a conspicuous signal of the economic relevance of university research to potential research collaborators in industry.

Figure 4.19. Number of university patents per 1 000 researchers in higher education



Source: www.wti2.nl.

Technology transfer offices (TTOs), which provide support for a wide range of market-oriented valorisation activities, were first established as early as the 1980s in different institutional forms. Today, all research universities have TTOs attached to them. A specific feature of the Netherlands is that universities have promoted spin-off creation through holding companies, which are legally separate but owned by the universities. The first holding company was established by the University of Twente in 1985, followed in 1992 by Maastricht University and the University of Amsterdam. After the Patent Act was passed in 1995, several others followed (Leisyte, 2011). The holding company owns the shares of the university's spin-off companies and it coaches these companies in matters related to intellectual property, taxation and financial matters. The university obtains the dividends from the shares owned by the holding company.

Box 4.2. YES!Delft incubator

YES!Delft describes itself as a high-technology entrepreneurship centre that seeks to build the leading firms of tomorrow. It coaches students, professionals and scientists to take their first steps on the path to becoming an entrepreneur and offers them support to turn their venture into a success. It conducts entrepreneurship forums and training programmes to motivate and help entrepreneurs lay a solid foundation for their company. Furthermore, it provides them with office space and many technical facilities, access to international networks and knowledge sharing to help promising companies grow even further. It also provides counselling on the several stages of the entrepreneurial process, emphasising access to finance. YES!Delft was initiated by Delft University of Technology, the city of Delft and TNO. It is sponsored by the European Union and several private companies.

Source: www.yesdelft.nl.

Knowledge parks can also be important mechanisms for technology transfer and commercialisation. In a report of the Dutch research organisations published in 2003, all but one university had structures, such as an incubator, to support the creation of spin-off companies (Zomer et al., 2010). Many of these support structures were created in the mid-1990s before the major funding initiatives launched in the 2000s. A more recently established incubator, located at the University of Delft, is briefly described in Box 4.2.

In contrast to the WO, where much research is fundamental in nature, knowledge valorisation lies at the heart of UAS applied research activities, which are supposed to be strongly rooted in professional practice. Much of the research funding available to the UAS, e.g. through the RAAK programme (see Section 5.6), is conditional on collaboration with firms, especially SMEs, and with public bodies. At the same time, most of the lectors appointed since 2001 work only part-time for the UAS and are employed elsewhere with a view to encouraging cross-pollination with professional practice (HBO-raad, 2010). New infrastructure investments, such as the RDM Campus in Rotterdam (see Box 4.3), are also designed to nurture close co-operation between teaching, research and valorisation. However, research expenditures in the UAS are still dwarfed by those in the WO.

Box 4.3. Research, Design and Manufacturing (RDM) Campus in Rotterdam

RDM Campus, whose acronym stands for Research, Design and Manufacturing, began operations in 2009 on the initiative of Rotterdam University of Applied Sciences, Albeda College and the Port Authority Rotterdam. Its main objective is to promote knowledge-based economic development by offering a physical location for research and by connecting it with manufacturers' interests. It gathers students, teachers, professors and entrepreneurs together in innovation teams and communities of practice to address concrete practical questions in the fields of construction, mobility, product design, maritime and maintenance. The Campus is located in the shipyard previously used by the Rotterdamsche Droogdok Maatschappij (Rotterdam Dry Dock) Company as an industrial hall of 23 000 m². In view of the Campus's potential for co-operation between business and educational partners, several government subsidies supported the renovation of the old shipyard's facilities.

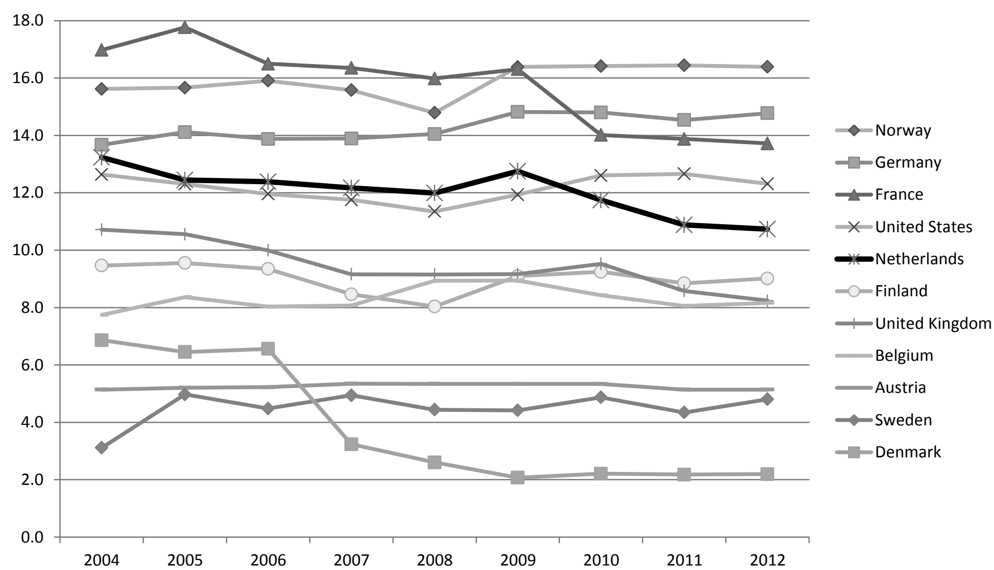
Source: www.rdmcampus.nl and B. Hooijer and G. Muris (2009), "RDM Campus: An innovative learning and working environment in the Port of Rotterdam", working paper.

To conclude, while acknowledging the limitations of the valorisation proxy indicators presented above, taken together, they suggest that Dutch universities are well aligned with the needs of industry and have been for some time. In an international comparison, Dutch universities appear to attract a higher share of their funding from industry than those in most other countries with advanced systems, while co-publications with industry are among the highest in the world. However, CIS evidence presented earlier in this chapter shows that the share of Dutch innovative firms collaborating with universities is low in international comparison. A plausible explanation for the seeming discrepancy could be the fact that the share of industrial funding of university research, which takes place through formal contracts, would be the outcome of a smaller number of larger contracts with large companies, but confirmation would require more detailed data.

4.3. Public research institutes

The R&D expenditures of non-university public research institutes accounted for 10.7% of Dutch GERD in 2012, down from 13.2% in 2004 (Figure 4.20). This places the Netherlands in a middle position *vis-à-vis* a comparator group of advanced economies. As Chapter 3 shows (Figure 3.3), R&D expenditures (in constant USD 2005 prices PPP) have remained largely unchanged in PRIs over this period while increasing in the business sector and universities. This explains the decline of PRIs' share of GERD. As Figure 4.20 shows, the Netherlands is not unique in this respect: France, the United Kingdom and Denmark have also seen declines in the share of GERD performed in PRIs. In Denmark, which has seen the sharpest fall, this is due to the absorption of most Danish PRIs by universities in 2007.

Figure 4.20. Percentage of GERD performed by the government sector, selected countries, 2004-12



Source: OECD (2014), *Main Science and Technology Indicators*, Volume 2013, Issue 2, OECD Publishing, doi: 10.1787/msti-v2013-2-en.

For the share of industry funding of research performed in PRIs, the Netherlands leads the comparator countries, with 11.3% of R&D funded by firms (Table 4.15).[25] It has a sizeable applied sciences institute sector geared to performing contract research work for the private sector (see below). Table 4.15 also shows a decline in the share of industry funding, down from 20.6% in 2001. At least part of this decline can probably be attributed to increased competition from universities, which have had an increasing share of their R&D expenditures funded by industry. On another measure of PRI-industry interaction, the share of academic papers co-authored with industry (using Web of Science-indexed research publications in 2008-11) stands at 5.1%, lower than 7.2% of industry co-authored papers emanating from the research university sector (Table 4.13) (Tijssen, 2012, 2013). The explanation may be the fact that several PRIs undertake fundamental research or are in the social sciences and humanities, where the opportunities for industrial collaboration are scant; several also pursue more practical research or research in less high-technology areas, which is unlikely to result in scientific co-publications.

Table 4.15. Share of industry funding of government sector research, 2000-11

Percentages

	2001	2003	2005	2007	2009	2011
Netherlands	**20.6**	**16.4**	**14.6**	**17.1**	**32.4**	**11.3**
Finland	15.2	13.6	12.4	13.7	13.6	11.0
United Kingdom	12.5	8.7	9.9	9.2	8.0	9.7
Norway	10.6	10.1	10.6	10.1	10.3	9.5
Germany	2.3	2.4	9.9	10.8	9.8	9.3
EU28	6.8	5.6	8.3	8.6	8.8	8.1
France	6.3	5.7	7.4	6.5	7.2	7.8
Belgium	12.4	8.9	9.2	9.6	7.7	5.7
Sweden	1.6	1.7	1.5	4.4	5.1	5.2
Austria				9.3	6.0	4.2
Denmark	7.4	1.5	2.1	0.6	0.4	3.4
Total OECD	3.2	2.7	3.6	3.7	3.7	3.4

Source: OECD (2014), *Main Science and Technology Indicatiors*, Volume 2013, Issue 2, OECD Publishing, doi: 10.1787/msti-v2013-2-en.

The data cited above are aggregates that mask the great variety of PRIs. The Dutch PRIs fall into three categories:

- The scientific research institutes that are under the Netherlands Organisation for Scientific Research (NWO) and the Royal Netherlands Academy of Arts and Sciences (KNAW).
- The government laboratories that conduct research and provide knowledge services to meet the knowledge needs of the state or society.
- The applied research (TO2)26 institutes that provide a range of knowledge-related services intended to meet the knowledge needs of industry. They include TNO (Netherlands Organisation for Applied Scientific Research), the DLO (Agricultural Research Services), and the large technological institutes (GTIs).

Each of these categories is described in more detail below.

Scientific research institutes: NWO and KNAW institutes

The intermediary organisations NWO and KNAW have a number of institutes that perform academically oriented research. NWO has eight institutes in the fields of astronomy, mathematics and computer science, physics, marine sciences, law and criminality, and space research (see Box 4.4). They have four core tasks: to carry out scientific research; to manage major national facilities and to serve as a gateway to international facilities such as CERN for Dutch researchers; to provide research facilities and infrastructure to researchers; and to develop new technologies (Rathenau Institute, 2008). The NWO institutes are independent legal entities with their own managing boards. Together, they employed 1 445 personnel (FTE) in 2012, 58% of whom were researchers. Of the NWO budget of EUR 755 million in 2011, EUR 166 million (22% of the total) was allocated to these institutes. This share has declined steadily over the last decade or so – it stood at around 26% in 2001, as the universities have gained an increasing proportion of the NWO budget from 53% in 2001 to 60% in 2011 (see Section 5.6). Given their roles in co-ordination and facilitation, NWO institutes have close links with Dutch universities. For example, NWO institute researchers can be part-time university lecturers or professors and university researchers can be appointed as temporary guest researchers at the institutes.

Box 4.4. NWO research institutes

ASTRON: Netherlands Institute for Radio Astronomy: Founded in 1949, ASTRON seeks to make discoveries in the field of radio astronomy through the development and operation of word-class equipment and facilities. It also introduces its technologies to the market by developing hardware and software prototypes and products. ASTRON received EUR 31 million in basic funding from NWO in 2011 and employed 112 researchers (FTE) in 2012. Website: www.astron.nl.

CWI: Centre for Mathematics and Computer Science: CWI is the national research institute for mathematics and computer science. The institute was founded in 1946 and is located at Amsterdam's Science Park. It contributes to solutions in a wide range of fields such as energy, health care, climate, communications, mobility and safety. CWI received EUR 18 million in basic funding from NWO in 2011 and employed 154 researchers (FTE) in 2012. Website: www.cwi.nl.

FOM: Foundation for Fundamental Research on Matter: There are three FOM institutes: AMOLF (Institute for Atomic and Molecular Physics), DIFFER (Dutch Institute for Fundamental Energy Research) and Nikhef (National Institute for Subatomic Physics). AMOLF conducts fundamental research in the fields of nanophotonics, solar cells and biomolecular systems. DIFFER focuses on sustainable energy: its generation through nuclear fusion and its storage in the form of solar fuels. Nikhef research centres on particle and astroparticle physics. Together, the FOM institutes received EUR 62 million in basic funding from NWO in 2011 and employed 291 researchers (FTE) in 2012. Websites: www.amolf.nl; www.differ.nl; www.nikhef.nl.

NIOZ: Royal Netherlands Institute for Sea Research: NIOZ conducts marine research in Dutch and overseas waters. Its research areas include biology, physics, chemistry and geology. Its origin goes back to 1876, making it is one of the oldest oceanographic research institutes in Europe. NIOZ received EUR 30 million in basic funding from NWO in 2011 and employed 145 researchers (FTE) in 2012. Website: www.nioz.nl.

NSCR: Netherlands Institute for the Study of Crime and Law Enforcement: NSCR carries out fundamental research into crime and law enforcement. It has three main complementary themes: mobility and the distribution of crime; citizens and the criminal justice system; and life course, crime and interventions. NCSR received EUR 3 million in basic funding from NWO in 2011 and employed 26 researchers (FTE) in 2012. Website: www.nscr.nl.

SRON: Netherlands Institute for Space Research: Founded in 1983, SRON aims to carry out and communicate research regarding astrophysics, the Earth, planets and exoplanets. It also develops new technologies for satellite instruments, health care and food-quality monitoring. SRON received EUR 22 million in basic funding from NWO in 2011 and employed 113 researchers (FTE) in 2012. Website: www.sron.nl.

Source: NWO website: www.nwo.nl.

As in the case of universities, a major output of NWO institutes is scientific publications, many of them co-published with international partners. In 2012, 1 174 scientific publications in the Thomson Reuters/CWTS Web of Science could be assigned to NWO institutes and their 2008-11 citation impact factor stood at 1.62 (where 1.0 is the global mean), a level slightly above that of the Dutch research universities as a whole.[27] These figures confirm the scientific excellence of the NWO institutes.

KNAW has 18 institutes in the fields of humanities and social sciences and life sciences. It also has institutes dedicated to science and technology assessment (see Table 4.16 for a full list of KNAW institutes and headline data). KNAW institutes have three core tasks: to undertake outstanding scientific research; to manage and provide access to unique scientific collections; and to provide services for science and society more generally (Rathenau Institute, 2008). Together, they employed 1 138 personnel in 2011, 60% of whom were researchers. In contrast to NWO, virtually the entire KNAW budget goes to KNAW institutes: in 2011, they accounted for 88% of KNAW's expenditures, up from 75% in 2001. This equates to institute expenditures of EUR 124 million in 2012 compared to EUR 63 million in 2001, i.e. an almost doubling of expenditures over a decade or so. Over the same period, direct block grant funding (flow 1) from the Ministry of Education, Culture and Science increased only moderately, from EUR 75 million (77% of KNAW's total income) in 2001 to EUR 94 million in 2012 (62% of total income). The relatively large increases in KNAW institute expenditures are therefore the product of their success in attracting third-party funding in the form of indirect (flow 2) and contract (flow 3) funding: KNAW's third-party funding rose from EUR 14 million in 2001 to EUR 48 million in 2012, virtually all of which is spent in the institutes.

Table 4.16. Main figures for the KNAW Institutes (2012)

KNAW institutes	Budget (EUR millions)	Personnel (FTE)	Research capacity (FTE)	Scientific publications	PhD theses
Total	109.9	1138.3	687.4	1713	74
Humanities and social sciences	42.8	454.9	171.5	642	23
Data Archiving & Networked Services (DANS)	4.4	45.8	4.6	24	0
Fryske Akademy	1.6	38.7	23.2	51	2
Huygens Institute	7.3	77	51.1	98	2
International Institute of Social History (IISG)	8.4	101.4	12.5	133	3
Royal Netherlands Institute of Southeast Asian and Caribbean Studies (KITLV)	3.8	34.3	13.3	88	9
Meertens Institute	4.9	45.1	18.1	97	1
Netherlands Institute for War Documentation (NIOD)	5.2	54.9	21.3	55	1
Netherlands Interuniversity Demographic Institute (NIDI)	3.7	41	26	81	4
Netherlands Institute for Advanced Studies (NIAS)	3.0	13.5	-	-	-
e-Humanities Group	0.4	3.2	1.4	15	1
Life sciences	60.8	630.7	498.0	1035	51
Fungal Biodiversity Centre (CBS)	6.9	63.2	52.2	134	4
Hubrecht Institute	18.5	198.2	132.9	129	7
Interuniversity Cardiology Institute of the Netherlands (ICIN)	6.1	60.3	75.1	363	19
Netherlands Institute of Ecology (NIOO)	12.6	128.1	116.3	210	15
Netherlands Institute for Neuroscience (NIN)	16.1	178.9	121.5	199	6
Spinoza Centre for Neuro-imaging	0.6	2	-	-	-
Other	6.3	52.7	17.9	36	0
Rathenau Institute	5.1	50.4	17.9	36	0
Waddenacademy	1.2	2.3	0.0	0	0

Source: Rathenau Institute, based on KNAW annual financial accounts and KNAW 2012 annual report.

The various KNAW institutes have different histories but all were set up to fulfil a scientific and/or public need for knowledge and/or for the consolidation of collections. Many of the collections are world-famous and have enabled outstanding research. This can be seen in the quality of their scientific publications: in 2012, 761 scientific publications in the Thomson Reuters/CWTS Web of Science could be assigned to the KNAW institutes and their 2008-11 citation impact factor stood at 1.65 (where 1.0 is the global mean), a level above that of the Dutch research universities as a whole.[28]

Recent years have seen numerous changes in the institutes' organisation in order to create more scope for scientific innovation and the exploration of new avenues of research. This has resulted in the merging or closure of a number of institutes, as well as the establishment of some new ones (Ministry of Education, Culture and Science, 2012). The institutes co-operate with universities on joint research programmes. Their researchers can be appointed to endowed chairs or have part-time appointments as professors at universities. Moreover, KNAW institutes are housed in the vicinity of Dutch universities to encourage institute staff to interact with university researchers and students.

All in all, both NWO and KNAW institutes have an obvious function in the innovation system. They provide research facilities and/or collections for use by researchers, both within and outside these institutes, and contribute to university activities by part-time appointments or more teaching-free research periods for university personnel. Overall, they are well connected with the university sector and subject to regular evaluation exercises similar to those of Dutch universities (see Section 5.6). Bibliometric analysis shows that they conduct outstanding research. In conclusion, they complement the universities and help to maintain institutional variety in the Dutch research system.

Government laboratories

Government laboratories are typically under ministries and their function is to carry out research or to pool research-based knowledge to meet the knowledge needs of the state or wider society. The heterogeneous nature of this category of PRIs is evident in the list of institutes in Box 4.5.

Applied research institutes

The applied research institutes constitute the largest part of the PRI sector and carry out a substantial part of the applied research performed in the Netherlands. The six institutes are the Netherlands Organisation for Applied Scientific Research (TNO); the Agricultural Research Service (DLO); and four large technological institutes (GTIs): the National Aerospace Laboratory (NLR); the Energy Centre of the Netherlands (ECN); Deltares; and the Maritime Research Institute of the Netherlands (MARIN). Each is described in more detail below. Since 2010, the six institutes have worked together in a federation called TO2. Their stated objective is to serve the needs of government departments (part of this research falls under statutory tasks), search for solutions to societal problems, and strengthen innovativeness in the business community. They also manage strategic research facilities, some of which are unique to the Netherlands and internationally (Ministry of Economic Affairs, 2013).

Box 4.5. Government laboratories

The *Ministry of Justice and Security* is responsible for two centres: the Scientific Research and Documentation Centre (WODC), which conducts research on the criminal justice system, commissions research, and has an advisory and knowledge dissemination role; and the Netherlands Forensic Institute (NFI), which conducts forensic research and is a centre of expertise. The annual research expenditure of these two institutes is of the order of EUR 20 million.

The *Ministry of Education, Culture and Science* has a number of cultural institutes with a research function, e.g. the National Service for Cultural Heritage (RCE) and the Netherlands Institute for Art History (RKD). Their annual research expenditure is estimated at EUR 10 million.

The *Ministry of Infrastructure and the Environment* has the Netherlands Environmental Assessment Agency (PBL), which was created by the merger of the agencies formerly responsible for research on spatial planning and the environment. The major function of the PBL is to pool knowledge of relevance to policy, and to conduct strategic policy analyses on the environment, natural habitats and spatial planning. Although this institute is part of the ministry, other ministries may commission studies from the PBL. The annual research budget of the PBL is EUR 30-40 million. The Ministry of Infrastructure and the Environment has a further three research institutions: the Royal Netherlands Meteorological Institute (KNMI), a national institute that studies the weather, climate and seismology, with an annual research budget of EUR 10-15 million; four Rijkswaterstaat centres of excellence on water, transport and infrastructure, construction, and ICT and data management; and the Netherlands Institute for Transport Policy Analysis (KiM), with an annual research budget of approximately EUR 4 million.

The *Ministry of Economic Affairs* has two agencies, Statistics Netherlands and the Netherlands Bureau for Economic Policy Analysis (CPB). They are not primarily research institutes, but conduct studies or research to a small extent. Out of the CPB's annual budget of around EUR 13 million, only part is spent on research; Statistics Netherlands has limited activities in terms of research.

The *Ministry of Health, Welfare and Sport* has the National Institute of Public Health and the Environment and the Netherlands Institute of Social Research, both of which have a key research role. Their annual budgets are EUR 200 million and EUR 8.5 million, respectively.

Note: all budget figures are for 2007.

Source: Rathenau Institute (2008).

Table 4.17 provides various headline statistics on the applied research institutes that draw attention to the diversity of the sector. They were typically founded before the Second World War[29] and differ markedly in their size (in terms of turnover and staff numbers), in their levels of government funding, and in their historical trajectories. They cover a wide variety of research areas and industries, each with its specific needs and challenges. Together, they employ around 8 500 people and in 2012 had a turnover of almost EUR 1.3 billion. As a whole, government contributions in the form of direct block grant funding accounted for about one-third of turnover in 2012, though there is significant variation across institutes. For example, just 11-12% of the turnover of Deltares and MARIN came through direct government funding while this figure was around 40% for DLO. The theoretical rationales for direct government funding of this sort are outlined in Box 4.6.

Table 4.17. Headline data for applied research institutes, 2012

Institute	Total income (2012, EUR millions)	Government direct funding (2012, EUR millions)	Workforce (2012)
TNO	587	192	3 409
DLO	343	137	2 879
GTIs	358	104	2 211
Total	**1288**	**433**	**8 499**

Source: Rathenau Institute. Workforce data come from Ministry of Economic Affairs (2013), "Our Vision for Applied Research" (in Dutch).

Box 4.6. Rationales for direct government funding of the TO2 applied research institutes

Market failure and the public interest. The TO2 institutes invest in precompetitive knowledge issues that receive insufficient attention from the business sector. The same is true for large-scale research facilities housed at the institutes, which are often expensive to run and cannot be financed from routine exploitation.

Scale and synergy. The TO2 institutes focus on the development and/or application of knowledge for the benefit of society and government. These objectives can be pursued thanks to a robust knowledge base that has been built over time. The knowledge developed at the TO2 institutes delivers benefits in terms of scale and synergy that would be lost if the research was scattered across many different organisations.

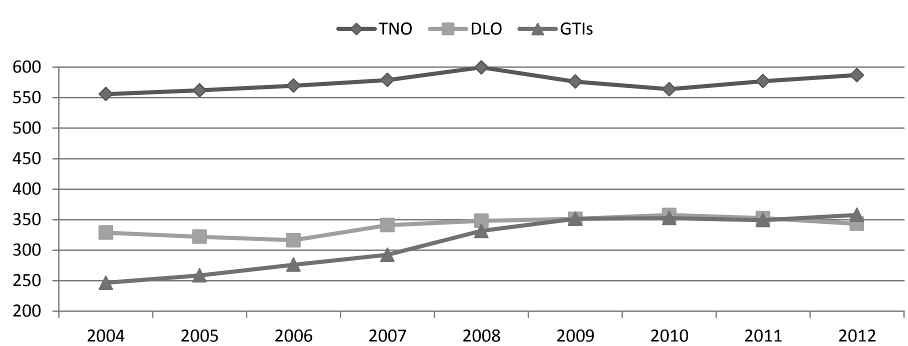
Independence and reputation. The independent status and reputation of the TO2 institutes is of crucial importance, particularly in societally relevant research, where the findings are not open to discussion and must be made directly accessible to government agencies. As the institutes serve the public interest, they are non-profit-making.

Source: Ministry of Economic Affairs (2013), "Our Vision for Applied Research" (in Dutch).

Much of the decline in the PRIs' share of GERD can be explained by the relatively flat rise in income of the TO2 institutes over the last decade or so. Figure 4.21 shows that 2012 income levels in both TNO and DLO are only slightly higher than in 2004 (for TNO, moving from EUR 556 million in 2004 to EUR 587 million in 2012; for DLO, from EUR 329 million to EUR 343 million). These figures point to a decrease in income in real terms and workforces have shrunk in both institutes. As Figure 4.21 shows, the situation is different in the GTIs, whose income has grown from EUR 247 million in 2004 to EUR 358 million in 2012.[30] Given their variety, each of the applied research institutes is discussed separately below.

Figure 4.21. Income of TO2 institutes, 2004-12

EUR millions



Source: Rathenau Institute, based on consolidated financial accounts of TNO and ECN and data provided directly by GTIs and DLO.

Netherlands Organisation for Applied Scientific Research (TNO)

TNO is the largest Dutch research organisation. It has around 3 400 employees and had revenues of EUR 587 million in 2012. It was founded in 1932 to enable business and government to apply knowledge. It is headquartered in Delft but has several other locations around the Netherlands, including The Hague, Rijswijk, Leiden, Groningen, Apeldoorn, Helmond, Hoofddorp, Soesterberg, Utrecht, Den Helder, Zeist, Enschede and Eindhoven. It also has two international branch offices in Qatar and Aruba. TNO is regulated by public law, but is independent: it is not part of any government body, university or company (see Box 4.7 for a short history). As such, TNO is an unusual organisation; its closest international analogues are the German Fraunhofer institutes and the Technical Research Centre of Finland (VTT). Like these German and Finnish counterparts, it aims to support the innovative capacity of companies and to apply scientific knowledge in contract and collaborative research with companies, sometimes in collaboration with universities.

Box 4.7. The changing organisation and presentation of TNO: a short history

TNO was founded by the Dutch government in the early 1930s to support the industrial development of the Netherlands through applied research and technical support. Over time the scope of the organisation broadened to include not only industrial research but also research on defence, food and health. Each of these fields was governed by a separate and relatively autonomous research organisation. These four organisations together shaped TNO as a rather loose federation under a central administrative umbrella. Near the end of the 1970s the need was felt to bring these research fields under a single strategic and operational management. In 1980 the four research organisations and the central organisation were brought together in a new organisation, TNO, under a single Board of Management appointed by the Dutch government.

This model was laid down in the revised TNO Act (1985) which states the goal of the TNO: "to serve [the] public interest and the specific interests of society through the effective contribution of applied technical and scientific research and related social scientific and other applied research". The Act states that TNO undertakes the following activities to attain this goal: applied research, initiated by TNO or commissioned by customers; making research results accessible and transferring these to users by giving information and advice and by supporting user activities aimed at practical applications; co-operation in the field of applied research with other research organisations; contributing to the co-ordination of applied research in the Netherlands and to international co-operation in applied research; and activities assigned by law or "order in council".

By 2000, TNO was composed of 15 institutes. In 2005, these were merged into five core areas, each of which consisted of a number of business units and centres of expertise (there were 28 business units and 21 centres of expertise in all in 2007). These five core areas accounted for about three-quarters of all TNO activities (the figures in brackets show the distribution of turnover for these five areas): TNO Quality of Life (22%); TNO Defence and Security (25%); TNO Industry and Technology (26%); TNO Built Environment and Geosciences (20%); and TNO Information and Communication Technology (8%) (Rathenau Institute, 2008). TNO was again reorganised in 2011 around a matrix management structure that implements projects under seven themes: Healthy Living; Industrial Innovation; Defence, Safety and Security; Energy; Transport and Mobility; Built Environment; and Information Society. The distribution of TNO turnover by theme is shown in Table 4.18.

The pressure for much of this frequent reorganisation over the past decade or so can be ascribed in part to political calls for reform, which has meant that TNO has had to be flexible in the way it organises and presents itself. Such calls are far from unique to the Netherlands, but the sheer size and complexity of TNO make it a larger target than most, as TNO is the fourth largest RTO (research and technology organisation) in Europe. With the introduction of the national top sectors policy, which has major implications for TNO and the other applied research institutes (see Section 5.6), further organisational changes can be anticipated in the coming years.

Sources: Leijten, J. (2007), "The future of RTOs: a few likely scenarios", in European Commission (2007), *The Future of Key Research Actors in the European Research Area*, EU 22962 EN, Luxembourg: Office for Official Publications of the European Communities; Rathenau Institute (2008); and the TNO website (www.tno.nl).

In common with the other TO2 institutes, TNO receives direct funding from the Dutch government for around one-third of its income. In 2011, the Ministry of Economic Affairs assumed the lead in providing this funding; previously, the Ministry of Education, Culture and Science had taken the lead. The arrangements for assigning and distributing direct funding changed in 2007 to involve more demand-driven funding and steering by the government (see Chapter 4). This has led to the creation of different categories of direct funding. One is funding of "knowledge as an asset", which roughly equates to basic funding and is made up of two components, "knowledge as an asset within themes" (which is driven by demand from the Ministry of Economic Affairs and amounted to EUR 49 million in 2012) and "knowledge as an asset across themes" (which covers R&D not directly linked to demand from society or government departments and amounted to EUR 23 million in 2012). The second is "policy and applied research", which is described as targeted funding and is provided by several ministries besides Ministry of Economic Affairs. It amounted to almost EUR 120 million in 2012 (Table 4.19). Thus, taken together, direct funding of TNO by the Dutch government totalled EUR 192 million in 2012.

Table 4.18. TNO turnover by theme, 2012
Percentages of total

Theme / area of expertise	% turnover
Defence, Safety and Security	17
Industrial Innovation	15
Healthy Living	13
Energy	9
Built Environment	8
Information Society	8
Transport and Mobility	7
Other	22

Source: Rathenau Institute, based on TNO accounts 2012.

Table 4.19. TNO income "Policy and applied research funding", by ministry, 2012

Ministry	Targeted funding, EUR millions
Ministry of Defence	41
Ministry of Economic Affairs	37
Ministry of Infrastructure and the Environment	19
Ministry of Social Affairs and Employment	11
Ministry of Health, Welfare and Sport	7
Ministry of Interior	5
Total	**120**

Source: Rathenau Institute, based on TNO accounts 2012.

The other two-thirds of TNO's income come from the market. It can be broken down into several components (Figure 4.22). Assignments funded by the Dutch public sector generated an income of EUR 100 million in 2012, representing 17% of total annual income. Income from the private sector can be divided between domestic and foreign sources. In 2012, contracts with Dutch firms generated an income of EUR 142 million (24% of total annual income), while contracts with foreign firms generated an income of EUR 110 million (19% of total annual income). Figure 4.23 shows how these private-sector income streams have evolved over the last decade or so. Since 2004, income from foreign firms has increased steadily while income from Dutch firms fell with the onset of the 2008 financial crisis and has yet to return to pre-crisis levels. Finally, income from international assignments have increased over time and stood at EUR 43 million in 2012 (7% of total annual income). This reflects TNO's success in the EU Framework Programmes.

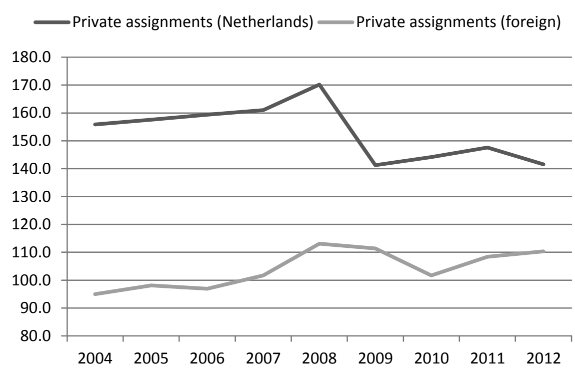
Figure 4.22. TNO income, by source of funding, 2004 and 2012

Percentages of total

Source: Rathenau Institute, based on consolidated financial accounts of TNO.

Figure 4.23. Trends in TNO income from private contracts, domestic and foreign, 2004-12

EUR millions



Source: Rathenau Institute, based on consolidated financial accounts of TNO.

Strong links with firms are an essential part of TNO's *raison d'être*. While the data presented above show that 43% of TNO's income came from private-sector sources in 2012, a large majority (even of domestic industry funding) comes from large firms. Nevertheless, many contracts are with SMEs (around 2 000 in 2011), and various tools are used to reach a wider group of firms, often in co-operation with other government agencies and/or company associations. Together, TNO claims that these activities mean that it reaches some 10 000 SMEs a year. Another part of TNO's market-oriented strategy concerns valorisation. Since the 1980s, pioneering applied research developed by TNO that has not been immediately taken up by the business sector has been spun off to companies for commercial exploitation. This is often done in alliance with other partners to get innovations out into the market more quickly (TNO, 2013). The companies are placed in a holding company, TNO Companies, which is independent of TNO in both the financial and legal sense but in which TNO is the shareholder. TNO Companies currently has around 90 companies, with a regular flow of new companies entering and established companies being sold off. Another valorisation channel is focused on intellectual property. TNO typically makes more than 100 patent applications a year and has many licence agreements with firms. It uses its IP portfolio to attract investors in start-ups.

TNO also works with the universities, most visibly in dedicated "knowledge centres", of which there were 18 in 2011. Furthermore, dozens of TNO's researchers work as part-time professors at a number of universities. These include "lectors" working in the UAS (see above). TNO also participates in the RAAK scheme for supporting applied research activities in the UAS (see Section 5.6). This kind of collaboration seeks to further strengthen the relationship between TNO and the SME sector. TNO researchers also publish in the academic literature. In 2012, 717 scientific publications in the Thomson Reuters/CWTS Web of Science could be assigned to TNO and their 2008-11 citation impact factor stood at 1.23 (where 1.0 is the global mean), a level below that of the Dutch research universities as a whole.[31]

DLO Foundation

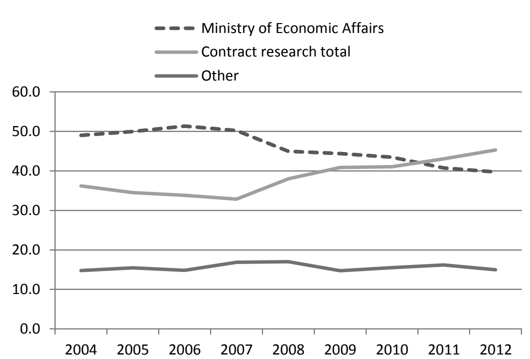
The DLO Foundation is a collection of nine research institutes[32] that perform agricultural research. Formerly a much larger number of institutes under the control of the former Ministry of Agriculture, Nature and Food Quality, the institutes were privatised in the second half of the 1990s under the umbrella of the DLO and entered into an alliance with Wageningen Agricultural University to create the Wageningen University and Research Centre (WUR). The DLO and the university remain separate legal entities under these arrangements but work closely together on application-oriented and field-based research. DLO has a workforce of just under 3 000, making it the second largest applied research performer in the Netherlands after TNO.

DLO's annual turnover of EUR 343 million in 2012 is second only to that of TNO. About 40% of DLO's budget is basic (direct) funding provided by the Ministry of Economic Affairs and is directed towards four areas (Rathenau Institute, 2008): fundamental research, which focuses on the medium-term needs of the Ministry of Economic Affairs, non-governmental organisations, other governmental agencies and Wageningen University; research to support policy making, with a focus on current policy issues; statutory research tasks, including research on current policy issues and meeting the requirements of legal frameworks; and other research projects.

As Figure 4.24 shows, the proportion of direct funding from the Ministry of Economic Affairs has fallen in recent years. As late as 2007, direct funding accounted for around half of DLO's revenues. The decline has been offset by an increase in contract research, which now constitutes around 45% of revenues. Figure 4.25 provides a breakdown of contract research income. While the private sector is the largest source of such income (EUR 62 million in 2012), its level has increased hardly at all over the last decade (EUR 59 million in 2004) and it now makes up less than 40% of all contract research income. The growth in contract income is in fact driven by large increases in funding from government sources (rising from EUR 34 million in 2004 to EUR 60 million in 2012) and from the EU (from EUR 13 million in 2004 to EUR 26 million in 2012). These shifts are symptomatic of the Dutch government's policy to reduce direct funding of the applied research institutes and to increase more competitive project-based funding.

Figure 4.24. DLO income, by source of funding

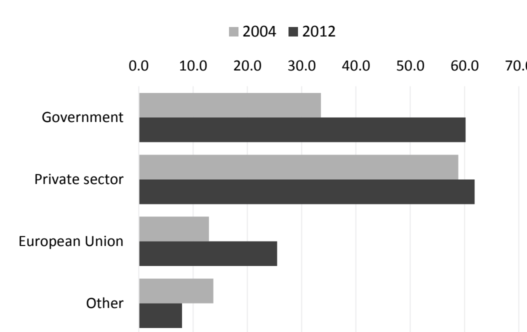
Percentages of total



Source: Rathenau Institute, based on Wageningen University Research Centre Annual reports.

Figure 4.25. Composition of DLO contract research income, by source of funding

EUR millions



Source: Rathenau Institute, based on Wageningen University Research Centre Annual reports.

Large Technological Institutes (GTIs)

The other four institutes for applied research are known as the Large Technological Institutes (GTIs). They conduct research and related activities in specific areas, as outlined in Box 4.8. They have two important roles: they are centres of technological expertise for companies and government; and they develop technology and make it available to companies and government.

Box 4.8. Main features of the Dutch Large Technological Institutes (GTIs)

Deltares works in the fields of hydrological engineering, integrated water management, geo-engineering, and groundwater management. It aims to provide innovative solutions for flood risk management, regulation of the availability of water and soil resources, delta infrastructure, healthy water and soil systems, and sustainable delta planning. It was established in 2008, with the merger of WL Delft Hydraulics, GeoDelft, and parts of TNO and the Ministry of Transport, Public Works and Water Management. Deltares employs close to 800 people and is based in Delft and Utrecht. With an annual turnover of EUR 111 million in 2012, its contracts and projects are financed both privately and by public research budgets.

The *National Aerospace Laboratory (NLR)* acts as an intermediary between universities and firms, translating scientific knowledge into technological ideas that industry can develop into concrete and competitive products. NLR also provides materials for policy development by the ministries that are responsible for the safety and environmental aspects of air transport. NLR generates around three-quarters of its turnover from paid contracts from the Netherlands and other countries, from governments to aircraft manufacturers, and from civilian to military clients. About half of NLR's industrial activities are carried out on behalf of SMEs. NLR employs more than 600 people. NLR's facilities include wind tunnels, simulators, and laboratory aircraft. Its revenue amounted to EUR 79 million in 2012, with contracts accounting for more than EUR 60 million.

The *Energy Research Centre of the Netherlands (ECN)* performs R&D in the fields of renewable energy (wind, solar and biomass), energy efficiency, environment energy, and engineering and related policy studies. With around 500 staff, ECN leads domestic and international projects in joint efforts with the industry, government authorities, universities and research institutes. It has three offices in the Netherlands (Petten, Amsterdam and Eindhoven) and branches in Belgium and China. ECN had a turnover of EUR 76 million in 2012.

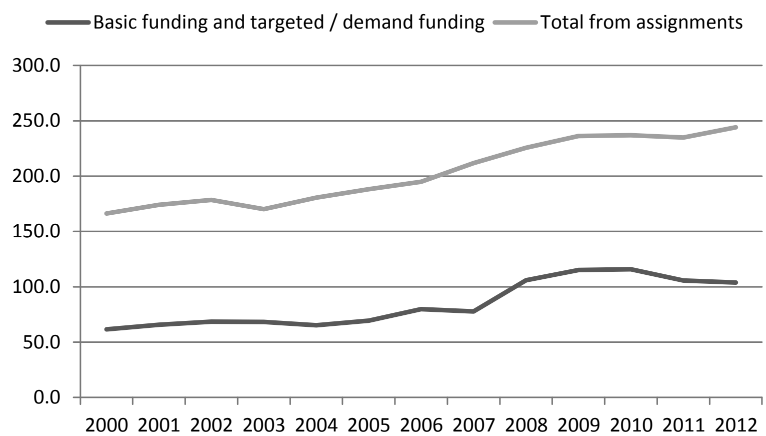
The *Maritime Research Institute Netherlands (MARIN)* provides innovative design solutions and carries out advanced research for the maritime business sector. It conducts research for shipbuilding, offshore technology and ocean engineering and develops software for maritime and mission bridge simulation. MARIN draws upon seven test facilities, has more than 300 employees and a worldwide network of scientists in hydro-dynamics and nautical support. More than 80% of its EUR 42 million turnover in 2012 was earned from the commercial worldwide maritime industry. Its customer base includes commercial ship builders, fleet owners, naval architects and offshore drilling companies.

Source: GTI websites.

As with the other TO2 institutes, the GTIs receive basic funding from the Ministry of Economic Affairs. The arrangements for earmarking and allocation are similar to those described above for TNO, i.e. there has been a shift towards greater articulation of government demand and steering of the GTIs' research activities. Other ministries provide targeted funding, another component of the direct funds flowing to the GTIs. Taken together, direct funding of the GTIs stood at EUR 104 million in 2012 (29% of their total annual income of EUR 358 million), down from EUR 116 million in 2010 when this funding constituted 33% of total annual income. As noted above, there is great variety in the share of this funding between the different institutes. Figure 4.26 shows that most of the GTIs' income is acquired on the open market in the form of public and private contracts. The share of such contracts as part of total turnover has remained fairly constant since 2000 and stood at 68% in 2012.

Figure 4.26. GTI income by source of funding

EUR millions



Source: Rathenau Institute, based on information supplied by the GTI.

The GTIs also collaborate with the universities; an example involving NLR is outlined in Box 4.9. Researchers from the GTIs also publish in the scientific literature. For example, in 2012, 171 scientific publications in the Thomson Reuters/CWTS Web of Science could be assigned to Deltares while their 2008-11 citation impact factor stood at 1.35 (where 1.0 is the global mean), a level almost on a par with the Dutch research universities as a whole.[33] The figures for ECN over the same period are: 158 publications in 2012, with a 2008-11 citation impact factor of 2.06, well above the Dutch research universities' average and the more academic NWO and KNAW institutes.

Box 4.9. Collaboration between the National Aerospace Laboratory and universities

The National Aerospace Laboratory (NLR) engages in fundamental research in close collaboration with Dutch universities. In addition to providing internships and opportunities for graduation projects, it has PhD students on its payroll who conduct fundamental research with the universities. It also works with various universities on projects in fundamental and applied research and often acts as an intermediary between academia and industry. External PhD students have regular access to its facilities. The NLR enjoys a special relationship with TU Delft as co-owner of a research plane. The two organisations share its maintenance and management, thus significantly increasing its cost-effectiveness. TU Delft uses it for teaching purposes and fundamental research and the NLR uses it for applied research and operational services. TU Delft and the National Aerospace Laboratory work intensively with the plane at the interface between fundamental and applied research.

Source: Ministry of Economic Affairs (2013), "Our Vision for Applied Research" (in Dutch).

Notes

1. This may partly be explained by the severity of the banking crisis in the Netherlands and may therefore not reflect business evaluations of returns to knowledge investment. Still, the decrease in investment in non-residential physical assets was equally or less severe than in countries in which investment in KBC increased (Denmark, Ireland, Portugal, Luxembourg, Slovenia and the United States).

2. It is not realistic to expect the Netherlands to be a leader in shifting the global knowledge frontier. By many estimates, even in systems as large and advanced as the United States most economic gains come from innovations from elsewhere. The argument here is about the share of new-to-the-world or less ambitious innovators *within* a country.

3. In addition to its potential for shifting the frontier, R&D of course also serves to facilitate national absorptive capacity.

4. An important limitation of the comparison is the fact that it does not capture the position of Dutch firms in global value chains. Given the internationalisation of the Dutch economy, and its proximity to key EU markets and knowledge centres, this may have implications for the R&D location choices of Dutch firms (see below).

5. Alternative calculations of business R&D intensity by firm size class as a share of GDP (not reported here) confirm this pattern and specify that the deficit with respect to the comparator group is greatest in firms with 500 employees or more (i.e. firms in the 250-499 employee size class have as narrow a gap as the SME sector).

6. It would be valuable to know the respective contribution of each explanation as it could point to problems in finer segments of the business sector. This could be the topic of firm-level studies, potentially accounting for other possible explanations.

7. In principle, the low costs relative to other advanced systems, in combination with strong research institutes, would appear to make the Netherlands an attractive location for internationally mobile R&D investment. However, as discussed below, there is little evidence that much additional business R&D has been attracted from abroad in recent years.

8. An alternative (or complementary) explanation may be the fact that R&D personnel are classified by education (den Hertog et al., 2012), rather than by occupation as recommended in the *Frascati Manual* (OECD, 2002: p. 92).

9. 57% of innovating firms in the Netherlands, against 72% in Germany, 70% in Denmark and the United Kingdom, 68% in France, 63% in Finland and Belgium, 62% in Sweden and 60% in Norway.

10. 49% of innovating firms in the Netherlands against, 60% in Denmark, 55% in Germany, Sweden and Austria, 54% in Finland and 53% in the United Kingdom.

11. Scientific and technological problems that require large scale efforts (large research teams, expensive infrastructure etc.) are sometimes said to be ‘indivisible’ as effective solutions cannot be obtained with only fractions of the required resources.

12. In a complementary explanation, den Hertog et al. (2012) find that Dutch international patents are increasingly concentrated over time in fewer technology

classes, a strong indicator of technological specialisation that would also operate in the direction of improving patenting productivity.

13. Not all large corporate R&D spenders choose to make this information public. According to de Heide et al. (2013) 59% of their expenditure took place abroad.

14. The picture emerging from fragmented evidence on the distribution of R&D expenditure across firms of various sizes suggests that the R&D deficit observed in Figure 4.7 is likely due to intermediate-sized firms (larger than SMEs but not in the top ten).

15. Information published separately by Statistics Netherlands (2014) on foreign affiliates according to country of ultimate control suggests that in 2011 about a third of foreign affiliate R&D (data only available for: Mining and quarrying, Industry, Energy, Water supply and waste management, and Construction) was performed by affiliates under Dutch ultimate control.

16. In addition to the university-level organisations, four universities which formerly were not funded by government but were "officially recognised" became "government-funded institutions" that provide teaching focused on theology or humanistic ideals (Chiong Meza, 2012, p. 5).

17. The research universities involved channel this last component of the budget in its entirety to the teaching hospitals.

18. For example, the UAS had revenues of EUR 3.6 billion in 2011, of which EUR 2.5 billion from Ministry of Education, Culture and Science grants, EUR 43 million from other government grants, EUR 675 million from tuition fees and EUR 204 million from contract work.

19. The new system also entails performance agreements made with individual HEIs, which include a strategic plan and targets for improving educational achievements, strengthening of the educational and research profile, and attention to impact and valorisation. These changes are discussed more fully in Section 5.5.

20. BRIICS: Brazil, the Russian Federation, India, Indonesia, China and South Africa.

21. UAS teachers had the lowest level of qualifications in universities of applied science in a recent comparison of ten countries (Weert and Soo, 2009).

22. In a recent study for the Dutch National Valorisation Commission, the Rathenau Institute and STW (2011) concluded that "a combination of quantitative and qualitative data is needed to achieve a good assessment. Valorisation cannot be measured through simple counting. The complexity and diversity of the valorisation process mean that an assessment based on a few quantitative indicators makes little sense. This also means that a simple comparison of valorisation performance is impossible."

23. University-industry co-publications are more usual in scientific fields with links to high technology. Electrical engineering and telecommunications, energy science and technology, instruments and instrumentation, civil engineering and construction, basic medical sciences, computer sciences, mechanical engineering and aerospace are fields for which, at a minimum, 10% of public-sector publications had at least one industry co-author. Public sector here means organisations other than for-profit companies: universities, for-profit organisations in the educational sector, and medical and health-care sector (Tijssen, 2012).

24. Cross-country evidence links the delocalisation of university-industry interaction to the level of business R&D (Azagra-Caro et al., 2013). It may also suggest Dutch firms' preference for collaborating with universities abroad, but the CIS evidence presented above counters this view somewhat, as Dutch firms collaborate less with partners abroad (of all types) than countries in the comparator group.

25. In June 2013 Statistics Netherlands published revised figures for GOVERD for the whole period 1999-2011. These changes are not reflected in internationally comparable OECD statistics. According to these revised figures, 16.8% of the R&D performed in PRIs was funded by industry in 2011.

26. TO2 is the acronym for Toegepast Onderzoek Organisaties (organisations dedicated to applied research).

27. Data from www.wti2.nl.

28. Data from www.wti2.nl.

29. Deltares, founded in 2008, is the product of an amalgamation of GeoDelft (founded in 1934) and WL Hydraulics (founded in 1933).

30. Some care is needed in interpreting these figures, since there has been some shift in the institutional boundaries of the various institutes. For example, Deltares, which was created in 2008, incorporated parts of TNO into its organisation.

31. Data from www.wti2.nl.

32. The institutes are AFSG: Agrotechnology & Food Sciences Group; Alterra in the field of green living environment; ASG: Animal Sciences Group; CIDC: Central Veterinary Institute Lelystad; LEI: Agricultural Economics Research Institute; PRI: Plant Research International; RIKILT: Institute of Food Safety; and Wageningen IMARES: Institute for Marine Resources & Ecosystem Studies.

33. Data from www.wti2.nl.

References

Azagra-Caro, J.M., D. Pontikakis and A. Varga (2013), "Delocalization Patterns in University–Industry Interaction: Evidence from the Sixth R&D Framework Programme", *European Planning Studies*, Vol. 21(10), pp. 1676-1701.

Chiong Meza, C. (2012), "Universities in the Netherlands: Facts and Figures", Rathenau Instituut.

Dialogic (2014), "Wetenschaps Technologie en Innovatie Indicatoren 2", www.wti2.nl.

de Heide, M., W. Manshanden, E. Poliakov and J. Ypma (2013), "Background report – OECD review the Netherlands", TNO.

European Commission (2011), *The 2011 EU Industrial R&D Investment Scoreboard,* http://iri.jrc.ec.europa.eu/scoreboard11.html.

European Commission (2013a), "2013 SBA Fact Sheet The Netherlands", Directorate-General Enterprise and Industry, http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/performance-review/files/countries-sheets/2013/netherlands_en.pdf.

European Commission (2013b), "Database for the Annual Report on European SMEs", Directorate-General Enterprise and Industry, http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/performance-review/index_en.htm.

European Commission (2013c), "SME Participation in FP7", Directorate-General for Research and Innovation, http://ec.europa.eu/research/sme-techweb/pdf/sme_participaton_in_fp7_june_2013.pdf.

European Commission (2014), "Innovation Union Scoreboard 2014", Directorate-General Enterprise and Industry, doi: 10.2769/88936.

Erken, H. and V. Gilsing (2005), "Relocation of R&D – a Dutch perspective", *Technovation*, Vol. 25, pp. 1079-1092.

Eurostat (2014), "Statistics Database", http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database.

Frenz, M. and R. Lambert (2012), "Mixed Modes of Innovation: An Empiric Approach to Capturing Firms' Innovation Behaviour", *OECD Science, Technology and Industry Working Papers*, 2012/06, OECD Publishing, http://dx.doi.org/10.1787/5k8x6l0bp3bp-en.

Hausmann, R. and C.A. Hidalgo (2013), "How Will The Netherlands Earn its Income 20 Years from Now? A Growth Ventures Analysis for The Netherlands Scientific Council for Government Policy (WRR)", WEBPUBLICATIONS 74, www.wrr.nl/fileadmin/nl/publicaties/PDF-webpublicaties/2013-11-04__74_How_will_the_Netherlands_earn_its_income_20_years_from_now.pdf.

HBO-raad (2010), *Towards a Sustainable Research Climate: Ambitions and Success Factors for Research at Universities of Applied Sciences*, HBO-raad.

Hertog, P. den, C.-J. Jager, R. te Velde, J. Veldkamp, D.W. Aksnes, G. Sivertsen, T. van Leeuwen and E. van Wijk (2012), Science, Technology and Innovation Indicators 2012, Dialogic, Utrecht.

Hooijer, B. and Muris, G. (2009), "RDM Campus: An innovative learning and working environment in the Port of Rotterdam", Working Paper

Jong, J.P.J. de and M. Freel (2010) "Absorptive capacity and the reach of collaboration in high technology small firms", *Research Policy*, Vol. 39, pp. 47-54

Jong, J.P.J. de and W. Hulsink (2010), "Patterns of innovation networking in Dutch small firms", www.ondernemerschap.nl/pdf-ez/H201002.pdf.

Leijten, J. (2007), "The future of RTOs: a few likely scenarios", in European Commission (2007), *The Future of Key Research Actors in the European Research Area*, EU 22962 EN, Luxembourg: Office for Official Publications of the European Communities

Leisyte, L. (2011), "University commercialization policies and their implementation in the Netherlands and the United States", *Science and Public Policy*, Vol. 38 (6), pp. 437-448.

Luukkonen, T. and D. Thomas (2013), "ndustrial Engagement of University Research", *ETLA Brief 20*, 19 December.

Lokshin, B. and P. Mohnen (2013), "Do R&D tax incentives lead to higher wages for R&D workers? Evidence from The Netherlands", *Research Policy*, Vol. 42(3), pp. 823-830.

Ministry of Economic Affairs (2013), "Our Vision for Applied Research", (in Dutch), The Hague.

Ministry of Education, Culture and Science (2012), *The science system in the Netherlands: an organisational overview*, The Hague.

Ministry of Education, Culture and Science (2013), *Key Figures 2008-2012*, The Hague.

Mol, M. (2005), "Does being R&D intensive still discourage outsourcing?: Evidence from Dutch manufacturing", *Research Policy*, Vol. 34, pp. 571-582.

OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, OECD Publishing, doi: 10.1787/9789264199040-en.

OECD (2012a), *OECD Economic Surveys: Netherlands 2012*, OECD Publishing, doi: 10.1787/eco_surveys-nld-2012-en.

OECD (2012b), "Key ICT Indicators: ICT-related patents as a percentage of national total (PCT filings)", www.oecd.org/internet/ieconomy/oecdkeyictindicators.htm.

OECD (2013a), *OECD Science, Technology and Industry Scoreboard 2013*, OECD Publishing, doi: 10.1787/sti_scoreboard-2013-en.

OECD (2013b), *OECD Reviews of Innovation Policy: Sweden 2012*, OECD Publishing, doi: 10.1787/9789264184893-en.

OECD (2013c), *Education at a Glance 2013: OECD Indicators*, OECD Publishing, doi: 10.1787/eag-2013-13-en.

OECD (2014), *Main Science and Technology Indicatiors*, Volume 2013, Issue 2, OECD Publishing, doi: 10.1787/msti-v2013-2-en.

Perkmann et al. (2013), "Academic engagement and commercialisation: A review of the literature on university-industry relations", *Research Policy*, Vol. 42, pp. 423–442.

Polder, M., G. van Leeuwen, P. Mohnen and W. Raymond (2009), "Productivity effects of innovation modes", *Statistics Netherlands, Discussion Paper* 09, www.cbs.nl/NR/rdonlyres/DD2A1AEF-A40B-4D71-9829-9CA81055400B/0/200933x10pub.pdf.

Rathenau Institute (2008), *Facts and figures: Public research institutes in the Netherlands*, The Hague.

Rathenau Institute and STW (2011), *Valuable – Indicators for valorisation*, Rathenau Institute and STW, The Hague / Utrecht.

Statistics Netherlands (2010), *Internationalisation Monitor 2010*, The Hague.

Statistics Netherlands (2012), *Internationalisation Monitor 2012*, The Hague.

Statistics Netherlands (2014), StatLine, http://statline.cbs.nl.

Tijssen, R. (2012), "Co-authored research publications and strategic analysis of public–private collaboration", *Research Evaluation*, Vol. 21, pp. 204–215.

Tijssen, R. (2013), "Measuring University-Industry Research Connectivity within and across National Systems of Higher Education", U21 Symposium "National Systems of Higher Education: Criteria for Evaluation", Shanghai, China, 7 November 2013.

TNO (2013), *TNO Annual Report 2012*, TNO, Delft.

Veerman Committee report (2010), *Threefold differentiation for the sake of quality and diversity in higher education, Recommendations of the Committee on the Future Sustainability of the Dutch Higher Education System*, Ministry of Education, Culture and Science, The Hague.

Weert, E. de and M. Soo (2009), *Research at Universities of Applied Sciences in Europe: Conditions, Achievements and Perspectives*, on the initiative of the European Network for Universities of Applied Sciences, HBO-raad and CHEPS, The Hague / Enschede.

Wong, P.K. and A. Singh (2013), "Do co-publications with industry lead to higher levels of university technology commercialization activity?", *Scientometrics*, Vol. 97, pp. 245-265.

Uhlaner, L.M., A. van Stel, V. Duplat and H. Zhou (2013), "Disentangling the effects of organizational capabilities, innovation and firm size on SME sales growth", *Small Business Economics*, Vol. 41(3), p. 581-607.

Zhou, H., R., Dekker and A. Kleinknecht (2011), "Flexible labor and innovation performance: evidence from longitudinal firm-level data", *Industrial and Corporate Change*, Vol. 20(3), pp. 941-968

Zomer, A.H., B.W.A Jongbloed and J. Enders (2010), "Do spin-offs make the academics' heads spin? The impacts of spin-off companies on their parent research organisation", *Minerva*, Vol. 48, pp. 331-353.

From:

OECD Reviews of Innovation Policy: Netherlands 2014

Access the complete publication at:

https://doi.org/10.1787/9789264213159-en

Please cite this chapter as:

OECD (2014), "Innovation actors in the Netherlands", in *OECD Reviews of Innovation Policy: Netherlands 2014*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/9789264213159-7-en