

R&D goes global

Policy implications for the Netherlands
as a knowledge region in a global perspective



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Rathenau Instituut

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Preface

On the back of my smart phone it reads “Designed by Apple in California. Assembled in China.” This division of labour between California and China seems typical for economic globalisation. Lucrative activities like research and development (R&D), design and marketing are done in the West, while production is outsourced to low-wage countries in the East and elsewhere. Increasingly, however, this reassuring narrative of globalisation is being challenged. China is striving to become a powerhouse in science and technology, and India and other emerging economies are trying to get a position in the more lucrative parts of globalised value chains. Western multinational corporations used to keep their core R&D activities close to their headquarters in their home countries, but this is no longer evident. Their R&D footprints are becoming truly global.

The R&D process is thus not as immune to globalisation as was once thought.¹ Have we entered a new phase of globalisation of R&D? This report aims to increase our understanding of what globalisation of business R&D means for a rich industrialised country like the Netherlands. To what extent are our home-grown multinational corporations (re-)locating their R&D activities to other countries? And to what extent does the Netherlands succeed in attracting R&D investment from companies from abroad, for example from Chinese or Indian multinationals? What competitive assets can Netherlands bring to the table in the international competition for R&D investments? In view of our mission to increase insight into the functioning of the science system, the report will pay special attention to the role that the science policy plays in retaining and attracting business research.

Interestingly, globalisation of R&D implies that the regional level is becoming increasingly important. Globalisation does not lead to the ‘death of distance’. Instead, proximity matters. R&D investments cluster in regional ‘hotspots’. Therefore, an important topic in this report is how policymakers in cities, provinces and the national government can get their policies together in hotspot promotion. The Netherlands should act as one region in Europe in the international competition for foreign investments in R&D.

This report is based on a study of the literature, an analysis of statistical data on R&D expenditures and on interviews with R&D leaders within multinational companies in the Netherlands and in China, and with policymakers in The Hague and in the Dutch regions.

The report shows that the globalisation of R&D is clearly visible in the R&D statistics for the Netherlands. Cross-border R&D investments are on the rise. Moreover, the growth in outward R&D investment is not matched by a growth in inward R&D investment. To understand what is happening, the report argues that we need to understand that the globalisation of R&D has two distinctive patterns. The globalisation of business research (aimed at creating new knowledge for innovation) is largely driven by access to excellent and relevant knowledge, access to labour pools of talented researchers, and attractive opportunities for research collaboration. The globalisation of development (aimed at exploiting existing knowledge for innovation), on the other hand, is much more driven by access to attractive markets, proximity to main customers

¹ Patel and Pavitt (1991) consider R&D as “an important case of non-globalisation”.

and/or suppliers (in globalised value chains), and proximity to production facilities. Both patterns of globalisation of R&D give rise to different worries and hopes. Outward investments in research suggest that the Netherlands is losing its position in science and technology. Outward investments in development, on the other hand, suggest that Dutch-based MNCs are stepping up their operations in foreign markets. Clearly, retaining and attracting investments in research and in development call for different policy approaches.

One recurrent theme is how to get all relevant stakeholders together in ensuring the Netherlands retains its position as an attractive location for research and development. I hope that this report inspires the discussion on how to deal collectively with the challenges of globalisation of business research and development.

Melanie Peters
Director, Rathenau Instituut

Summary

Globalisation has changed the way companies develop, produce and market their products and services. With the opening of markets in countries like China and India, companies can make and sell their products and services across the globe. Advances in information and communication technologies, international standardisation and modularisation, trade liberalisation, and transport and logistics, have led to the fragmentation of value chains and the emergence of complex divisions of labour between specialised suppliers in many different countries. Value chains, in which these products and services are created, have also globalised. Global competition spurs companies to innovate faster and more effectively. They seek collaboration with external knowledge partners in open innovation strategies in global knowledge networks.²

Globalisation forces companies to carefully consider where they locate their business activities. For each of their activities they seek locations where conditions are most favourable. For different types of activities, different location factors play out. For instance, many Western multinational corporations (MNCs) have moved labour-intensive production operations offshore to other countries where wages are lower. Until recently, rich industrialised countries could find comfort in the thought that knowledge-intensive activities, such as research and development (R&D), would remain relatively 'immune' to globalisation. Increasingly, however, MNCs are deploying or acquiring R&D activities in Asia or other parts of the world. Emerging economies like China are stepping up their investments in knowledge and innovation in an effort to strengthen their position in the more profitable knowledge-intensive parts of global value chains. Is the position of rich industrialised countries like the Netherlands as location for business R&D under threat? A next question is, how should such countries respond to the challenges of globalisation of R&D? These questions are particularly important for the Netherlands with its open economy and the large role that multinational corporations play in its national economy and innovation system.

The R&D position of the Netherlands in a globalising R&D landscape

This report aims to improve our understanding of what the globalisation of R&D means for a rich, industrialised country like the Netherlands. How does the globalisation of business R&D affect the R&D position of the Netherlands? Statistics on R&D expenditures show a gradually weakening position of the Netherlands in the global R&D landscape. CBS statistics show that the domestic business sector spends an increasingly larger share of their R&D investments abroad, and this trend is not matched by an increase in incoming R&D investments.³ Moreover, large technology-based MNCs in the Netherlands are spending a smaller share of their world-wide R&D budgets in the Netherlands.⁴

2 OECD (2014a).

3 R&D statistics show that the share of R&D expenditures that firms in the Netherlands spent abroad increased from 10% in 1999 to 23% in 2013 (CBS statline). See also CBS (2015).

4 Based on the annual overviews made by the *Technisch Weekblad* on R&D expenditures of the largest R&D spenders in the Netherlands.

Separating the R and D: two patterns of R&D globalisation

How concerned should the Netherlands be about this trend? A key insight from our interviews with R&D leaders in large technology-based firms in the Netherlands and in foreign affiliates of Western MNCs in China, and from our study of the extensive literature on R&D globalisation, is that the answer to this question requires us to distinguish between the ‘R’ and the ‘D’ in R&D. Whereas *research* aims to create new knowledge, *development* uses existing knowledge gained from research and/or practical experience in order to create innovations in materials, products, devices, processes, systems or services.⁵

Each of the two patterns of R&D globalisation is shaped by different sets of location drivers and has different implications. On the one hand, the globalisation of *research* is largely driven by MNCs that want to get access to (scientific) knowledge and expertise, access to talented researchers, and opportunities for research collaboration with universities, research institutes, specialised suppliers and others. The globalisation of *development*, on the other hand, is mainly driven by MNCs that seek access to markets, proximity to partners in the supply chain and proximity to manufacturing sites. This helps them to adapt their products and services to local tastes, preferences and requirements faster and more effectively.

These different sets of location drivers lead to different global footprints of research and development. Large MNCs tend to concentrate their research in one or a few core labs, often supplemented by smaller centres, in order to gain access to interesting ‘hotspots’ in science and technology all over the world. Mature core labs are firmly embedded in and interconnected with their knowledge environments. They tend to be ‘sticky’ and costly to relocate. Development centres, on the other hand, are usually dispersed across all the various markets in which they operate.

It is unfortunate that the statistics on cross-border R&D expenditures do not make this distinction. This makes it difficult to assess how worrisome the trend is that companies in the Netherlands spend relatively more on R&D abroad. It could mean that the Dutch knowledge infrastructure is becoming less attractive – which would be worrisome. It could also mean that Dutch companies are successful in foreign markets and need to perform development abroad – which would be positive.

Based on our interviews and study of the literature on the globalisation of R&D we can give a qualitative answer. The globalisation of research and development can happen in three main modes: through greenfield investments when MNCs decide to set up a new lab abroad; via extending the remit of established foreign affiliates with research and/or development tasks; and via cross-border mergers and acquisitions (M&A) that bring R&D centres under foreign ownership. The third mode is prevalent in many industries. It could be argued that M&A are often motivated by broader strategic consideration and that specific location drivers for research or development are a side issue in these decisions. However, M&A often lead to the consolidation of business activities. When new owners decide how to reorganise the footprints of their research and development activities, the specific location drivers of research (access to knowledge, access to researchers, opportunities for research collaboration) and development (access to markets, proximity of supply chain partners and proximity to manufacturing sites) are all the more important.

5 See the the Fascati Manual of the OECD (OECD, 2002).

The Dutch economy has the advantage that it is home to relatively many MNCs that have core research labs rooted in the Netherlands, close to their headquarters. The inertia of such labs, as described above, may help to explain why we found no indications of a mass exodus of R&D investments in our interviews with R&D leaders in technology-based MNCs. Indeed, several interviewees reported new investments in these core labs.

In the longer term, however, this stickiness offers no guarantee to the 'home' economies of MNCs. For instance, when developments in science and technology lead to radically new innovations, accumulated knowledge and expertise and historical ties become less relevant; research labs become less 'sticky'. The slogan 'Refresh in the West, grow in the East' sums up the trend that Western MNCs do not so much close or relocate their existing research centres, but that they make their investments in new innovation domains increasingly abroad, notably in Asia.

We can conclude that the two patterns of R&D globalisation give rise to different concerns. In short, trends in outward and inward investments in business research tell us something about the quality of the knowledge infrastructure, the quality and quantity of human capital in science and technology and opportunities for research collaboration, or at least about how MNCs perceive this. Trends in outward and inward investments in development, on the other hand, inform us about where MNCs have their (lead) markets and where their supply chain partners and manufacturing sites are located.

Implications for the Netherlands and Dutch policymakers

A third question is what are the implications of the globalisation of R&D for the Netherlands and Dutch policymakers? The policy ambition to raise the gross domestic expenditure on R&D to 2.5% of GDP in 2020 is under pressure as outward R&D investments outgrow inward R&D investments. The perspective of R&D globalisation highlights that intensifying R&D investment is not only a matter of stimulating (domestic) firms to spend more on R&D, but also to stimulate companies – whether domestic or foreign, existing or new – to make these expenditures in the Netherlands. The Netherlands should strengthen its attractiveness as a location for such investments vis-à-vis competing countries and regions. We argue that the competitive arena varies according to the different types of R&D investment. For the core research labs, the Netherlands mainly competes with knowledge regions in (Northwest) Europe. For specialised smaller research centres, the arena is truly global and is based on specialist knowledge and opportunities for research collaboration. For development centres, the Netherlands competes with other countries and regions in the single European market.

It follows from our analysis that in the competition between countries for investment, the main competitive assets are distinctive strengths in specific location drivers. For investment in research, they include strengths in the knowledge infrastructure, high quality and sufficient quantity of human capital in science and technology, and distinctive opportunities for research collaboration. The main competitive assets in the competition for business investments in development, on the other hand, are related to the specific location drivers for development. These include attractive lead markets, attractive ecosystems or clusters with complementary firms, sufficient well-trained technologists and technicians, and good conditions for advanced or smart manufacturing.

Policy issues

Based on our interviews with R&D leaders in technology-based MNCs in the Netherlands and in foreign affiliates of Western MNCs in China, our interviews with policymakers in central and regional governments, and on our study of the literature, we highlight various issues.

Firstly, it is important to consider how international businesses perceive the quality of the knowledge infrastructure. They seek to source knowledge for a variety of reasons, from idea generation to practical problem solving. This means that they are not only attracted by demand-driven and application-oriented research. 'Free' basic research can also be attractive for them – if only because it attracts talented scientists. Simplistic dichotomies between 'science-for-science is good for science' and 'science-for-competitiveness is good for business' should therefore be avoided in the policy discourse and in the offerings in research programmes of science councils.

Secondly, different knowledge needs call for different modalities of public-private research collaboration. Countries or regions can create an important strategic asset when they offer distinctive modes of collaboration that go beyond conventional co-funded PhD-projects in temporary programmes or virtual institutes. In particular, long-term strategic partnerships and mission-oriented research institutes can be an attractive location driver for research investments. In general, the connectivity of the public knowledge infrastructure can be improved if the current bias in the academic incentive system (towards disciplinary research that can be published in high-impact journals) were to be removed. Complementary incentives need to be developed to create more room for multidisciplinary, mission-oriented research.

Thirdly, business investors perceive the attractiveness of the knowledge infrastructure in many different ways. One aspect is the capacity to generate high-potential technology-based start-ups. These innovative companies are important knowledge partners and investment targets for MNCs that follow open innovation strategies. In a general sense, they contribute to the vitality of innovation ecosystems as they challenge existing businesses and business models. A second aspect is the knowledge infrastructure as the supplier of human capital. MNCs seek access to talent pools of scientists and engineers (for research) as well as talent pools of technologists and technicians (for development). The alignment of academic and vocational training with business needs can be a strong competitive asset. A third aspect is the knowledge infrastructure as gateway to international knowledge networks. Universities that act as a portal to these networks can be attractive knowledge partners for firms.

Acting as one knowledge region in Europe

Globalisation enhances the importance of regions and regional governments. Regional governments have more attention and higher policy budgets for the development of the knowledge economy at regional level. The high-tech regional Brainport around Eindhoven is an example of this regional development. There is a spatial dimension to many of the competitive assets in the international competition for business investments in research and development. Connections are fundamental to (open) innovation therefore proximity between knowledge partners is advantageous. This is enhanced by agglomeration: investments in research and development often cluster in regional hotspots.

The term region can easily arouse misunderstanding. In Northwest Europe, the Netherlands has to compete with metropolitan regions around Paris, London, Munich, etc. From a global

perspective, the Netherlands is a single knowledge region. Dutch regions are too small on their own to carry comparable weight so it makes sense to bundle regional strengths and act as a single knowledge region in Europe. The high-tech cluster Brainport, for example, is underpinned by an innovation ecosystem that stretches across multiple provinces. This presents a major coordination challenge for policymakers at municipal, provincial and national levels and for other stakeholders in the Dutch innovation system.

On the one hand, there is a proliferation of regional policies and initiatives that leads to fragmentation. Many 'valleys', technology campuses and other regional cluster initiatives are being promoted. Often they have subcritical mass from a global perspective. On the other hand, the central government has a largely decentralised regional economic policy and has refrained from including an explicit spatial strategy, notably in its 'top-sector' policy.⁶ Moreover, national science and innovation policies tend to suffer from an inward looking bias. For instance, Dutch science policy expects universities to differentiate themselves vis-à-vis other universities in the national science system, rather than considering how the Dutch science system could be organised from a globalisation perspective. In Dutch top-sector policy there is much attention given to stimulating domestic firms to collaborate with national knowledge institutes, but much less attention for stimulating cross-border R&D collaboration and attracting foreign R&D parties. The sectoral perspective reinforces this bias because it does not capture the reality of fragmented global value chains and the need for cross-sectoral innovations to address societal challenges.

To enhance the attractiveness of the Netherlands as a location for investments in research and development, all stakeholders in the Dutch innovation system should join forces. The starting point is that hotspots are underpinned by innovation ecosystems that spread across and beyond provincial jurisdictions. The core of the agrocluster is located in Wageningen, but it is strongly supported by innovative producers and business activities throughout the Netherlands. Seen from Asia, Wageningen is located next to the mainport Schiphol and Aalsmeer, the largest flower auction in the world. The high-tech cluster in the province of North-Brabant, for instance, is based on a high-tech ecosystem that has branches in the metropolitan area of Amsterdam, the region of Twente, and elsewhere. Collaborative policy arrangements should be based on the underlying flows of knowledge, in the same way that age-old Dutch Water Boards are based on flow areas or rivers that may span several municipalities and provinces.

The collective ambition should be to create competitive assets that make a difference in the international arenas for investments in research and development. We have already argued that different assets matter in different arenas. This should be reflected in the coordination arrangements that are developed and the parties that are involved. To strengthen location drivers for investments in development, for instance, universities of applied sciences and regional triple-helix organisations are important parties.

6 This policy aims to stimulate nine 'top-sectors' in the Dutch economy that are knowledge-intensive and export-oriented, and can make a substantial contribution to solving global societal problems. A key aim of this policy is to strengthen collaborations between businesses and knowledge institutes.

Attracting foreign investment in research and development

The growth of private R&D spending will also depend on foreign investment. Foreign investment policy needs to be closely aligned with science and innovation policies in order to succeed in attracting investments in research and development. There should be a two-way interaction. On the one hand, science and innovation policy can benefit from insights into how foreign investors perceive the Netherlands as a location for research and development. On the other hand, the promotion policy should be based on the strategic choices made in science and innovation policies.

One approach to attract foreign investment in R&D is by targeting affiliates of foreign MNCs that are already present in the Dutch economy and have the potential to do more in terms of R&D. The aim is to make their presence more knowledge-intensive and connect them with the (regional) innovation ecosystem.

A second approach targets R&D-intensive companies that are not yet present in the Netherlands, but that would have a fit with the Dutch knowledge economy. This calls for a targeted, strategic approach to acquisition. It is important to identify firms that have a fit with the various location strengths found in the Netherlands. Which firms seek access to knowledge, researchers, supply chain partners or markets in areas where the Netherlands has distinctive strengths? They need to be approached in an early stage of their decision-making with tailor-made propositions based on detailed evidence. Such an approach requires coordination and collaboration between multiple parties including national and regional foreign investment agencies together with knowledge institutes and organisations active in the specific innovation domains. Such an approach is knowledge and labour-intensive. In order to be effective, it requires long-term commitment from all stakeholders including political (and budgetary) commitment from national and regional governments.

Nederlandse samenvatting

Ontwikkelingen in informatie- en communicatietechnologieën, internationale standaardisatie, liberalisering van de wereldhandel en innovaties in transport en logistiek zijn belangrijke drijvende krachten achter de huidige mondialisering. Het heeft geleid tot vergaande wereldwijde economische integratie. Bedrijven kunnen hun producten en diensten over de hele wereld ontwikkelen, produceren en verkopen. Mondialisering betekent ook dat activiteiten die vroeger in één bedrijf zaten, nu verdeeld worden over meerdere bedrijven en landen. Door deze fragmentatie van waardeketens ontstaan er complexe arbeidsdelingen tussen toeleveranciers en producenten in verschillende landen. Mondiale concurrentie noopt bedrijven om sneller en effectiever te innoveren en om open innovatiestrategieën te volgen waarin ze samenwerken met externe kennispartners wereldwijd.⁷

Mondialisering dwingt bedrijven tot een zorgvuldige locatiekeuze voor al hun bedrijfsactiviteiten. Voor elk van hun activiteiten zoeken ze locaties waar de omstandigheden voor dat type activiteit het meest aantrekkelijk zijn. De factoren die de aantrekkelijkheid van een locatie bepalen verschillen per type bedrijfsactiviteit. Zo hebben veel multinationale ondernemingen (MNO's) hun arbeidsintensieve productieactiviteiten in de afgelopen decennia verplaatst naar laaglonenlanden. Rijke industrielanden konden zich lange tijd troosten met de gedachte dat kennisintensieve bedrijvigheid, zoals Research & Development (R&D) relatief 'immuun' zou blijven voor mondialisering.

Tegenwoordig zien we echter steeds meer MNO's die ook kennisintensieve R&D-activiteiten ontwikkelen in opkomende economieën in Azië en andere delen van de wereld. Opkomende landen zoals China investeren steeds meer in kennis en innovatie om daarmee toegang te krijgen tot de meer lucratieve kennisintensieve delen van mondiale waardeketens. Staat de positie van rijke industrielanden zoals Nederland als locatie voor R&D onder druk? Een vervolgvraag is hoe zulke landen moeten omgaan met de uitdagingen van de mondialisering van R&D. Deze vragen zijn juist voor Nederland belangrijk vanwege zijn open economie en de grote rol die multinationale ondernemingen spelen in de nationale economie en in het nationale innovatiesysteem.

De positie van Nederland in een mondialiserend R&D-landschap

Dit rapport heeft als doel om het inzicht te vergroten in de betekenis van de mondialisering van R&D voor een rijk industrieland als Nederland. Wat is de invloed van de mondialisering van R&D op de positie van Nederland? De mondialisering van R&D betreft het verschijnsel dat MNO's hun onderzoek steeds meer via een netwerk van buitenlandse R&D-vestigingen organiseren. Statistische informatie over R&D-uitgaven wijzen op een geleidelijk verslechterende positie. CBS-cijfers tonen dat bedrijven in Nederland een steeds groter deel van hun R&D-uitgaven in het buitenland doen. Omgekeerd neemt het aandeel van de bedrijfs-R&D dat vanuit het buitenland wordt gefinancierd af. Ook micro-data over R&D-uitgaven van acht grote R&D-investeerders in het Nederlandse bedrijfsleven laten zien dat het deel van het wereldwijde R&D-budget dat deze grote bedrijven in Nederland besteden onder druk staat.

7 OECD (2014a).

Vershil tussen de mondialisering van research en van development

In hoeverre zijn deze trends een reden tot zorg voor Nederland en daarmee voor het Nederlandse beleid? Een belangrijk inzicht uit deze studie is dat we voor een goed antwoord op deze vraag een onderscheid moeten maken tussen de R (research) en D (development) in R&D. Dit blijkt onze interviews met R&D-managers bij grote R&D-investeerders in het Nederlandse bedrijfsleven en bij buitenlandse R&D-centra van Westerse bedrijven in China en wordt bevestigd door onze literatuurstudie. Research is gericht op het creëren van nieuwe kennis. Development is gericht op het inzetten van bestaande kennis om concrete innovaties te realiseren.

Het gaat om verschillende type activiteiten waarbij bedrijven verschillende afwegingen maken om een locatie te kiezen. De mondialisering van research wordt grotendeels gedreven door kenniszoekende motieven: MNO's zoeken toegang tot (wetenschappelijke) kennis en expertise, tot getalenteerde onderzoekers en tot mogelijkheden voor samenwerking in onderzoek met kennispartners, zoals universiteiten, onderzoeksinstituten en/of gespecialiseerde toeleveranciers. De mondialisering van development wordt daarentegen grotendeels gedreven door marktzoekende motieven: MNO's vestigen hun development-activiteiten bij voorkeur dichtbij hun belangrijke gebruikers, klanten, toeleveranciers en/of hun productiefaciliteiten. Hierdoor kunnen ze producten en diensten sneller en beter aanpassen aan lokale eisen en voorkeuren.

Deze twee verschillende sets van locatiemotieven leiden tot verschillen in de wijze waarop research en development mondiaal zijn georganiseerd. MNO's spreken van verschillende 'global footprints' voor research en development. Grote MNO's concentreren hun research-activiteiten veelal in één of enkele strategische researchcentra met daaromheen vaak meerdere kleinere gespecialiseerde centra waarmee ze wereldwijd toegang krijgen tot interessante 'hotspots' in wetenschap en technologie. De grote strategische labs zijn vaak nauw verweven met hun kennisomgeving. Het kost jaren om een goed draaiend lab op te bouwen. Dat maakt ze lastig en kostbaar om te verplaatsen. Voor development zien we een ander locatiepatroon. MNO's hebben veelal meerdere centra verspreid over de verschillende markten waarin ze actief zijn.

Helaas wordt het onderscheid tussen R en D niet gemaakt in de beschikbare statistieken over grensoverschrijdende investeringen in R&D. Daardoor is het lastig om een goede inschatting te maken over hoe zorgwekkend de trend is dat MNO's in Nederland relatief meer R&D gaan doen in het buitenland. Dat kan er op wijzen dat de Nederlandse kennisinfrastructuur minder aantrekkelijk wordt – en dat zou zorgwekkend zijn. Het kan er ook op wijzen dat Nederlandse bedrijven succesvol zijn op buitenlandse markten en daarvoor ter plekke meer Development moeten doen – en dat is positief.

Wel is het mogelijk om een kwalitatief antwoord te geven op basis van onze interviews en studie van de literatuur over de mondialisering van R&D. De mondialisering van research en development gebeurt op drie manieren: (1) door 'greenfield' investeringen van MNO's, dat wil zeggen het opstarten van geheel nieuwe R&D-vestigingen in het buitenland; (2) doordat MNO's bestaande buitenlandse vestigingen nieuwe R&D-taken geven; en (3) door internationale fusies en overnames (M&A: 'mergers and acquisitions') waardoor bestaande R&D-centra een nieuwe buitenlandse eigenaar krijgen. M&A worden vaak gedaan om strategische redenen, waarbij specifieke R&D-gerelateerde motieven vaak bijzaak zijn. Na fusie of overname, wanneer de nieuwe eigenaar moet besluiten over de reorganisatie van de R&D-organisatie, zijn de locatiefactoren voor research (toegang tot kennis, onderzoekers en samenwerking) en development (toegang tot gebruikers, klanten, toeleveranciers en/of productiefaciliteiten) juist des te belangrijker.

De Nederlandse economie kent relatief veel MNO's van Nederlandse origine. De private R&D-investeringen in Nederland worden gedomineerd door een paar grote bedrijven die hun strategische R&D van oudsher in Nederland hebben georganiseerd, nabij het hoofdkantoor. Zoals hierboven beschreven zijn deze labs lastig en kostbaar te verplaatsen. Dit verklaart mede waarom in deze studie geen aanwijzingen werden gevonden voor een massale uittocht van R&D-investeringen. Een aantal MNO's heeft juist recent weer geïnvesteerd in de modernisering van hun strategische researchcentra in Nederland.

Op de langere termijn biedt deze verankering echter geen garantie voor het thuisland van een MNO. Met name wanneer ontwikkelingen in wetenschap en technologie zorgen voor radicale innovatie, worden opgebouwde kennis en expertise en historisch gegroeide verbanden met de kennisinfrastructuur minder relevant. De slogan 'Refresh in the West, grow in the East' verwijst naar de trend dat Westerse MNO's niet zozeer hun bestaande researchcentra sluiten of verplaatsen, maar dat ze hun investeringen in nieuwe innovatiedomeinen steeds meer in het buitenland doen, met name in Azië.

De twee mondialiseringspatronen leiden tot verschillende uitdagingen voor beleid. Ontwikkelingen in buitenlandse investeringen in research zeggen iets over MNO's oordelen over de kwaliteit van de kennisinfrastructuur, de kwaliteit en kwantiteit van onderzoekspersoneel, en over de mogelijkheden voor publiek-private samenwerking in onderzoek. Ontwikkelingen in buitenlandse investeringen in development zeggen daarentegen iets over waar MNO's hun belangrijkste markten zien en over waar hun belangrijkste klanten, toeleveranciers en/of productiefaciliteiten zijn gevestigd.

Beleidsimplicaties voor Nederland

Wat zijn de implicaties van de mondialisering van R&D voor Nederland en het Nederlandse beleid? De beleidsdoelstelling om de totale uitgaven aan R&D (dus publiek en privaat gezamenlijk) te intensiveren tot 2,5% van het bruto binnenlands product in 2020 staat onder druk, mede omdat uitgaande R&D-investeringen sneller groeien dan inkomende R&D-investeringen. Het R&D-mondialiseringsperspectief laat zien dat het intensiveren van R&D-investeringen niet alleen een zaak is van het stimuleren van bedrijven in Nederland om meer uit te geven aan R&D. Het is ook een zaak van het stimuleren van bedrijven, zowel in binnen- als buitenland, om deze investeringen in Nederland te doen. Daarbij gaat het niet alleen om bestaande bedrijven, maar ook om nieuwe snelgroeiende technologiegebaseerde bedrijven.

Het is dus een belangrijke uitdaging voor Nederland om zijn aantrekkelijkheid als locatie voor investeringen in research en development ten opzichte van concurrerende landen en regio's te versterken. Met welke landen en regio's Nederland concurreert verschilt per type R&D-investeringen. De concurrentie om de grote strategische researchlabs van MNO's speelt zich met name af tussen landen binnen een landenregio (EU, VS, Azië) omdat mondiaal opererende bedrijven veelal in elk werelddeel aanwezig willen zijn met een hoofdvestiging. Nederland concurreert hier dus met andere kennisregio's in de Europese Unie, met name in Noordwest Europa. De concurrentie om de kleinere gespecialiseerde researchcentra is mondiaal en is gebaseerd op specialistische kennis en expertise en bereidheid tot samenwerking. De concurrentie om developmentcentra speelt zich vooral af binnen afzetgebieden. Nederland concurreert hier vooral met andere landen in de gemeenschappelijke Europese markt.

Uit onze analyse volgt dat belangrijke concurrentievoordelen in de concurrentie om internationale investeringen in research en development worden gevormd door onderscheidende sterktes in specifieke locatiefactoren. Bij investeringen in research gaat het om sterktes in de kennisinfrastructuur, de kwaliteit en kwantiteit van onderzoekers en mogelijkheden voor publiek-private samenwerking in onderzoek. Bij investeringen in development gaat het om sterktes die worden gevormd door aantrekkelijke markten voor innovatieve producten en diensten, aantrekkelijke ecosystemen of clusters met complementaire bedrijven, voldoende goed opgeleid technisch personeel, en goede mogelijkheden voor geavanceerde productie of 'smart manufacturing'.

Uitgangspunten voor beleid

Naar aanleiding van onze bevindingen uit interviews met R&D-managers en beleidsmakers en uit de literatuurstudie formuleert het rapport enkele belangrijke uitgangspunten voor beleid.

Een eerste uitgangspunt is om het perspectief van internationale bedrijven op de kwaliteit of aantrekkelijkheid van de kennisinfrastructuur serieus te nemen. MNO's zoeken toegang tot externe kennisbronnen om meerdere redenen, variërend van inspiratie voor nieuwe ideeën voor innovatie tot praktisch oplossingen voor problemen. Ze worden niet alleen aangetrokken door goed pragmatisch toepassingsgericht onderzoek. Ook baanbrekend 'nieuwsgierigheids-gedreven' fundamenteel onderzoek draagt bij aan de aantrekkelijkheid van de kennisinfrastructuur voor MNO's – niet alleen als bron van inspiratie voor nieuwe innovaties maar ook omdat het excellente wetenschappers aantrekt. De kwaliteit van de kennisinfrastructuur wordt dus niet alleen bepaald door prestaties in 'science for competitiveness', maar ook door prestaties in 'science for science'.

Een tweede uitgangspunt is dat verschillende kennisbehoeften vragen om verschillende vormen van publiek-private samenwerking. Landen of regio's kunnen een concurrentievoordeel behalen met een aanbod van onderscheidende modaliteiten van samenwerking die verder gaan dan de conventionele private co-financiering van AiO-projecten in tijdelijke onderzoeksprogramma's of virtuele instituten. Met name lange termijn strategische partnerships en missiegeoriënteerde onderzoeksinstituten kunnen een aantrekkelijke locatiefactor vormen voor bedrijfsinvesteringen in research. Meer in het algemeen kan de connectiviteit van de publieke infrastructuur verder verbeterd worden als de huidige bias in de academische incentive structuur wordt weggenomen. Momenteel worden universitaire onderzoekers met name geprikkeld om disciplinair onderzoek te doen dat publiceerbaar is in wetenschappelijke tijdschriften met een hoge impact-score. Om meer ruimte te creëren voor multidisciplinair, missiegedreven onderzoek zijn andere prikkels nodig.

Een derde uitgangspunt is dat de publieke kennisinfrastructuur op veel verschillende manieren aantrekkelijk kan zijn voor MNO's als investeerders in research. Een aspect is het vermogen van de kennisinfrastructuur om technologiegebaseerde start-up bedrijven met groeipotentie te genereren. Dit soort bedrijven zijn belangrijke kennispartners en investeringsobjecten voor MNO's met open innovatiestrategieën. In algemene zin dragen jonge, snelgroeiende bedrijven bij aan de vitaliteit van innovatie-ecosystemen omdat ze bestaande bedrijven en business modellen uitdagen. Een tweede aspect is de kennisinfrastructuur als leverancier van goed opgeleid R&D-personeel. MNO's zoeken toegang tot 'talent pools' van wetenschappers en ingenieurs (voor research) en technici (voor development). De afstemming van opleidingen van universiteiten en hogescholen op behoeften uit het bedrijfsleven kan een belangrijk concurrentievoordeel opleveren. Een derde aspect is de kennisinfrastructuur als 'toegangspoor' tot

internationale kennisnetwerken. Universiteiten kunnen bij uitstek deze rol vervullen en daarmee aantrekkelijke kennispartners zijn voor bedrijven.

Optreden als één kennisregio binnen Europa

Een gevolg van mondialisering is dat regio's en regionale bestuurslagen een belangrijkere rol gaan spelen in het R&D- en innovatiebeleid. Regionale overheden hebben meer aandacht en meer middelen voor de ontwikkeling van de kenniseconomie op regionaal en stedelijk niveau. De high-tech regio Brainport is een voorbeeld van deze regionale ontwikkeling. Veel van de troeven in de internationale concurrentie om bedrijfsinvesteringen in research en development hebben een ruimtelijke dimensie. Samenwerking in (open) innovatie gedijt bijvoorbeeld bij nabijheid tussen kennispartners. Door agglomeratie- en clustervoordelen worden aantrekkelijke regio's steeds aantrekkelijker. Investerings in research en development clusteren in regionale hotspots.

De term regio kan makkelijk misverstand wekken. Nederland concurreert in Noordwest-Europa met metropoolgebieden rondom steden als Parijs, Londen, München, etc. Mondiaal gezien is Nederland één kennisregio. Ieder voor zich missen Nederlandse regio's vergelijkbare agglomeratiekracht. Nederland moet het hebben van regionale krachtenbundeling. Dit creëert een grote coördinatie-uitdaging voor beleidsmakers op gemeentelijk, provinciaal en nationaal niveau en voor andere partijen in het Nederlandse innovatiesysteem.

In de praktijk zien we enerzijds een proliferatie van regionale beleidsinitiatieven die leidt tot een gefragmenteerd beeld op nationaal niveau met allerlei 'valleys', technologiecampussen, science parks, etc. die vanuit mondialiseringsperspectief veelal onvoldoende kritische massa hebben. Anderzijds heeft de Rijksoverheid het regionaal economisch beleid grotendeels gedecentraliseerd. In het topsectorenbeleid ontbreekt bijvoorbeeld een expliciete ruimtelijke strategie. Bovendien speelt het perspectief van de mondialisering van R&D in het nationaal wetenschaps- en innovatiebeleid vaak geen hoofdrol. In het profileringsbeleid ten aanzien van Nederlandse universiteiten gaat het bijvoorbeeld vooral om onderlinge differentiatie van universiteiten binnen het nationale wetenschapssysteem. Terwijl juist ook de vraag centraal zou moeten staan wat de mondialisering van R&D betekent voor de huidige organisatie van het Nederlandse wetenschapssysteem met zijn 13 gelijkwaardige researchuniversiteiten. In het topsectorenbeleid is er bijvoorbeeld veel aandacht voor het stimuleren van Nederlandse bedrijven om met nationale kennisinstellingen samen te werken, en veel minder voor het stimuleren voor grensoverschrijdende samenwerking en het aantrekken van buitenlandse R&D-intensieve bedrijven. De sectorale insteek versterkt de nationale bias omdat die niet goed aansluit bij de realiteit van gefragmenteerde mondiale waardeketens en het belang van cross-sectorale innovatie voor het ontwikkelen van oplossingen voor maatschappelijke uitdagingen.

Het verder versterken van de internationale aantrekkelijkheid van Nederland als locatie voor investeringen in research en development vraagt om een bundeling van krachten van alle betrokkenen in het Nederlandse innovatiesysteem. Het uitgangspunt hiervoor is dat hotspots worden gedragen door innovatie-ecosystemen die dwars door bestuurlijke grenzen heen gaan. De kern van het agrocluster ligt in Wageningen, maar wordt sterk ondersteund door innovatieve producenten en bedrijfsactiviteiten door heel Nederland. Vanuit Azië ligt Wageningen naast Schiphol en Aalsmeer. Het high-tech cluster in Noord-Brabant is bijvoorbeeld gebaseerd op een onderliggende ecosysteem met vertakkingen in het metropoolgebied rond Amsterdam, de regio Twente en elders. De krachtenbundeling en samenwerking in beleid moeten daarom zijn

gebaseerd op de kennisnetwerken en kenniscirculatie in een bepaald innovatiedomein. Een mooie analogie is de manier waarop de eeuwenoude waterschappen in Nederland zijn gebaseerd op stromingsgebieden van rivieren die dwars door allerlei bestuurlijke grenzen van provincies en gemeenten lopen.

De gezamenlijke ambitie zou moeten zijn om concurrentievoordelen te creëren die onderscheidend zijn in de internationale arena's voor investeringen in research en development. In verschillende arena's zijn verschillende concurrentievoordelen bepalend. Dit moet weerspiegeld worden de coördinatiemechanismen die worden ingezet en in de partijen die erbij betrokken zijn. Om locatiefactoren voor investeringen in development te versterken zijn hogescholen en regionale 'triple-helix' organisaties bijvoorbeeld belangrijke partijen.

Aantrekken van buitenlandse investeringen in research en development

De groei van private R&D uitgaven is ook afhankelijk van buitenlandse investeringen. Het aantrekken van buitenlandse investeringen in research en development vraagt om nauwe afstemming en wisselwerking tussen buitenlands investeringsbevorderingsbeleid en wetenschaps- en innovatiebeleid. Enerzijds kunnen het wetenschaps- en innovatiebeleid profiteren van inzichten in hoe buitenlandse investeerders aankijken tegen Nederland als locatie voor research en development. Anderzijds moet het investeringsbevorderingsbeleid gebaseerd zijn op strategische keuzen in het wetenschaps- en innovatiebeleid.

Een eerste aanpak om meer buitenlandse investeringen in R&D aan te trekken is om het R&D-gehalte van bestaande buitenlandse investeringen te vergroten. Als buitenlandse MNO's eenmaal een dochteronderneming hebben in Nederland is het zaak om deze aanwezigheid kennisintensiever te maken en hun te verankeren in het (regionale) innovatie-ecosysteem.

Een tweede aanpak is gericht op R&D-intensieve bedrijven die nog niet in Nederland actief zijn, maar wel goed zouden passen bij de Nederlandse kenniseconomie. Dit vraagt om een gerichte, strategische acquisitieaanpak. Eerst moeten buitenlandse bedrijven worden geïdentificeerd die passen bij de verschillende locatiesterktes van Nederland. Welke buitenlandse bedrijven zoeken toegang tot kennis, onderzoekers, ketenpartners en/of markten in gebieden waarin Nederland zich kan onderscheiden? Deze bedrijven moeten al in een vroeg stadium van hun R&D-investeringsbesluitvorming worden benaderd met op maat gemaakte proposities die zijn onderbouwd met specifieke informatie. Een dergelijke aanpak vereist coördinatie en samenwerking tussen verschillende partijen; niet alleen tussen de nationale en regionale overheidsinstanties voor het aantrekken van buitenlandse investeringen, maar ook met publieke en private partijen in het specifieke innovatie-ecosysteem die over de inhoudelijke kennis omtrent R&D-locatievoordelen beschikken. Dit maakt een gerichte strategische acquisitieaanpak kennis- en arbeidsintensief. Het is bovendien een zaak van de lange adem. Om effectief te zijn is lange termijn commitment vanuit de nationale en regionale politiek onontbeerlijk.

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1 Introduction

1.1 What is at stake?

Globalisation has changed the way companies develop, produce and market their products and services. With the opening of markets in countries like China and India, companies can make and sell their products and services across the globe. Advances in information and communication technologies, international standardisation and modularisation, trade liberalisation, and advances in transport and logistics, have led to the fragmentation of value chains and the emergence of complex divisions of labour between specialised suppliers in many different countries. Global competition spurs companies to innovate faster and more effectively. They seek collaboration with external knowledge partners in open innovation strategies in global knowledge networks.⁸

Globalisation forces companies to carefully consider where they locate their business activities. For each of their activities they seek locations where conditions are most favourable. For different types of activities, different location factors play out. For instance, many Western multinational corporations (MNCs) have offshored labour-intensive production operations to countries where wages are lower. China has become the 'factory of the world'. India has become a favourite location for software development and customer support services. For quite some time, rich industrialised countries found comfort in the globalisation narrative that suggested globalisation mainly affected non-core activities. Key knowledge-intensive activities, such as research and development (R&D), were assumed to be relatively 'immune' to globalisation.⁹ Core activities including R&D were thought to be firmly tied to the location of the headquarters of MNCs.

Increasingly, however, MNCs deploy or acquire R&D activities in Asia or other parts of the world. Emerging economies like China are stepping up their investments in knowledge and innovation in an effort to strengthen their positions in the more profitable, knowledge-intensive parts of global value chains. These developments are illustrated by news items about MNCs that open new R&D labs in Asia or other parts of the world (see Textbox 1). When an MNC decides to close an R&D facility in the Netherlands, it fuels worries about the effects of globalisation for the Netherlands as a 'knowledge-based economy'. An example is the Dutch pharmaceutical company Organon that was taken over by the American Schering-Plough (later merged into MSD) in 2007. The new foreign owner announced the restructuring of the global R&D operation. As a consequence, the R&D centre in the Dutch city Oss had to be closed. This led to concerns and political debate in the Netherlands.

The question is whether the position of rich industrialised countries like the Netherlands as preferred location for business R&D is under threat. For the Netherlands with its open economy in which MNCs play a prominent role, this threat is an urgent issue. A next question is, how such countries should respond to the challenges of globalisation of R&D?

8 OECD (2014a).

9 Patel and Pavitt (1991) considered R&D as "an important case of non-globalisation".

Textbox 1 Examples of multinational corporations with Dutch origins setting up R&D centres abroad

In 2014, **Philips** announced the establishment of the Philips Africa Innovation Hub in Kenya as the centre for developing innovations “in Africa-for Africa” in the areas of healthcare, lighting and healthy living.¹⁰

In 2013, the Dutch dairy company **FrieslandCampina** opened a new Development Centre in Singapore.¹¹

In 2011, **NXP Semiconductors** announced the establishment of a new Automotive Technical Center in Shanghai as a regional hub for technical expertise in automotive systems and applications.¹²

In 2008 **Océ**, an international provider of document management and printing for professionals, opened Océ Technologies Asia in Singapore to become the control tower for Océ’s Asian activities including research and development, product introductions, supply chain management and procurement.¹³

DSM (life sciences and materials sciences) opened its DSM China Campus in Shanghai in 2007. DSM recognised that China is not only a market and production base, but also a strategic starting point for research and development.¹⁴

From the perspective of the home countries of Western MNCs, there are several reasons to have at least some concerns about the globalisation of R&D.¹⁵ A rise in outward R&D investment could result in a loss of high quality jobs and a loss of capabilities in science and technology. It could result in the ‘hollowing out’ of domestic industry with companies losing their position in global value chains; the disappearance of collaboration or contract partners for universities and research institutes; and the overall unravelling of research and innovation networks. On the other hand, globalisation offers opportunities for rich industrialised countries as the host country for inward investments in R&D. For example, from foreign MNCs that seek to expand the global footprint of their R&D within Europe (see Textbox 2). Outward investments can have beneficial aspects as well, in particular when they are complementary rather than substitutive for domestic investments. MNCs with multiple foreign R&D centres may act as channels for international knowledge flows.

10 http://www.newscenter.philips.com/main/standard/news/press/2014/20140321-philips-to-establish-research-and-innovation-hub-in-africa.wpd#.VNYCN-aG_QI.

11 <https://www.frieslandcampina.com/en/news/2013-09-09-frieslandcampina-opens-development-centre-in-singapore/>

12 <http://www.nxp.com/news/press-releases/2011/04/nxp-relocates-automotive-sales-and-marketing-headquarters-to-shanghai-and-establishes-new-automotive-technical-center-in-china.html>.

13 <http://global.oce.com/news/press-releases/2008/oce-opens-technology-center-in-singapore.aspx>.

14 <http://www.dsm.com/corporate/media/informationcenter-news/2007/09/55-07-DSM-china-campus-shanghai.html#>.

15 See for example Moncada-Paternò-Castello, P. et al. (2011).

Textbox 2 Examples of multinational corporations from abroad setting up R&D centres in the Netherlands

In January 2014, the Swedish company **SKF** (active in bearings, seals, mechatronics, lubrication systems and services) announced plans to build a new Global Technical Centre in Nieuwegein, the Netherlands, as part of a Global Technical Centre Europe (GTCE) structure.¹⁶

In January 2013, the Indian multinational corporation **Apollo Tyres** announced the opening up of a new global R&D centre in Enschede, the Netherlands.¹⁷

In July 2011, the dairy firm **Fonterra** from New Zealand opened a new R&D centre in Amsterdam as a European complement to its main research centre in New Zealand.¹⁸

1.2 The phenomenon of the globalisation of R&D

In essence, the globalisation of R&D refers to multinational corporations (MNCs) increasingly organising their R&D activities on a global scale, by using a network of foreign affiliates to perform R&D.¹⁹ Rather than being predominantly tied to the location of the corporate headquarters in the home country, a network of R&D centres are globally dispersed. In other words, the globalisation of R&D refers to MNCs getting a global 'R&D footprint'. As a result, a global division of R&D labour emerges.

The globalisation of R&D is a key element in the broader globalisation of an economy. However, within this broad globalisation process, there are differences in globalisation patterns between industries. Location factors for various business activities work out differently in different sectors. Aspects like R&D intensity, labour intensity, capital intensity, energy intensity, trade intensity and value density, determine how companies decide on the location of their business activities.²⁰

A general phenomenon is that companies – and countries – try to get or maintain a position in the upstream and downstream parts of the value chain. This is where most value is usually created. Upstream activities include R&D, new product development, and manufacturing of key components. Downstream activities include sales and marketing. Companies and countries do not just compete for market share in high value-added industries but also increasingly compete for high value-added activities within globalised value chains. MNCs usually have a prominent position in these global value chains because of their international investments and international (intra-firm) trade.

The globalisation of R&D occurs in three basic modes. A common route in many industries is through cross-border merger and acquisition (M&A) that results in foreign ownership of R&D

16 <http://www.skf.com/group/investors/press-releases/skf-invest-two-new-global-technical-centres-europe>.

17 <http://www.apollovredestein.com/nieuws/314/apollo-tyres-opens-its-global-r-d-centre-in-the-netherlands>.

18 <http://www.oostnv.com/news/fonterra-opens-new-european-rd-centre-amsterdam-proximity-wageningen-ur-was-significant-factor>.

19 OECD (2008) and OECD (2014a).

20 McKinsey Global Institute (2012).

centres. It should be noted that because M&A tend to be based on broader strategic business considerations than solely R&D, the globalisation of R&D might be an unintended consequence of cross-border M&A. A second route is through 'brownfield' investments. This means that MNCs expand the remit of their existing foreign affiliates with an R&D function. A location for manufacturing or distribution now becomes a centre for R&D as well. A third route is through 'greenfield' investments. This means that an MNC sets up a completely new R&D centre abroad.

The globalisation of R&D is not in itself a new phenomenon. It appears, however, that it is developing rapidly and in new ways. In the past, internationalisation of R&D referred to MNCs setting up R&D activities abroad to support their foreign subsidiaries in the sales and marketing, distribution and/or manufacturing of products. Foreign subsidiaries needed to adapt products that had been developed for a home market to the demands and requirements of markets in other countries. Nowadays, MNCs also have foreign R&D centres to perform innovative R&D, not just adaptive R&D.²¹ Foreign R&D centres have become part of global innovation strategies.

1.3 Structure of the report

How does the globalisation of R&D affect the international position of the Netherlands in industrial R&D? In the next chapter we will discuss what statistical data tell us about outward and inward investments in R&D and the extent to which multinational corporations (MNCs) in the Netherlands spend their R&D budgets abroad.

In chapter 3 we will discuss how to assess this quantitative evidence. We will argue that the two basic components – 'R' and 'D' – need to be considered separately. The globalisation of research is driven by a different set of location drivers than the globalisation of development. Unfortunately, in the statistical data this distinction cannot be made, which makes it difficult to make a good assessment of the situation based on quantitative evidence only.

In chapter 4 we will discuss qualitative evidence from our interviews with R&D leaders in technology-based MNCs in the Netherlands and in foreign affiliates of Western MNCs in China and on our study of the extensive literature on globalisation of R&D. What are the strategic considerations behind the two patterns of R&D globalisation? And what does the rise of China mean for the globalisation of research and development?

Chapter 5 argues that both patterns in R&D globalisation call for a different approach. How to strengthen the location of the Netherlands as a location for business investments in both research and development? What are key competitive assets in the international competition for business investments in research and development? We discuss several focus points for policymakers, based on our interviews and study of the literature.

The attractiveness of the knowledge infrastructure is an important location driver for business investments in research. Chapter 6 focuses on what attractiveness means in the eyes of international business investors in R&D.

21 See also OECD (2008).

Chapter 7 elaborates on the role of regions in creating distinctive competitive assets in the international competition for investments in research and development. How can the Netherlands compete with large metropolitan regions in neighbouring countries and elsewhere?

Finally, in chapter 8 we discuss strategic approaches to attracting foreign investments in research and development.

1.4 Our approach

This report is based on a study of scientific articles and reports on globalisation of R&D (see the Bibliography at the end of this report).

In addition, we interviewed 20 R&D leaders from technology-based MNCs in the Netherlands. They informed us about their global R&D footprints and explained their R&D location decisions. We also asked them for their views on public policies that could affect their location decisions. In a background study, International Top Talent (ITT) interviewed 14 R&D leaders in foreign affiliates of Western MNCs in China and one expert at the China Europe International Business School of Zhejiang University. A specific focus in these interviews was the changing role of China in the globalisation of R&D.

We also interviewed policymakers at national and regional policy levels in order to get insights into relevant policies and policy instruments, and their rationales. Several of these interviews took place as part of a second background study on regional initiatives by Bodewes Beleidsadvies.

In the Appendix our methodology is further explained.

2 Quantitative evidence on R&D in the Netherlands

In this chapter quantitative evidence on R&D expenditure in the Netherlands is discussed. Firstly, a general picture of R&D expenditure by funding source and sector of performance is given. This helps to understand how much the domestic business sector spends on R&D and which share is funded from abroad. These figures are put in a historical perspective to identify trends. Next, the focus is on R&D that is outsourced abroad by firms in the Netherlands. To assess the position of the Netherlands in a globalising R&D landscape both incoming and outgoing R&D funding flows are compared. Finally, the focus is on eight large R&D-intensive multinational corporations in the Netherlands to examine trends in the proportion of their world-wide R&D budgets that they spend in the Netherlands. The chapter concludes with an assessment of the trends in view of the Dutch policy objective to increase R&D expenditure to 2.5% of GDP in 2020.

2.1 R&D expenditure in the Netherlands

The Netherlands is considered to be a rather attractive destination for foreign direct investments in many respects.²² It ranks highly in terms of the climate for living, for doing business, for working and for studying. But specifically for R&D expenditure, the Netherlands does not compare well internationally. The total expenditure on R&D in the Netherlands amounted to no more than 1.98% of gross domestic product (GDP) in 2013, which is still far below the Dutch government's objective of 2.5% of GDP in 2020.²³ In absolute terms, companies, higher education institutes and research institutes in the Netherlands spent EUR 12.7 billion on intramural R&D in 2013 (Table 1). The business sector contributed the most funding (EUR 6.5 billion or 51%) and also performed the most research (EUR 7.1 billion or 56%). In international comparison the Dutch business sector is not very R&D intensive (1.14% of GDP, well below the OECD average of 1.64% in 2013). This is partly related to the structure of the Dutch economy in which the services sector plays a large role. If the Netherlands were to have an average OECD industrial structure, the adjusted business R&D intensity for the Netherlands would be above the OECD average of 2.5% of GDP.²⁴ That said, it remains an important policy objective of the Dutch government to increase the R&D intensity (and sector structure) of the Dutch economy in order to ensure the future competitiveness and innovativeness of the Dutch knowledge economy.

22 According to the KPMG report "Investment in the Netherlands" (KPMG, 2014), the attractiveness of the Netherlands as an investment location is related to factors such as a stable economy, a reliable and equitable tax regime, a sophisticated, internationally oriented infrastructure, a society and culture of openness – both to outsiders and to new ideas, stable industrial relations, a productive and well-educated workforce and excellent IT connectivity. The Netherlands plays an important role as a European transportation hub.

23 Source of the data used in this section is the website 'De Nederlandse Wetenschap' of the Rathenau Instituut. (<http://www.rathenau.nl/nc/web-specials/de-nederlandse-wetenschap.html>). It uses data from Statistics Netherlands CBS and OECD.

24 OECD (2013: 220).

Table 1 R&D expenditure in the Netherlands by funding source and sector of performance in 2013 (in million euro)

Destination:	Business	Research institutes	Higher Education	Total
Sources:				
Business	5 946	258	311	6 515
Government	143	954	3 151	4 248
Higher Education	17	20	0	37
Private non-profit	32	50	309	391
Abroad	957	277	318	1 552
Total	7 095	1 559	4 089	12 743

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Source: Data on the funding of R&D performed by companies, higher education institutes (HEI) and research institutes in the Netherlands are from the website 'De Nederlandse Wetenschap' of the Rathenau Instituut which uses data from Statistics Netherlands CBS and OECD. The data are retrieved from http://www.rathenau.nl/fileadmin/user_upload/rathenau/De_Nederlandse_Wetenschap/F-Financiering-uitvoering_van_R_D_vanaf_1990_CBS_.xlsx.

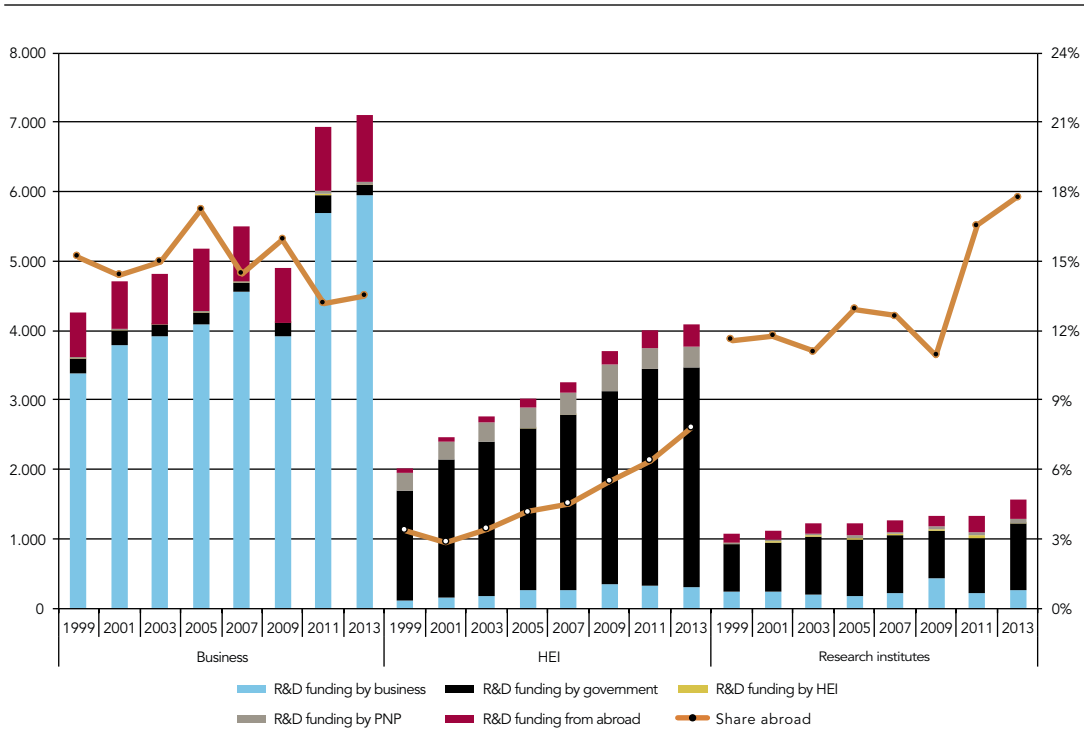
2.2 R&D funding from abroad

Table 1 shows that R&D funding from abroad plays a significant role within the Netherlands at EUR 1,552 million in 2013. This amounts to 12.2% of the total gross domestic expenditures on R&D of EUR 12.7 billion in 2013. In relative terms the share that is financed from abroad has increased in the past decades from 5.3% in 1993, to 10.8% in 2003, and to 12.2% in 2013.²⁵

A historical perspective on R&D expenditure in the Netherlands (Figure 1) shows that while R&D funding from abroad for the business sector increased in absolute terms, it decreased in relative terms. The share of R&D funding from abroad dropped from 15.2% to 13.5% in the period 1999-2013. The R&D funding from abroad cannot keep pace with the growth in domestic R&D funding sources. In contrast, the share of R&D funding from abroad increased rapidly for the Higher Education Institutes sector (from 3.4% to 7.8%) and the Research Institutes sector (from 11.6% to 17.8%) in the same period.

²⁵ See the website 'De Nederlandse Wetenschap' of the Rathenau Instituut (http://www.rathenau.nl/fileadmin/user_upload/rathenau/De_Nederlandse_Wetenschap/F-Financiering-uitvoering_van_R_D_vanaf_1990_CBS_.xlsx).

Figure 1 Evolution of R&D expenditure in the Netherlands by funding source and sector of performance in 1999-2013 (in million euro)



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Source: Data on the funding of R&D performed by companies, higher education institutes (HEI) and research institutes in the Netherlands are from the website 'De Nederlandse Wetenschap' of the Rathenau Instituut which uses data from Statistics Netherlands CBS and OECD. The data are retrieved from http://www.rathenau.nl/fileadmin/user_upload/rathenau/De_Nederlandse_Wetenschap/F-Financiering-uitvoering_van_R_D_vanaf_1990_CBS_.xlsx.

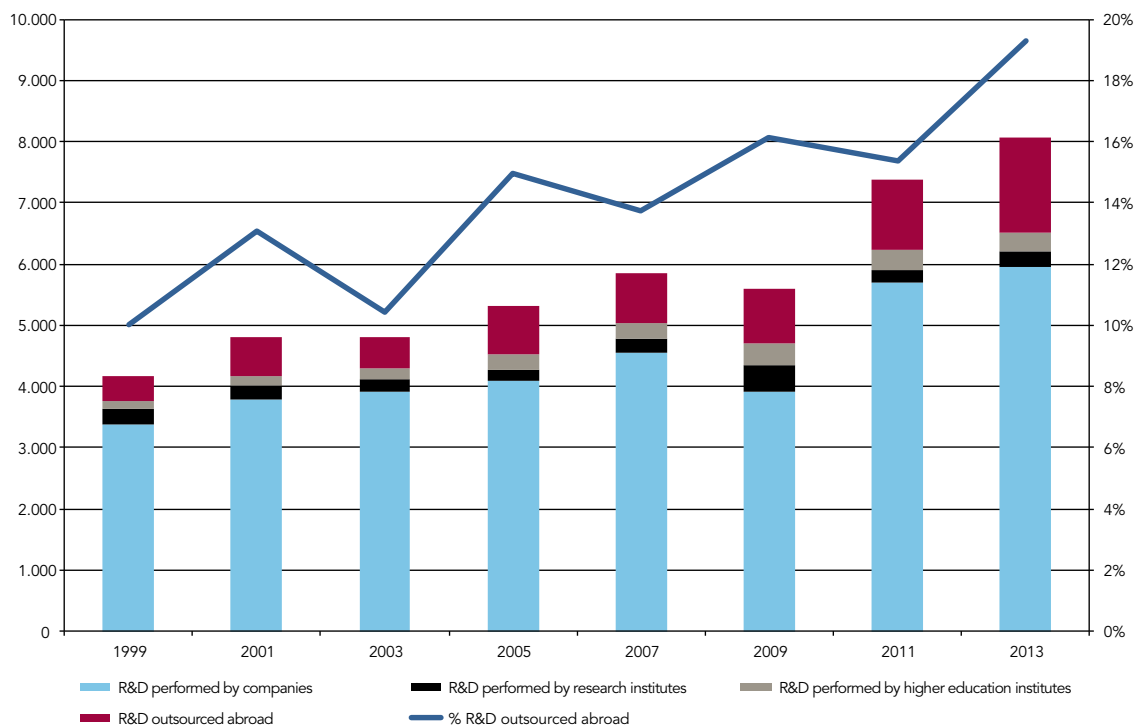
Funding sources from abroad are particularly substantial for the business sector, which is not surprising given that most of these cross-border funding streams concern flows within MNCs. OECD data show that foreign affiliates perform an increasingly large share of R&D in the Netherlands. At the turn of the century, the share of foreign-affiliated R&D in the total business expenditures in the Netherlands was around one-fifth of the total (21.5% in 1999) and by 2011 it had risen to almost one-third (32.5%).²⁶

26 See Figure 1.10 in OECD (2014b).

2.3 Outward R&D funding

Obviously, R&D funding does not only come from abroad, it also goes abroad. The share of R&D expenditure by Dutch-based firms outsourced to firms or institutes abroad has increased significantly from EUR 417 million in 1999 to EUR 1559 million in 2013.²⁷ Figure 2 shows the developments in the destinations of business R&D expenditure in the period 1999-2013.

Figure 2 Destinations of R&D expenditure by firms based in the Netherlands in the period 1999-2013



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Source: Data on the business R&D funding of R&D performed by companies, by research institutes and by higher education institutes are from the website 'De Nederlandse Wetenschap' of the Rathenau Instituut which uses data from Statistics Netherlands CBS and OECD. The data are retrieved from http://www.rathenau.nl/fileadmin/user_upload/rathenau/De_Nederlandse_Wetenschap/F-Financiering-uitvoering_van_R_D_vanaf_1990_CBS_.xlsx.

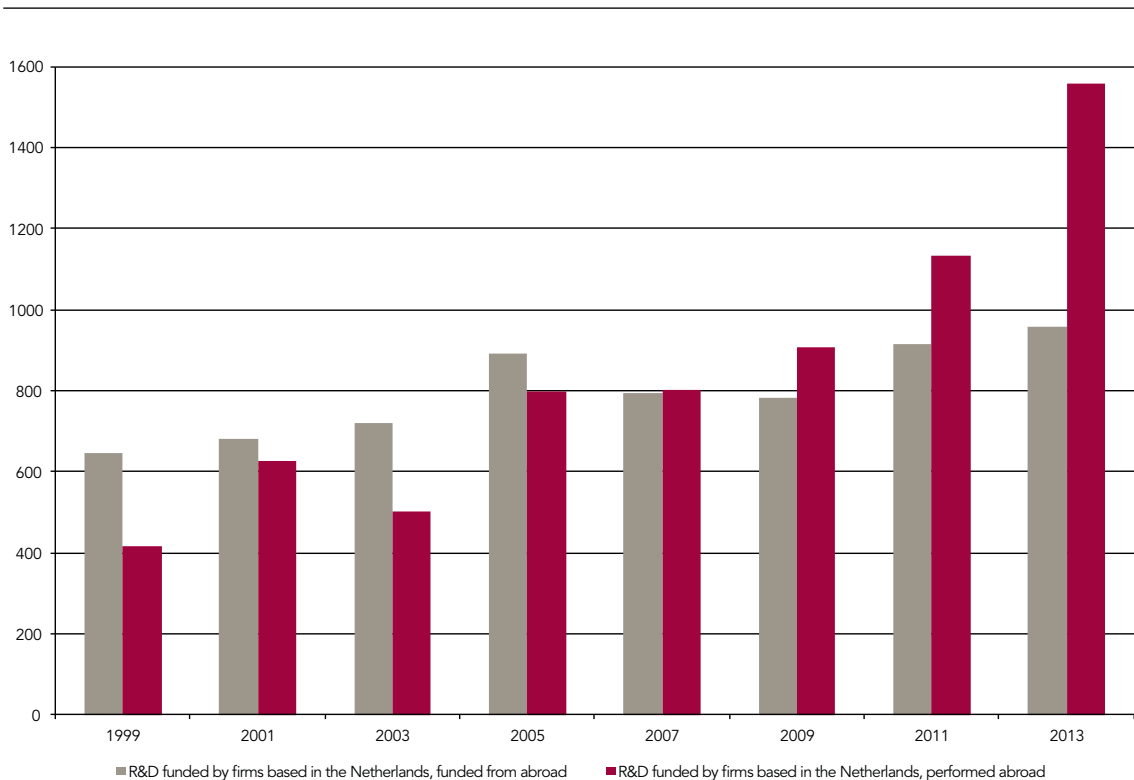
Data on the R&D outsourced abroad by companies in the Netherlands are from CBS StatLine. Data are retrieved from <http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=81244NED&D1=4&D2=1&D3=a&VW=T> (1999-2009) and <http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=82042NED&D1=a&D2=a&D3=a&VW=T> (2011-2013).

27 This outsourcing of R&D is dominated by cross-border funding flows within MNCs with foreign affiliates that perform R&D. Source: CBS StatLine (For 1999-2009: <http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=81244NED&D1=4&D2=1&D3=a&VW=T>; for 2011-2013: <http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=82042NED&D1=a&D2=a&D3=a&VW=T>).

2.4 Inward and outward R&D funding

Figure 3 combines incoming and outgoing R&D funding. It shows that since 2007 the balance has shifted. Before 2007, R&D funded from abroad outweighed R&D outsourced abroad. Since then, firms in the Netherlands outsource more R&D to foreign parties than that they receive in terms of R&D funded from abroad.²⁸ The figure also shows that share of their total R&D budgets that they spend abroad has grown rapidly, from 10.0% in 1999 to 19.3% in 2013.

Figure 3 Balance between incoming and outgoing cross-border investments in R&D



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Source: Data on R&D performed by firms in the Netherlands, funded from abroad are from the website 'De Nederlandse Wetenschap' of the Rathenau Instituut which uses data from Statistics Netherlands CBS and OECD. The data are retrieved from http://www.rathenau.nl/fileadmin/user_upload/rathenau/De_Nederlandse_Wetenschap/F-Financiering-uitvoering_van_R_D_vanaf_1990_CBS_.xlsx.

Data on the R&D outsourced abroad by companies in the Netherlands are from CBS StatLine. Data are retrieved from <http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=81244NED&D1=4&D2=1&D3=a&VW=T> (1999-2009) and <http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=82042NED&D1=a&D2=a&D3=a&VW=T> (2011-2013).

²⁸ The share of business expenditures on R&D that is funded from abroad fluctuates around 15% in the past decade. (OECD Main Science and Technology Indicators, <http://www.oecd.org/sti/msti.htm>). This is well above EU average. Note that the foreign funding for business R&D performed in the Netherlands is dominated by cross-border funding flows within MNCs of which the mother or daughter company is located in the Netherlands (see CBS, 2014: 54).

2.5 R&D funding by MNCs in the Dutch economy

A specific characteristic of the Dutch expenditure on R&D is that a few large multinational companies are responsible for a large share. Eight of the largest private R&D investors (Philips, ASML, Shell, DSM, NXP, Unilever, Océ and AkzoNobel) account for more than one-third of the total business expenditure on R&D in the Netherlands. Philips and ASML together represent 20% of the total.

Of these eight large private R&D investors, there is no indication of a massive relocation of R&D investment from the Netherlands to other parts of the world. For most companies, however, the trend is that domestic R&D expenditure as a proportion of total R&D expenditure worldwide has been decreasing since 2003, but the decrease is in most cases not large.

Textbox 3 R&D expenditures worldwide and in the Netherlands of eight large technology firms in the Netherlands (in million euro and as %)



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Source: Own calculations based on Technisch Weekblad's annual publication of the Top 30 of R&D investors in the Netherlands. The figures have to be treated with care, because in some cases the Technisch Weekblad had to make an estimation. In addition, companies sometimes change their internal procedures of administrating and reporting R&D expenditure.

For **Philips**, the share of domestic R&D expenditure fluctuates around 40%, with domestic expenditure dropping until 2010 and showing an upward trend since then. For **ASML**, the domestic share has recently dropped from around 90% to 80% in 2013, although in absolute terms the domestic R&D expenditure did increase. For **Shell**, the share of R&D expenditure in the Netherlands has dropped since 2005 from half of all expenditure to one-third in 2013. In absolute terms, the domestic expenditures on R&D have also decreased since 2011. The share of **DSM**'s domestic R&D expenditure shows a slight downward trend. It has dropped recently, mainly because the world-wide expenditures grew faster than the domestic expenditure on R&D. Since 2010 **NXP**'s world-wide R&D expenditure grew faster than their domestic R&D expenditure, resulting in a decreasing share of R&D expenditure in the Netherlands. **Océ**'s domestic R&D expenditure has been declining since 2008, but in relative terms remain fairly stable. **Unilever**'s R&D expenditure in the Netherlands fluctuates around 15%, but show a declining trend since 2010 (from 18% in 2010 to 13% in 2013). **AkzoNobel**'s R&D expenditures have dropped significantly in 2007 with the disinvestment in Organon. Since then, the volume has increased until 2011. After 2011 the expenditure on R&D in the Netherlands has been declining both in absolute and relative terms.

2.6 In conclusion

The quantitative evidence suggests the position of the Netherlands in a globalising R&D landscape has been gradually weakening. Large domestic R&D-intensive MNCs have spent a smaller proportion of their world-wide R&D budgets in the Netherlands; the domestic business sector outsourced a larger share of their R&D investments abroad; and this trend is not matched by an increase in incoming R&D investments. In view of the Dutch policy objective to increase R&D expenditure to 2.5% of GDP in 2020, it is unrealistic to expect that this objective can be met without focusing on attracting more inward investments in R&D.

3 Two patterns of R&D globalisation

In order to understand the policy implications of the trends in cross-border R&D funding and spending, it is important to realise that R&D is a broad category that covers various types of activities, ranging from basic research to technological development (section 3.1). Investment decisions in research follow a different logic than investment decisions in development. Section 3.2 shows how this results in typical global footprints for research and development activities by MNCs. Sections 3.3 and 3.4 discuss the various 'location drivers' for research and development. The globalisation of R&D does not follow a uniform pattern across all industries: there are differences between industries and within industries. This is discussed in section 3.5.

3.1 Unravelling R&D

How should we interpret the trends in cross-border R&D funding and spending? It is important to realise that R&D covers several types of activities, ranging from basic research and applied research through to experimental development. Whereas *research* aims to create new knowledge, *development* uses existing knowledge gained from research and/or practical experience in order to create innovations in materials, products, devices, processes, systems or services.²⁹ The nature of research and development activities is different, and within companies the two types of activities are often separated. For example, research may be organised in a corporate research laboratory, while development is organised at the level of the business units. Both types of activities also require different types of personnel. On the one hand, research typically requires researchers with a scientific background (e.g. PhD graduates) that are trained to create new technological knowledge and that have ties with the scientific community. Development, on the other hand, depends more on development engineers that are good at using existing knowledge in novel ways to develop concrete products or processes and that are used to closely interact with other business functions (production, marketing & sales, customer support).

The distinction between *research* and *development* is crucial for understanding the dynamics of the globalisation of R&D. The reason is that both have different 'location drivers' which result in different globalisation patterns and different geographic 'footprints' for research and development.

It is unfortunate that the distinction between 'R' and 'D' is not made in national and international statistics on inward and outward R&D funding. This makes it difficult to assess which part of the cross-border R&D funding flows concern research and which concern development.

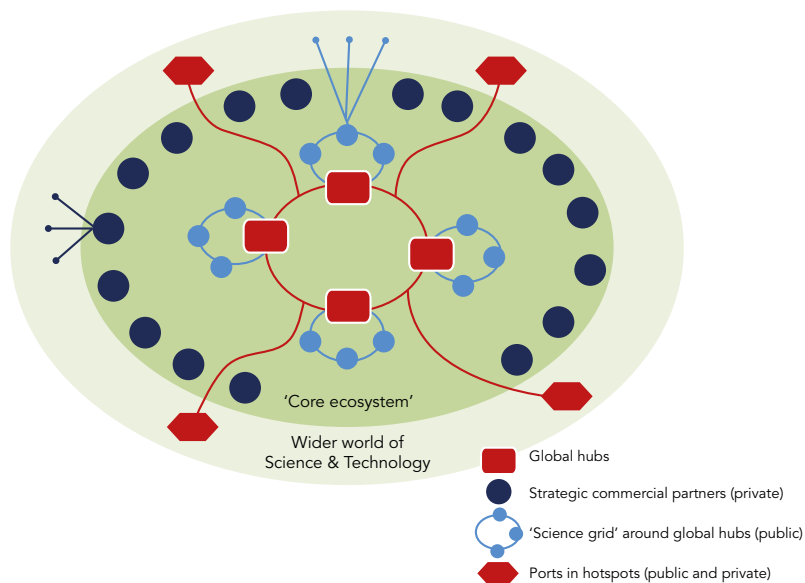
29 According to the OECD Frascati Manual (OECD, 2002) the term R&D covers three activities: basic research, applied research and experimental development, which are defined as follows: **Basic research** is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. **Applied research** is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. **Experimental development** is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

3.2 Establishing a global research footprint

Based on our interviews with R&D leaders in large technology firms in the Netherlands and our study of the literature on R&D globalisation, we identified a trend in how these MNCs organise their global R&D footprints.³⁰

A current trend is that large MNCs tend to centralise their research activities in a few core research centres, or 'hubs', in the main geographical regions and markets in which they are active (i.e. the EU, the USA and Asia). Within each of these main regions, MNCs look for the most attractive knowledge environments for their core labs, where they can develop strong connections with various knowledge partners, including supply chain partners, research universities and other public research organisations. In addition, they have multiple smaller and more flexible research groups located in so-called hotspots around the world to monitor new developments and create linkages with interesting partners. Figure 4 illustrates this trend, where global hubs are embedded in a core ecosystem of supply chain partners and a 'science grid' consisting of partnerships with universities and research institutes.

Figure 4 Global research footprint



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Source: Adapted from a presentation by Jon Hague, Vice-President Open Innovation for Unilever, on Transformational Innovation Partnerships.

For development activities, a much more dispersed global footprint was found. MNCs tend to have development centres in many parts of the world.

30 E.g. Sachwald (2008) and Von Zedtwitz & Gassmann (2002).

Textbox 4 Examples of global R&D footprints

Unilever employs more than 6,000 scientists, engineers, chefs and technicians in its R&D centres around the globe. Unilever has concentrated much of its research in six strategic R&D laboratories that focus on delivering groundbreaking technologies. These hubs are located in the Netherlands (Vlaardingen), the United Kingdom (Port Sunlight and Colworth), in the United States (Trumbull), in India (Bangalore) and in China (Shanghai). Furthermore, Unilever has 31 major development centres that develop and implement product innovations. Additionally, throughout 92 locations around the globe there are R&D teams implementing innovations in countries and Unilever's factories.³¹

Danone has concentrated its research in two main international research centres and four specialised research centres. The two core labs are located at the original sites (France and the Netherlands), while the four specialised centres are located in France, Spain (1997), Singapore (since 2011) and China (since 2013). In addition, Danone has 55 local R&D branches mainly for development and engineering.³²

Textbox 5 American MNCs establishing research 'ports' in the Netherlands

IBM set up a global centre of excellence for water management in Amsterdam in 2008. The main location factor was the world-leading quality of the knowledge and expertise in this field in the Netherlands, although the Dutch market is also attractive thanks to the active role of the Dutch government in water management.³³

In 2009 Boeing decided to become partner in the ThermoPlastic Composite Research Centre (TPRC) on the campus of the University of Twente in Enschede, the Netherlands. It opened in 2012. In the TPRC, researchers, suppliers and manufacturers work together on the research and development of thermoplastic composites.³⁴

In 2015, Intel announced a 10-year collaborative relationship with the Delft University of Technology and TNO, the Dutch Organisation for Applied Research, to accelerate advancements in quantum computing. To achieve this goal, Intel will invest US\$ 50 million and will provide significant engineering resources both on-site and at Intel, as well as technical support.³⁵

The typical global research footprint with centralised core labs and decentralised auxiliary centres helps MNCs to balance the pros and cons of decentralisation (e.g. go where the

31 See <https://www.unilever.com/about/innovation/our-r-and-d-locations/>.

32 See <http://www.danone.com/en/for-all/research-innovation/our-research-at-a-glance/a-global-presence/>.

33 See <http://www-03.ibm.com/press/us/en/pressrelease/23427.wss>.

34 See <http://www.utwente.nl/en/newsevents/!/2012/6/260000/boeing-royal-tencate-fokker-and-the-ut-have-opened-new-tprc-laboratory-and-visiting-center>.

35 See http://newsroom.intel.com/community/intel_newsroom/blog/2015/09/03/intel-invests-us50-million-to-advance-quantum-computing.

knowledge is) and centralisation (e.g. benefit from economies of scale and scope) of research activities. It also implies that governments with aims to retain or attract research investments need different approaches for the hubs and the ports. For the Netherlands, the competitive arena for retaining and attracting core research labs is usually (Northwest) Europe because MNCs. The competitive arena for the smaller research centres (ports) is, however, truly global.

In the next two sections we discuss what location drivers determine where the MNCs locate their large research hubs and their smaller research centres (section 3.3), and their development centres (section 3.4). It should be noted that in reality location decisions are always made as part of broader business strategies. For instance, if a company decides to implement a business strategy to focus on different products, customers and/or geographical markets, then this will obviously affect research and development activities and their footprints as well.

3.3 Location drivers: research

Knowledge related factors play a crucial role for companies in considering the location (or relocation) of research activities. They need access to distinctive knowledge sources, excellent research groups, unique research facilities, talent pools of PhD graduates, etc. But there are other (economic and historical) factors as well, such as economies of scale and scope, and the inherent inertia of research labs.³⁶

A key location driver for research activities is good access to unique, cutting-edge knowledge. In order to innovate effectively, even the largest companies cannot develop all the knowledge they need in-house. Such knowledge has become more variegated and dispersed worldwide. Companies are more likely to pursue 'open innovation' strategies which are much more dependent on external sourcing of knowledge and collaboration with partners.³⁷ These partners may include supply chain partners, companies in adjacent value chains, university research groups and non-academic research institutes. The relevance of the various sources depends on individual company strategies and the type of industry they are in.

MNCs in science-based industries need to make use of advances in science originating in universities in order to remain innovative. They seek to link up with excellent university groups.³⁸ For other industries, links with supply chain partners or other specialised firms in the regional innovation ecosystem may be more important. In section 3.5 differences between industries in globalisation of research and development are further elaborated.

36 This section is based on our interviews with R&D leaders in large technology-based firms in the Netherlands and on our study of the literature on R&D globalisation (see Bibliography).

37 'Open innovation' strategies are driven the need to speed up and improve innovation processes. They allow firms to deal with increased complexity, higher costs and risks of innovation. Therefore, open innovation strategies have become especially important in R&D-intensive industries where technological innovation is characterised by short technology life cycles, high complexity and high risk. In general, the more complex the underlying knowledge bases for new products, services or processes become, the more dependent innovation becomes on combining various external sources of knowledge (OECD, 2014a).

38 Science-based industries are characterised by a high intensity of product and process innovation based on technological developments and scientific discoveries (Pavitt, 1984). Science-based firms source their knowledge needed for the development of new products from in-house research, research of other firms and from the public research system. Typical science-based industries include electronics, chemical, pharmaceutical, biotechnology and nanotechnology industries. Parts of the food industry are also science-based.

Globalisation has resulted in vertical disintegration and globally dispersed value chains. This has made the linkages between the various chains become ever more important for the overall innovativeness. Especially in value chains where the responsibility for research, development and innovation is partly delegated to suppliers of system integrators or final assemblers, and innovation at the component and sub-systems level happens in joint innovation between suppliers and systems integrators, proximity and co-location are beneficial for the speed and efficiency of innovation. Innovative suppliers seek access to relevant innovation ecosystems around value chains, while system integrators try to orchestrate such ecosystems around them.

MNCs have an international perspective when they look for the best external knowledge sources. It is unlikely that they can find all the knowledge they need within one national research and innovation system. This is especially the case for national systems that are relatively small and specialised in specific research and innovation areas. Companies that are based in small countries like the Netherlands therefore have to develop linkages across borders in order to gain access to all the knowledge they need. The linkages with these various parties can have different functions, varying from keeping informed about relevant scientific and technological developments or market developments, to more strategic cooperation.³⁹ In-depth collaborations with research partners induce firms to locate a research centre in the vicinity, in order to facilitate or improve collaboration and develop a partnership with a supply chain partner, university research group or other knowledge provider.⁴⁰

Thus, geographical proximity remains important for knowledge sharing and knowledge transfer, despite developments in information and communication technologies that have greatly facilitated knowledge sharing and collaboration at a distance.⁴¹ The need for proximity to knowledge sources relies on the nature of the underlying knowledge base and the mode of knowledge exchange, i.e. the degree of tacitness of knowledge and the need for personal face-to-face communication. The transfer of tacit knowledge, which is particularly dependent on close and regular interaction, personal contact, and trust, is much easier and cheaper when collaboration partners are located close to each other. In-depth industry-university collaboration flourishes when business partners spend time in university labs, bringing industry closer to fundamental research and allowing universities to benefit from industry's expertise to proof-of-concept and proof-at-scale activities. PhD students and post-docs spending time in industrial research settings also benefit.

39 See Herstad et al. (2010).

40 Partnerships can be in the form of strategic alliances, joint ventures, joint development, etc. There are also other modes of external knowledge sourcing which do not create such a strong driver to locate a research centre abroad. For example when knowledge is sourced through acquisition or sale of knowledge (contract R&D, purchasing, licensing) or via corporate venturing (equity investments in university spin-offs or in venture capital investment funds).

41 See also Breschi and Malerba (2005).

Textbox 6 ASML and the importance of proximity

ASML is the world's leading provider of lithography systems for the semiconductor industry. ASML's success depends on how they orchestrate a complex value chain with many suppliers of advanced components and subsystems. Although ASML is a global company with more than 70 locations in 16 countries, a significant part of ASML's research and innovation activities is centralised in the Netherlands. A main reason for this is the need to cooperate very closely with suppliers in research and development.⁴² Geographical proximity facilitates such in-depth collaboration.

To accelerate the development of extreme ultraviolet technology, ASML has a level of cooperation with suppliers called 'virtual integration': a form of open and trusted collaboration, whereby ASML and suppliers share their skills and processes, with the aim of working as a single enterprise. This means bringing together partners from diverse parts of the value chain and from different countries, and encouraging them to share knowledge and insights so all parties can innovate better and more quickly. For this reason, maintaining a supply base close to ASML sites is key to the success of ASML's innovation processes, as it requires ASML and their suppliers to continuously align their processes and approaches to design challenges.

While the need for proximity to key suppliers creates a location driver to centralise research activities around Veldhoven, the need for proximity to major customers creates a driver to locate development activities (aimed at optimising systems and adapting it to the context of use) in Asia. Because most clients are located in Asia, ASML decided to set up an ASML Centre of Excellence (ACE) in Taiwan in 2007.

The need for access to knowledge abroad is not limited to scientific or technological knowledge. Research strategies become increasingly informed and guided by market needs. It is increasingly important for research to be 'in touch' with end-users, especially in fast-growing markets. One of the reasons why Western MNCs have research centres in China and other emerging economies is to get a better understanding of those markets.⁴³ MNCs from the West also want to understand the innovation processes of their competitors from the East in order to anticipate competition Chinese rivals, for example, on their home markets. Undertaking research activities in foreign markets allows firms to monitor interesting developments in technologies and markets.

Firms do not only seek proximity to a specific knowledge source, but also to attractive innovation ecosystems where complementary firms and knowledge institutes cluster, typically in regions that are specialised in specific knowledge areas. Regional clustering leads to economies of agglomeration, which are the benefits that actors obtain by locating near each other.⁴⁴ These benefits include better access to specialised knowledge thanks to proximity to

42 In many cases, suppliers are expected to share part of the risk involved in developing and marketing new-generation lithography machines, rather than simply delivering the machine parts or services that ASML requests based on well-defined specifications. In return, suppliers are allowed to use technology that has been developed together for other customers in other market applications.

43 Study by ITT on behalf of the Rathenau Instituut.

44 There are also 'diseconomies of agglomeration', for instance increased competition for scarce human capital, problems with crowding and congestion.

supply chain partners, other firms in adjacent industries, universities, centres-of-excellence, etc. Other benefits are better access to talent pools and specialised labour markets, more opportunities for facility sharing, and better access to (specialised) markets and important customers. A good physical infrastructure and various aspects relating to 'quality of life', benefit from urban agglomeration. Thus, co-location with other R&D performing firms and knowledge institutes helps firms to benefit from knowledge spillovers, i.e. knowledge 'leaking' out from R&D activities of others.⁴⁵

Textbox 7 Philips and access to knowledge

An example of the importance of good access to unique knowledge as a location for research is the reorganisation of the R&D function of Dutch MNC Philips in the United States. It is moving its U.S. R&D headquarters to Cambridge, Mass. from its current headquarters in Westchester County, New York where it has been since the late 1940s. The move to the Boston Area allows Philips to collaborate with Massachusetts Institute of Technology (MIT) and other leading-edge institutes and partner companies that are part of the area's rich innovation ecosystem. Philips seeks co-location and strategic partnership with MIT.⁴⁶ The close proximity of the MIT campus will allow Philips researchers to collaborate readily with MIT faculty and PhD students on jointly defined research programmes, as well as participate in open innovation projects.⁴⁷

Although access to knowledge is a key determinant of research location decisions, there are other location drivers that can be taken into account when MNCs choose where to (re)locate their research centres.

- Firms seek to locate research centres in locations that give access to labour pools of well-trained researchers. The presence and size of such talent pools can determine the attractiveness of a location making it easier for MNCs to recruit and retain talented researchers from abroad. The rapid rise in the supply of research talent from China, India and other emerging economies has globalised the scope for MNCs in seeking access to talent pools.
- It is costly and time consuming to relocate a well-running research laboratory. This inertia sets in because it takes many years to build up a well-performing lab. Researchers may not be willing to move house – let alone emigrate – because of established social and cultural ties. Relocating a lab might mean that a company could lose a significant part of

45 Three types of agglomeration benefits can be distinguished (Raspe et al. (2012a: 17):

- Urbanisation benefits for all firms in an urban region, thanks to the concentration of economic, social, political and cultural organisations in densely populated urban areas, as well as the presence of universities, research institutes, facilities for consumers, industry associations and government agencies;
- Localisation benefits for firms in clusters within the same sector;
- Benefits resulting from the variety of sectors in the vicinity.

46 Philips has signed a US\$ 25 million, five-year research alliance with the university. (See <http://fortune.com/2015/05/19/philips-rd-mit/>).

47 http://www.biospace.com/News/royal-philips-electronics-n-v-to-move-workers-to/377954_

their research personnel, in the worst case, to an immediate competitor.⁴⁸ The inertia is further strengthened as research centres become interlinked with universities and other research partners in the environment.⁴⁹ In industries where innovations rely on close collaborations and long-term partnerships with complementary parties in the surrounding innovation ecosystem, companies will think carefully before they close a well-running lab and open a new lab abroad.

The particular phase of the technology life-cycle is important here, because over time, interdependencies grow and innovation becomes more incremental. But when the underlying technological knowledge base of an industry transforms, for instance through a radical innovation that makes the existing knowledge base largely obsolete, the embedded nature of a research centre may become less of a barrier to relocation.

- Thirdly, firms want to exploit economies of scale and scope. Spreading out research across many locations is often inefficient as it leads to underutilisation of expensive research facilities and personnel and introduces additional costs for management and coordination. Centralisation allows for knowledge sharing, cross-pollination, multidisciplinary research collaboration, establishment of joint technology platforms, joint access to specialised equipment, and synergies in technology development through interdisciplinary interaction. Moreover, it can create better career opportunities for researchers, which helps to further attract and retain talented researchers.
- Finally, there are a variety of other location drivers for research that may also be taken into account in the integral decision-making process. These could include: concerns relating to the protection of intellectual property (particularly in countries where the intellectual property regimes are weak); the need to support local development and innovation projects; specific regulations requiring R&D investments in a host country; existence of attractive subsidies for research and innovation; and prevalent attitudes to (controversial) research e.g. in the case of biotechnology.⁵⁰

3.4 Location drivers: development

The globalisation of development unfolds according to a different logic than the globalisation of research. In considering a location for development activities, market related factors play a crucial role. These include access to important (new) customers and supply chain partners and understanding of client preferences and regulatory requirements, etc. But there are other

48 An example of the 'stickiness' of research due to immobility of research personnel is the relocation of Danone's R&D centres in the Netherlands into one new centre. After the acquisition of the Dutch food and nutrition firm Numico, the French multinational Danone wanted to consolidate the R&D centres it had acquired in the Netherlands (in Wageningen, Zoetermeer, Cuijk and Schiphol) into one new innovation centre. Eventually, the campus of the University of Utrecht was selected as the location for this new centre. The distance the research personnel would be willing to commute was one of the considerations.

Also in the case of FrieslandCampina's new consolidated R&D centre at the campus of the Wageningen University, the location decision was partly influenced by the distance personnel would be willing to commute.

49 Patent analysis shows that specialisation patterns of firms and public knowledge institutes in the Dutch innovation system coincide. This further strengthens the stickiness of research labs.

50 See Von Zedtwitz & Gassman (2002).

factors as well, such as access to talent pools of engineers and technical personnel and proximity to other business functions.⁵¹

A key location driver for development activities is good access to markets. When firms enter new foreign markets, it is important that their products and services meet local requirements and user preferences. Products often need to be adapted to, or 'localised' for, foreign conditions.⁵² A local development centre helps firms to develop tailored products more quickly with better interactions in those markets. Firms can work with local staff that know the local conditions and understand the local market. In particular when the foreign region or country is a lead market for innovative products, it is particularly important to locate development activities in the vicinity.⁵³

Textbox 8 Examples of MNCs seeking access to markets through local development centres

A striking example of the need to have development centres abroad is the crop breeding industry. Since every climate zone needs their own customised seeds, the development activities of seed companies need to be present in all climate zones in which they want to sell seeds. Global seed companies therefore have many development and testing centres across the globe (while they tend to keep their research centralised in their home countries).

NXP Semiconductors is manufacturer of semiconductors that are used in a wide range of 'smart' automotive, identification, wireless infrastructure, lighting, industrial, mobile, consumer and computing applications. For NXP, being involved in lead markets is vitally important. Therefore, the company tries to be where there is the biggest momentum for new applications, where complex system solutions are being developed, and where there are value chain partners. One example is Singapore, where new solutions are being developed for the 'smart city'.⁵⁴

Access to overseas markets is a key location driver for development, but other location drivers can be taken into consideration as well. Firstly, firms seek access to talent pools of skilled engineers and product developers. It is not sustainable to have a development centre in a

51 This section is based on our interviews with R&D leaders in large technology-based firms in the Netherlands and on our study of the literature on R&D globalisation (see Bibliography).

52 Global companies often develop generic product 'platforms' which can be customised to local requirements at low cost.

53 A lead market matches one or more of the following criteria (Meyer-Krahmer and Reger, 1999):

1. a demand situation characterized by high income elasticity and low price elasticity or a high per capita income
2. a demand with high quality requirements, great readiness to adopt innovations, curiosity concerning innovations and a high acceptance of technology
3. good frame conditions for rapid learning processes by suppliers
4. authorization standards that are 'setting standards' for permit authorization in other countries e.g., pharmaceuticals in the USA.,
5. a functioning system of exploratory marketing 'lead user' principles.
6. specific, problem-driven pressure to innovate
7. open, innovation-oriented regulation and frame conditions.

54 "Singapore plans to be world's first 'Smart Nation'"(<http://www.cnet.com/news/singapore-unveils-plan-to-be-worlds-first-interconnected-smart-nation/>).

location where there is a structural shortage of trained engineers; there is a limit to the number of engineers and developers that can be hired from abroad. As education systems in emerging countries improve and develop, so does the attractiveness of these countries as a location for development activities. For example, India has a large supply of well-trained software engineers, which has led many companies to set up software development centres there.

Secondly, firms seek location benefits from the proximity of their development activities to other business activities, in particular manufacturing. The more advanced the products and manufacturing or assembly processes are, the more beneficial it is to co-locate development and manufacturing.⁵⁵ This location driver works two ways: development may follow manufacturing, but manufacturing may also follow development. The 'value density' of products partly determines the extent to which production can be done at a distance from the main markets.⁵⁶ This means that development is more likely to follow manufacturing when products have a relatively low value density.

The current debate on 'reshoring' of manufacturing – in particular in the United States, where MNCs have been very active in offshoring manufacturing to low-wage countries – is relevant here. Due to new production technologies (e.g. 3D printing, robotisation), changing circumstances (e.g. rising wages, trade barriers) and/or strategic reassessment of costs and benefits, MNCs may decide to 'bring back' advanced manufacturing operations. The benefits of development and manufacturing being at a shared location help to outweigh the benefits of offshoring, when MNCs have their main R&D activities located in their home country. Moreover, when MNCs decide to reshore manufacturing, their overseas development centres are likely to follow in their wake.

Textbox 9 Philips' shavers come home: reshoring advanced manufacturing

Philips decided in 2012 to reshore the manufacturing of electric shavers for the European market from China back to the Netherlands in 2012. Not only in order to reduce transportation costs and gain proximity to the advanced European market, but also because of the co-location benefits for R&D and advanced robotised manufacturing. According to the CEO of Personal Care, Phillips, "Laboratory and factory must be close to each other; that is essential". This is particularly the case for highly advanced products and production processes.⁵⁷

55 Indeed, a traditionally important mode of R&D internationalisation – next to pure greenfield investments and M&A of existing R&D centres – is internationalisation of R&D via sequential process whereby a firm first sets up a subsidiary in a foreign market for manufacturing or customer support. Once it is established the foreign affiliate gradually becomes engaged in R&D. See Guimón (2011) with references to Costa and Filippov (2008); Guimón (2009); Mudambi and Mudambi (2005); Narula and Dunning (2009).

56 Products with a high 'value density' are economically more transportable from production sites to customers across the globe. A good example are the lithography machines of ASML that are assembled in Veldhoven and shipped all over the world. Product with a low value density need to be made close to customers in relevant markets in order to minimize transportation cost. (McKinsey Global Institute, 2012).

57 Het Financieele Dagblad, 'De mens ontwerpt, de robot zet in elkaar', 30 October 2014, p. 11. See also <http://www.bloomberg.com/news/articles/2012-01-19/china-no-match-for-dutch-plants-as-philips-shavers-come-home-1->.

There are a variety of benefits that firms seek from co-locating their development activities with their research activities. Innovation can be speedier – a strategic goal for many MNCs – when research and development activities closely work together. When MNCs concentrate their research in strategic hubs, it is beneficial to locate development activities nearby, for example on the same technology campus. This is, for instance, the goal of Philips with the High Tech Campus in Eindhoven, the Netherlands, which houses both Philips Research and the headquarters and R&D of the Lighting Division. Similarly, the Philips Innovation Campus in Bangalore, India, is set up as a tech hub where research, development, engineering, marketing and sales are brought together.⁵⁸ In the USA, Philips announced it will move its R&D centre to MIT in Cambridge, Massachusetts.⁵⁹

Thirdly, firms seek efficiency benefits in (re)locating development activities. The wage cost of development personnel can be a factor – usually much more so than in the case of research personnel. Software development has been offshored to India by many MNCs, for instance, largely because of the lower wages of software engineers in India. Cost advantages are becoming less influential, however, because R&D labour costs have risen significantly in China and other emerging economies over the last decade.

Finally, MNCs may take into account several other location drivers for development. The need to provide local support, for example, or for setting up in-depth collaboration with local partners. In addition, firms may want to have multiple foreign development centres to enable simultaneous product launching across the globe, or to make use of different time zones. Finally, national regulations may require firms to set-up development activities in the host country and/or to collaborate with local partners.

As a result of the integral decision-making process on the (re)location of development, an MNCs' development footprint tends to be much more decentralised than their footprint of research (with a few global hubs complemented by ports in regional hotspots).

3.5 Differences between industries in R&D globalisation

Industries differ in how the various location drivers shape the patterns of globalisation of research and development. Also within industries, the location drivers may work out differently for different firms, depending on their position in value chains and their business strategies.

With regard to *access to knowledge* industries differ in terms of which external knowledge sources are most important for them. The underlying innovation pattern in industries determines which external knowledge sources are relevant. These patterns reflect different interdependencies and role-relations between suppliers, producers, and customers. Various innovation patterns can be identified.⁶⁰ In 'user-driven innovation patterns' there is a division of labour in which specialised suppliers supply to and cooperate with professional users or customers. It is

58 See <http://www.bangalore.philips.com/html/AboutUs.html>.

59 See http://www.newscenter.philips.com/us_en/standard/news/press/2015/20150519-philips-signs-five-year-research-alliance-with-massachusetts-institute-of-technology.wpd#.VfAuNtKeDRY.

60 See Van de Poel (1998) who elaborated Pavitt's (1984) taxonomy of innovating firms.

essential that suppliers have good access to these users or suppliers. Governments are important customers in the case of 'mission-oriented innovation patterns'. This pattern is visible in sectors like the defence industry, the nuclear power plant industry, etc. where the (national) government acts as a mission actor. In 'supplier-dependent innovation patterns' there tends to be a division of labour in which suppliers are science-based firms and customers are either supplier-dominated firms (which compete on nontechnical features) or scale-intensive firms. In 'R&D-dependent innovation patterns' large science-based firms play a prominent role. For 'science-based' firms in access to universities and other research institutes is very important as their innovations rely on scientific breakthroughs.⁶¹ It is a general trend that universities and other public research organisations have become more important for science-based firms. The 'era of the big industrial research labs' is over since the 1970s. The labs of MNCs have become less big and less engaged in basic research. They have come to rely more on research universities for their knowledge needs.

In industries where value chains are vertically disintegrated in complex divisions of labour between suppliers of materials, components, devices and subsystems and system integrators, linkages between the various parts of the chains are important. Around a system integrator an ecosystem of suppliers may emerge – ASML is a good example – which, in turn, anchors the R&D activities to that specific regional cluster.

Access to markets and customers is especially important for industries that produce products that need to be tailored to local demands and requirements. Products developed for the home market need to be adapted to local markets elsewhere.⁶² For instance in the food industry, consumers in different countries have different tastes and preferences that need to be taken into account. Also in the crop breeding industry, seeds need to be tailored to local conditions in terms of climate and soil. In industries where innovation is driven by 'lead markets' and 'lead users', access to markets and customers is not just important for the location of (adaptive) development but also for the location of research activities. When research activities are located in countries, regions, or cities where were the biggest momentum for new products or applications is, innovation tends to be faster and more effective.⁶³

The relative importance of *proximity to other business functions* also varies across industries. In industries characterised by advanced manufacturing or assembly processes, colocation of production and development activities is highly beneficial. The location of manufacturing depends on several factors, including intensity of R&D, labour, capital, energy, trade and value.⁶⁴ A high value density of products, for instance, makes products economically transportable from production sites to customers across the globe (e.g. products like semiconductors and electronics, computers and office machinery, medical, precision and optical instruments).

61 Science-based industries are characterised by a high intensity of product and process innovation based on technological developments and scientific discoveries (Pavitt, 1984). Science-based firms source their knowledge needed for the development of new products from in-house research, research of other firms and from the public research system. Typical science-based industries include electronics, chemical, pharmaceutical, biotechnology and nanotechnology industries. Parts of the food industry are also science-based.

62 Firms may develop generic or global product platforms that can easily tailored to local conditions.

63 A lead market can be defined as a regional market that is first to adopt a global innovation.

64 McKinsey Global Institute (2012).

Also within industry sectors the drivers may play out differently. In the pharmaceuticals industry, for instance, access to lead markets is especially important in clinical research, less so in pre-clinical research. In the telecommunication technology sector access to lead markets is much more important for software development than for hardware development. Hardware development depends more upon access to scientific knowledge and proximity to production than software development.⁶⁵

3.6 In conclusion

In this chapter we have argued that there are two patterns in the globalisation of R&D. In short, we have argued that the location of research is to a large extent driven by knowledge-seeking motives. The location of development, on the other hand, is mainly driven by market-seeking motives.

Both patterns give cause for different policy concerns and call for different responses by policymakers.

Research location decisions by MNCs tell us something about how such globally active companies perceive the international position of a country (or region) in knowledge and innovation. Inward investments in research are indicative of the attractiveness of a country's knowledge and innovation climate. Outward investments in research by 'home-grown' MNCs give cause for concern about a weakening position of the home country in the global competition for research investments. Apparently, these firms are increasingly sourcing their knowledge abroad (through their foreign affiliates), where they perceive better access to relevant knowledge sources.

Development location decisions by MNCs, on the other hand, inform us about where they see the most attractive markets. Outward investments in development by 'home-grown' MNCs can be seen as a sign that they are strengthening their position in foreign markets. In order to be successful in overseas markets, they need to have development centres in those geographies. Inward investments in development would suggest that the host country is an important market for the investor.

Unfortunately, statistical data on inward and outward investments in R&D (see chapter 2) do not distinguish between investments in research and investments in development. So we do not know how much of the (outgoing or incoming) cross-border R&D investments are driven by knowledge-seeking motives or market-seeking motives. It is important that statistical systems are adapted in order to make such distinctions.⁶⁶

In absence of differentiated quantitative evidence we will make a more qualitative assessment on the question whether there are causes for policy concern in the next chapter.

65 See also Frieder Meyer-Krahmer and Reger (1999).

66 This recommendation is part of broader efforts to develop an internationally harmonized measurement framework for international trade and economic globalisation by organisations like Eurostat and the OECD. See http://ec.europa.eu/eurostat/statistics-explained/index.php/Global_value_chains and <http://www.oecd.org/sti/ind/oecdhandbookoneconomicglobalisationindicators.htm>.

4 Causes for (policy) concerns?

The previous chapter showed that research labs appear to be ‘sticky’ and that outward investments in development are not necessarily a negative sign. So, are there causes for policy concerns? This is the central question of this chapter.

In section 4.1 we use insights from our interviews with R&D leaders in MNCs to assess whether the position of the Netherlands as a home base for corporate research labs is under threat in the longer term. The Dutch economy has the advantage that it is home to relatively many MNCs that have their core research labs rooted in the Netherlands, close to their headquarters. The inertia of such labs, as explained in the previous chapter, may help to explain why we found no indications of a mass exodus of R&D investments. To what extent does this ‘stickiness’ of research labs offer guarantees to the ‘home’ economies of MNCs?

In section 4.2 we will discuss the impact of the rise of Asia and China in particular. China is increasingly focussing on R&D and innovation to achieve continuous and healthy economic development.⁶⁷ This changes the global competition, not only for foreign investments in development, but also in research.

Finally, in section 4.3 we consider the role of specific location drivers for research and development in R&D globalisation via M&A. To what extent do M&A ‘distort’ the dynamics of R&D globalisation? Do M&A overshadow the specific location logics of research and development?

4.1 “Refresh in the West, grow in the East”

In our interviews with major R&D performing firms in the Netherlands we found no indications that they were moving (or considering to move) a substantial part of their investments in research to other countries. Indeed, several of these private R&D investors in the Netherlands have recently made significant investments in their research and innovation centres in the Netherlands.

Textbox 10 Examples of R&D reinforcement in the Netherlands

- In 2014, **DSM** opened a new centre for the research and development of high-performance materials on the Brightlands Chemelot Campus in Sittard-Geleen, the Netherlands. It is DSM’s largest materials centre worldwide.
- In 2013, **Danone** opened a new global research centre at the campus of the University of Utrecht in the area of early life nutrition and advanced medical nutrition.⁶⁸

67 The Economist (2015).

68 <http://www.danone.com/en/danone13focus/rd/>.

- In 2013, **FrieslandCampina** opened a new Innovation Centre at the campus of the Wageningen University & Research Centre. Various R&D disciplines, laboratories and a pilot plant were brought together in one building.⁶⁹
- In 2012, **Nunhems**, a Bayer CropScience company, invested in a major expansion of its state-of-the-art vegetable research and development centre in Nunhem, the Netherlands.⁷⁰
- In 2009, **Shell** opened a new state-of-the-art technology centre in Amsterdam as one of its three global technology hubs.

These investments show that companies still view the Netherlands as an attractive location for their research activities. Large technology-based firms in the Netherlands appear to keep their existing research centres in the Netherlands up-to-date. While this may be reassuring in the short term, it is no reason for complacency in the long term. As explained in the previous chapter, inertia is a factor in why these firms have decided to stay or expand: it takes a long time to establish a well-running laboratory, and industrial labs become increasingly interconnected with their knowledge environment.

However, with radically new innovations (for instance as part of converging developments in nano- bio-, information- and/or neuro-technosciences), MNCs have to build up new capabilities and competences as well as new research networks and partnerships. In this situation, location decisions are less influenced or constrained by historical path dependencies and MNCs have more freedom to choose the best location for their research activities.

Research investments in new innovation domains increasingly take place abroad, notably in Asia. This trend is summed up in the slogan 'Refresh in the West, grow in the East'.⁷¹ Although the West is not in danger of losing their lead in research and technology immediately, its position could be eroded gradually.⁷²

4.2 The impact of China and Asia

In the 1990s and early 2000s, Western MNCs performed development activities in China which focused on simplifying and modifying Western products to make them more affordable and attractive for consumers in Asia. Chinese affiliates of Western MNCs have now moved beyond this relatively low-end development work by developing global R&D centres that are engaged in research and creating intellectual property. They increasingly take the lead in developing new products for Asian and even global markets. Thus, the R&D function of Chinese affiliates of Western MNCs is continuing to evolve as their contribution to global innovation projects

69 <https://www.frieslandcampina.com/en/news/queen-maxima-to-open-frieslandcampina-innovation-centre-2013-09-11/>.

70 <http://www.greenportvenlo.nl/artikel/nieuw-research-laboratorium-nunhems>

71 One implication of this development is that the growth of R&D investments in China by Western MNCs occurs mainly through gradual expansion, rather than through relocation or replacement of existing R&D activities from the West to China, or through M&A. The pharmaceutical industry is an exception: M&A is an important route in this sector.

72 See also WRR (2014).

increases.⁷³ Efficiency and market-seeking motives are no longer the only main reasons for large Western MNCs to locate R&D in China. Knowledge-seeking motives have become important as well.

It should be noted, however, that the role of basic research in innovation processes in China is still limited. The market is growing so rapidly that there is hardly any time for longer-term research-based innovation. This is starting to change as Asian markets become more advanced, for instance in Singapore, South Korea and Taiwan.⁷⁴

Western MNCs seek access to various sources of knowledge in China. Supply chain partners and universities are the main magnets for research investments. But knowledge regarding Chinese customers and end-users as well as knowledge of Chinese competitors, are also important as research location drivers. In addition, getting access to Chinese graduates (in science and engineering) is a main research location motive.

China offers attractive innovation ecosystems for many industries. Shanghai and Beijing, in particular, are traditionally attractive destinations of R&D investments due to their highly developed knowledge infrastructures and the clustering of companies, suppliers and research talent active in the same industry. The Chinese government has the ambition to move higher up the value chain to a more knowledge-based economy. China's 12th Five-Year Plan (2010-2015) identifies seven priority sectors for which more international knowledge cooperation with experts in these fields is sought. This adds to the attractiveness of China as a location for research activities.

The Chinese government focuses on the development of science parks to enhance clustering of companies and offers incentives for (foreign) companies to establish R&D facilities. For example Guangzhou has a medical delta focusing on biotechnology, medicine and pharmaceuticals. Expansion of R&D to the Western part of China is also a trend in the geography of R&D locations. The Chinese government creates competition between cities in steering innovation. In terms of size and scale, the Netherlands is comparable to a metropolitan area like Shanghai or Guangzhou.

The Chinese science system has developed rapidly in both quantitative and qualitative terms. According to the Shanghai ranking, for instance, China has seven universities among the top 200 universities in 2015.⁷⁵ The improving research quality makes Chinese universities more attractive as research partners. They also contribute to a large and growing talent pool of skilled

73 This part is based on a study by International Top Talent (ITT) on behalf of the Rathenau Instituut. ITT conducted personal in-depth interviews with 15 R&D leaders working for Dutch companies in China. These Dutch companies are active in various industries and include nine MNCs, five SMEs, and one independent expert.

74 Economist Intelligence Unit (2012) quotes an interviewee from Philips who argues that Asia has some way to go before it is ready for deeper engagement in pure science. "Asia's growth is so phenomenal that the type of R&D it does is very practical. It's about harnessing opportunities at great speed and capturing the growth opportunity through product development," he explains. "The science side calls for much greater patience. You have to set out a hypothesis, create an experimental design, test the hypothesis, record the results, adjust and start again. It takes time and a steady, methodical approach and Asia's pace of growth isn't necessarily suited to that yet."

75 These are: Peking University, Shanghai Jiao Tong University, Tsinghua University, Zhejiang University, Fudan University, Sun Yat-sen University, and University of Science and Technology of China. (<http://www.shanghairanking.com/World-University-Rankings-2015/China.html>).

scientists and engineers in China that attracts Western MNCs.⁷⁶ Due to the rising wages of trained engineers and researchers in China, the cost advantages have become much less important. Instead, competences and expertise are now the main motives.⁷⁷

Knowledge of end-users and their (unmet) needs has become increasingly important to inform and orient global research and innovation strategies. These needs are the starting point for designing new products and services and obviously, end-users in China and Asia often have different needs and demands than end-users in Western markets. Proximity to end-users in China is therefore an important location driver, not only for (adaptive) development activities, but also for research activities.

Furthermore, being present in China with research and development activities helps Western firms to better understand and emulate how firms in emerging markets innovate. This requires a different approach than innovation for advanced Western markets. In China, innovation processes tend to be much faster and deliver novel solutions that are low-cost and could also be successful on Western markets. Indeed, Chinese companies are increasingly internationalising themselves and MNCs from the West need to anticipate their competition in their home markets. Huawei, Lenovo and Alibaba are already household names in Western markets.⁷⁸

For development activities, other location drivers remain important. In order to strengthen the location driver associated with access to important (lead) markets, the Chinese government uses its purchasing power to create specific lead markets, which attracts R&D investments in these areas.⁷⁹ China also has location benefits that derive from the fact that many Western MNCs have manufacturing operations in China to make products for the Asian or global market. Proximity to (advanced) production processes can be a strong location driver for development.

While all these developments contribute to the attractiveness of China as a destination, there remain serious management challenges for Western MNCs to fully integrate their Chinese R&D operations into their global R&D organisation. Geographic, social and cultural distances between Chinese and Western parts of the company tend to be large and need to be bridged, for example, cultural differences in leadership styles. The home country headquarters may not always have a full understanding of the Chinese market. Its staff may be prejudiced against the quality of Chinese capabilities in research and development. And R&D staff in the West may be reluctant to share knowledge with their Chinese counterparts because they fear that R&D activities will be eventually relocated to China, resulting in job losses at home.

76 According to national sources, Chinese universities delivered more than 27,000 doctorates in science and engineering in 2011, possibly more than American universities (24,792) (OECD, 2014b).

77 This development is driven by policies of the Chinese government that place more and more emphasis on talent and talent development as indicated in its Talent Development Plan (2010 – 2020). These policies give Chinese researchers the chance to work and learn abroad and offer incentives to Chinese overseas talent to return to China.

78 See also *The Economist* (2014).

79 An example given is the decision of the Chinese government that all street lights need to have LED lighting. This policy attracts companies leading in LED to China, hence initiating a climate for innovation that led to China being a leader in this area now.

In addition, Western MNCs often have serious concerns about the security of intellectual property rights in China, which may make them reluctant to (re)locate R&D activities sensitive to IP leakage. The Chinese government is aware of such concerns and implements IP protection policies.⁸⁰

Another challenge for Western MNCs in China is to recruit and retain the most talented engineers and researchers. They now have to compete with domestic firms that also offer attractive conditions. A particular challenge is retaining staff, as Chinese R&D workers tend to be highly mobile and change jobs quickly.⁸¹

Textbox 11 Singapore: the rise of an R&D hub in Asia

Singapore has offered a model for successful economic development that other emerging countries are trying to emulate. Since its political independence in 1965, Singapore has developed from an agricultural economy into a highly developed industrialised economy. Singapore's development can be divided into four phases.⁸² In the first 'industrial take-off' phase (mid-1960s to mid-1970s) Singapore relied on technology transfer from foreign MNCs to establish Singapore as a labour-intensive offshore manufacturing base in South-East Asia. In the second 'local technological deepening' phase (mid-1970s to late 1980s), new and upgraded MNC operation brought about rapid growth of local process technological capabilities. This was enabled by the emergence of a critical base of local supporting industries in precision engineering and components assembly. In the third 'applied R&D expansion' phase (late 1980s to late 1990s), applied R&D activities by global MNCs in Singapore expanded rapidly, enabled by the establishment and growth of new public R&D institutions that were geared primarily to complement and support MNC innovation activities. In the fourth 'high-tech entrepreneurship and basic R&D' phase (since the late 1990s) the emphasis has shifted towards indigenous technological innovation capabilities, the formation of local high-tech start-ups, and an increasing shift towards basic R&D and the development of new science-based industries, particularly in the pharmaceutical/life sciences industry.

4.3 M&A: do specific location factors really matter?

To answer the question on causes for policy concern, it is important to consider to what extent outward and inward investments in business research and development do indeed reflect the attractiveness of a country as a location for specifically research and development. We have already noted that globalisation of R&D is always part of broader business strategies. This raises the question whether specific location factors for research and development are not overshadowed by more general business location factors, i.e. the investment climate in

80 For instance, the Chinese government recently opened a large IP protection office in Beijing to further strengthen and underline its focus on this topic.

81 Study by International Top Talent (ITT) on behalf of the Rathenau Instituut.

82 Edquist and Hommel (2008).

general? Such general factors include the macroeconomic conditions, the functioning of the apparatus of government, infrastructure, cultural and societal aspects, human capital and labour supply, quality of life, etc.

In the Introduction, three basic routes or modes of globalisation of R&D were identified: greenfield investment in a new lab abroad; broadening the remit of a foreign affiliate with R&D tasks; and cross-border merger and acquisition where labs get a new owner from abroad. This last route, in which MNCs globalise their R&D footprints via cross-border mergers and acquisitions (M&A), is the most common. It is in this third mode where broader strategic considerations may be much more decisive than location factors relating specifically to research or development.

The global R&D footprint of a MNC may thus be a consequence of a series of acquisitions (and divestments) rather than the outcome of a well-planned R&D strategy as such. M&A could 'distort' the picture with regard to the various location drivers for research and development.

This 'jungle growth'⁸³ of R&D globalisation is, however, often 'corrected' when MNCs want to call a halt to the proliferation of R&D centres and rationalise or consolidate their R&D sites. Global MNCs often want to achieve a pattern of a few hubs in which they centralise their research efforts and create a series of smaller, dispersed centres in specific hotspots. In this restructuring process, specific location drivers for research (e.g. access to knowledge) and development (e.g. access to markets) are decisive. Eventually, the global R&D footprint of an MNC can indeed be shaped to a large extent by location drivers that are specific to research and development.

When a domestic R&D centre becomes an affiliate of a foreign MNC, its position and location attract scrutiny. From a policy perspective this means that it is important that the location factors for research and/or development are strong and perceived as attractive by the new owner. There is always a fear that new foreign ownership may have negative effects on the domestic business expenditures for R&D and may affect the relationship with the domestic research and innovation system – not only because the cultural ties between the domestic R&D site and the MNC's headquarters abroad become weaker, but also because foreign owners are less familiar with the strengths (and weaknesses) of the domestic knowledge system. In that sense, cross-border M&A can be seen as a test of location strengths.

In the Netherlands, several of the largest private R&D centres have become part of the global R&D footprint of foreign MNCs. For instance, the printing and copying company Océ is part of Canon from Japan (since 2010). The steel company Corus is part of Tata Steel from India (since 2007). The food and nutrition company Numico is part of Danone from France (since 2007). The vegetable seeds company Nunhems is part of Bayer Cropscience from Germany (since 2002). DAF Trucks is part of PACCAR from the United States (since 1996).

While these examples illustrate that cross-border M&A do not necessarily lead to a 'hollowing out' of the domestic research and innovation systems, there are also examples of stories with a less fortunate plotline. In recent years, the closure of the laboratory of the Dutch pharmaceutical

83 The term was used by Von Zedtwitz and Gassmann (2002).

company Organon after a takeover by Schering Plough⁸⁴ from the United States has fed these concerns. It is a clear example of a foreign MNC that has sought to consolidate its R&D functions after an M&A process. It should be noted, however, that the pharmaceutical industry is a very specific sector which faces declining R&D productivity, expiring patents and downward pricing pressure. This had led to an upsurge in the level of consolidation. The industry's drug innovation crisis forces pharmaceutical firms to rethink and restructure their R&D and innovation function.

In sum, cross-border M&A are an important route for globalisation of R&D. They often lead to reconsiderations of the global footprint for research and development. All the more reason, therefore, for countries (and regions) to ensure that the specific location factors for research and development are strong – and perceived as strong.

4.4 In conclusion

The main question of this chapter was: are there causes for policy concerns? Our discussion on the inertia of research labs showed that this stickiness does not give any guarantees for the longer term, especially in case of radical technological innovation. The slogan 'Refresh in the West, grow in the East' sums up the dynamic. The challenge is to offer an attractive investment climate not only for established industries and R&D areas, but also for new and emerging industries and R&D areas.

Our discussion on the rise of China showed that China is no longer mainly attractive as a location for investments in development, but increasingly also for investments in research. The competition between countries (and regions) for foreign investments in research has become truly global. The challenge is to ensure that the Netherlands remain an important part of global research footprints of MNCs.

Finally, our discussion on M&A showed that specific location factors for research and development remain important, even if the globalisation of R&D occurs via M&A. While M&A are often beyond immediate policy control (unless they impede competition), governments face the challenge of ensuring that R&D establishments in their country survive or even benefit from the consolidations that tend to follow M&A.

Thus, the globalisation of R&D should be high on the policy agenda. In the next chapter we will explore the implications for policy of the globalisation of research and development.

84 Later merged with Merck & Co. into Merck Sharp & Dohme (MSD).

5 Implications for policy

This chapter examines the policy implications of our analysis of the two globalisation patterns for research and development. Section 5.1 shows that our perspective on the globalisation of R&D suggests that increasing the R&D intensity of the economy requires a differentiated approach for research and development. In section 5.2 main focus points for policy are identified.

5.1 Raising R&D intensity in the context of globalisation

As part of the Europe2020 strategy, the Dutch government has formulated the ambition to increase the R&D intensity of the Dutch economy to 2.5% of GDP by 2020. Given the current level of R&D expenditures (less than 2%) and the R&D extensive sector structure, this is an ambitious objective. This is particularly so given that outward investments in R&D currently outgrow inward investments (see Chapter 2).

The perspective of globalisation suggests that increasing R&D intensity is not only a matter of stimulating firms to spend more on R&D, but to stimulate firms – whether domestic or foreign, existing or new – to spend it in the Netherlands. This means that the Netherlands should strengthen its attractiveness as a location for R&D investments vis-à-vis competing countries and regions.

The policy objective of increasing R&D intensity should not simply be translated in a dual approach of increasing inward investments and decreasing outward investments. Outward investments by domestic MNCs can also make a home economy stronger, e.g. through reverse technology transfer.⁸⁵

How to strengthen the attractiveness of the Netherlands for business investments in R&D? Our analysis also suggests that policy should distinguish between stimulating and attracting investments in research and those in development. Research investments are to a large extent knowledge driven (section 3.3), whereas development investments are mainly market driven (section 3.4).⁸⁶ While national governments have a broad mix of policies and instruments to strengthen the knowledge investment climate, the development of global markets is to a large extent beyond the direct control of national governments.

85 See Guimón (2011).

86 It should be noted that location decisions of research investments and development investments are not completely independent, as firms may seek to co-locate research and development in order to speed up innovation processes. In that case, the location drivers that are typical for research become important for development as well – and vice versa. Furthermore, the location of research may also be driven by access to 'lead markets' where innovations that are new to the world are adopted for the first time.

There are at least three main approaches to increasing the R&D intensity of the economy: (1) stimulate domestic firms to spend more on R&D in the domestic economy; (2) stimulate foreign firms to spend more in the domestic economy; and (3) stimulate technology-based start-ups.⁸⁷

In Table 2 we summarise for the two globalisation patterns of research and development the main location drivers, the potential causes for policy concern, the competitive arenas for countries and regions, and the competitive assets that are key in this global competition for foreign investments in research and development.

The competitive arena for internationally mobile investments in research is different from the arena for investments in development. With regard to the first, a further distinction should be made between investments in large global research hubs and in smaller auxiliary research centres. MNCs that seek a location for a (consolidated) global research hub look for the best locations within a main geography (e.g. EU, USA or Asia). For the Netherlands, the competitive arena for attracting and retaining strategic research centres of foreign MNCs is Europe; in particular Northwest Europe where the quality of the knowledge infrastructure is at a comparable level. When locating their auxiliary, specialised research centres, MNCs seek access to distinctive hotspots. The competitive arena for the Netherlands in attracting these smaller centres is global.

With regard to international investments in development, MNCs seek to locate development centres in their main markets. As an integral part of the single European market, the Netherlands usually competes with other EU-countries to attract investments in development.

87 These start-up firms may evolve into new technology powerhouses themselves, although this does not occur often. They can also attract foreign investments of venture capital funds or MNCs that invest in or acquire high-potential startup companies as part of their innovation strategies. Startup companies also 'rejuvenate' ecosystems and make them more attractive as a location for research and development in a broader sense.

Table 2 Summary of location drivers, causes for policy concern, competitive arenas and competitive assets in those arenas

Globalisation	Research	Development
Main location drivers	<ul style="list-style-type: none"> • Access to external knowledge sources (universities, start-ups, suppliers, etc.) • Access to researchers • Inherent inertia of long-established labs • Economies of scale and scope • Concerns relation to intellectual property (and leakage) 	<ul style="list-style-type: none"> • Access to markets (customers, suppliers) • Access to engineers and technical personnel • Proximity to other business functions (e.g. manufacturing and research) • Efficiency gains (wage cost reduction) • Legal requirements of host country
Cause for concern	<ul style="list-style-type: none"> • Inward and outward business investments are indicative of the attractiveness of a country in terms of science and technology. • Inherent inertia of long-established research labs may conceal weaknesses in location factors in the long term 	<ul style="list-style-type: none"> • Inward and outward investments are indicative of the attractiveness of a country in terms of market prospects and ecosystems of supply chain partners. • Outward investments could be interpreted negatively but can also indicate the strength of domestic firms in the global market
Competitive arena	<ul style="list-style-type: none"> • Countries/regions in Northwest Europe (for core research labs or 'global hubs') • The world (for specialised, auxiliary centres or 'ports') 	<ul style="list-style-type: none"> • Countries/regions in European market⁸⁸
Competitive assets (focus point for policy attention)	<ul style="list-style-type: none"> • The quality of the knowledge infrastructure • The quality and quantity of human resources in science and technology • The opportunities for public-private partnerships • Capacity to generate and scale technology-based start-ups 	<ul style="list-style-type: none"> • Innovation-friendly markets (e.g. lead markets, innovation-friendly regulation) • Distinctive clusters with attractive (potential) value chain partners • The quality and quantity of human resources in engineering and technical professions • Attractive conditions for advanced manufacturing (e.g. smart industries)

Rathenau Instituut

In the next section we discuss the specific competitive assets that shape the competition between countries and regions in the globalisation of research and development. These competitive assets are the focus points for policies that aim to retain and attract R&D investments.

5.2 Policy focus points

Initiatives and policy measures to improve the attractiveness of a country (or region) as a location for research and/or development should focus on strengthening their specific location drivers.⁸⁹ Specific location strengths are competitive assets in the international competition for such investments.

88 The Netherlands is part of the single European market (and thanks to its 'mainports' (e.g. the Rotterdam harbour and Schiphol airport) an important gateway to this European market).

89 In section 4.3 we discussed how R&D investment location decisions are always part of broader business considerations. Specific location drivers for research or development do, however, play a key role if only when MNCs seek to consolidate their research or development functions.

5.2.1 Strengthening location drivers for research

The quality of the Dutch knowledge infrastructure is a main competitive asset in the battle to retain and attract business investments in research. Universities and research institutes are important ingredients of this infrastructure. Not only as knowledge producers, but also as key actors in attractive ecosystems where technology-based start-ups and specialised, innovative suppliers can thrive. Universities, start-ups, and other specialised suppliers and firms can be attractive knowledge partners for MNCs.

The quality and quantity of human capital in science and technology is also a key asset. Obviously, universities play a crucial part in this as well. The alignment of academic training with business needs can create a distinctive location strength (or prevent a location weakness caused by a shortage of well-trained human capital).

The knowledge infrastructure should also be accessible for companies that seek to source external knowledge. Such accessibility can be organised and stimulated in many different ways, each with their own merits.

5.2.2 Strengthening location drivers for development

A main competitive asset in the international competition for business investments in development is the presence of attractive markets. In the Netherlands, the home market is inherently small. The Dutch market is however, part of the single European market, which offers better opportunities for the Netherlands as ‘the gateway to Europe’. The relative small size of the home market should not deter the Netherlands in attracting foreign investors that seek access to specific lead markets, where innovative products, processes or services are brought to– and co-developed with – the market for the first time. In such cases, the market is an important source of knowledge, which might also attract investments in research, not just development.⁹⁰ In the last decade, demand-side innovation policy has received more attention. A core element of such policies is that governments use innovation-friendly regulation and/or use their buying power to stimulate market developments that attract investments in innovation.

A second focus point for development policy is the presence of distinctive clusters or ecosystems with suppliers and other specialised firms.⁹¹ Especially in industries with fragmented value chains, co-location with key partners in the supply chain and an open innovation culture can be a strong asset.

A third focus point is the quality and quantity of human capital at the level of vocational training and polytechnics. Universities of applied sciences play a key role in this asset.

90 For example, the government of Singapore has launched a plan to become the world's first ‘smart nation’ to become the place-to-be for these innovative developments. (<http://www.ida.gov.sg/Infocomm-Landscape/Smart-Nation-Vision>).

91 Note that attractive clusters or ecosystems are also an asset in the competition for investments in research. Both types of investment (in R and D), are attracted by different types of ecosystems. See AWTI (2014) for a typology of hotspots.

Finally, the presence of advanced manufacturing operations can be a strong asset. Complex production activities attract development activities (and vice versa).

5.2.3 A distributed responsibility

Strengthening the competitive assets for retaining and attracting investments in research and development cannot be the sole responsibility of the central government. Many actors have to be enrolled in order to implement an effective approach. Regional and urban governments should play a role, as well as actors from the knowledge infrastructure (e.g. research universities and universities of applied sciences) and businesses. In chapter 7 we will elaborate on this coordination challenge.

5.2.4 Promoting location strengths abroad

The Netherlands should not only aim to develop distinctive location strengths for investments in research and development, it should also promote these strengths abroad. Potential investors must be made aware and convinced of the specific strengths of the Netherlands as a location for research and development investments. In Chapter 8 we will elaborate on this further.

5.3 In conclusion

It is beyond the scope of this report to discuss all the angles and issues associated with creating and promoting location strengths or competitive assets.

In the next chapter, we will first discuss what constitutes an attractive knowledge infrastructure from the perspective of globalisation. We will focus on issues that were brought up in our interviews with R&D leaders in technology-based multinational firms in the Netherlands and that we considered relevant in view of our study of the literature and analysis of R&D statistics.

In Chapter 7 we will discuss how strengthening location strengths for investments in research and development requires a multi-actor approach. The challenge is to overcome fragmentation and 'provincialism' in making the Netherlands an attractive location for research and development.

Chapter 8 discusses foreign investment promotion policies, specifically targeted at investments in research and development.

6 An attractive knowledge infrastructure

The quality of research is a key component of an attractive knowledge infrastructure. But what does 'quality' mean in the eyes of international investors in research? How do they assess the quality of research, research groups or research universities? In section 6.1 we discuss quality of research as a competitive asset. In section 6.2 a second aspect of the attractiveness of the knowledge infrastructure: its connectivity with industry. In section 6.3 various other dimensions that determine the attractiveness of the science system for global investors.

6.1 What is a high-quality knowledge infrastructure?

From our interviews, it became clear that we need to reconsider what constitutes 'high quality' research as perceived by industry. It is not helpful to make a simplified contrast between fundamental research where 'excellence' is a main criterion and application-oriented research where 'utility' is a main criterion. This type of compartmentalisation can be seen in the programmes offered by research councils, for example. The suggestion in this dichotomy is that the performance in 'free' curiosity-driven research is the decisive factor in the quality of the knowledge infrastructure. Application-oriented or demand-driven research then appears as a threat to the quality of the knowledge infrastructure.

Business investors do not necessarily equate the utilisation perspective of research with quality. They take a more differentiated view. They need access to different types of scientific research ranging from basic disciplinary research to application-oriented multidisciplinary research. As we have seen in section 3.3, MNCs have strategic hubs as well as smaller research centres in order to fulfil their varied knowledge needs. It follows that a high-quality knowledge infrastructure should cater for different types or modes of research.

Responding to the globalisation of business R&D does not mean that universities should turn themselves into research contractors for large companies that want to outsource research. Nor does it mean that all universities have to focus much more on 'science for competitiveness' and 'science for society', at the expense of 'science for science'.⁹² Instead, the knowledge infrastructure should accommodate and foster both structural partnerships with (proximate) core labs of MNCs as well as cutting-edge basic research that contributes to development of distinctive science-based regional hotspots.⁹³

92 The distinction between the types of research is used in the Horizon 2020 framework programme of the EU and in the Science Vision 2025 in the Netherlands. 'Science for competitiveness' refers to research aimed at the development of the technologies and innovations (e.g. in ICT, nanotechnology, advanced materials, biotechnology, advanced manufacturing and processing) that will underpin tomorrow's businesses and help innovative SMEs to grow into world-leading companies. Industry sets the agenda. 'Science for society' refers to challenge-driven research that combines resources and knowledge across different fields, technologies and disciplines in order to develop innovative solutions for societal challenges. 'Science for science' refers to academic research where the agenda is determined by scientific community.

93 See AWTI (2014) for a typology of hotspots.

‘Science for science’, i.e. investigator-driven, long-term basic research in promising emerging areas of science and technology, remains crucial for attracting business investments. In a direct sense because science-based industries are looking for leads for innovation, and also indirectly, because it helps to attract the best students and scientists in a specific field from all over the world. This in turn helps to attract the interest of science-based firms who want to keep track of the latest developments in a particular field, and who are looking to recruit the best and most talented students and researchers. The presence of world-class universities or research groups helps to strengthen the reputation of a country or region as a ‘place to be’ for research.⁹⁴

In considering what constitutes an attractive knowledge infrastructure, the answer is that the attractiveness is determined by what it has to offer in ‘science for science’ and ‘science for competitiveness’ and ‘science for society’.

A practical consequence of this broad view on the attractiveness of university research and the quality and quantity of human capital is that researchers and research groups in the science system must be able to partake in the international frontlines of scientific research, in particular in research areas that are considered strategically important for the future of the Netherlands as a ‘knowledge-based economy’. The conditions for scientific research should thus be sufficiently attractive to retain and attract the best researchers worldwide. This means, *inter alia*, that public investments in science should be at an internationally competitive level and research facilities should be state-of-the-art.

6.2 Connectivity of the knowledge infrastructure

In the era of global open innovation, firms need to collaborate with knowledge partners. Universities can be important partners in research and innovation. The intensity and form of collaboration varies between different industries, depending on the nature of their technology base (e.g. high-tech or low-tech). Since the 1980s, successive generations of Dutch research and innovation policies have aimed to improve the connection between academic research and industrial innovation. Recent examples are the ‘top consortia for knowledge and innovation’ (TKIs) that have been set up as part of the current top-sector policy. The TKIs are vehicles for public-private collaboration based on joint innovation agendas and roadmaps. Other examples include the FOM Industrial Partnership Programme (IPP)⁹⁵ and the STW Partnership Programme.⁹⁶ Such initiatives have contributed to changing the research culture within universities, making academic researchers more open to public-private collaboration.⁹⁷ The

94 World rankings of universities play a role here in signalling where the ‘best’ universities are. There is a lot of debate about the value and trustworthiness of these rankings. In practice, however, these rankings do have an effect on decisions of internationally mobile students, researchers and investors. This suggests that universities and science policy cannot ignore such rankings.

95 The Foundation for Fundamental Research on Matter (FOM) is part of the research council NWO and funds fundamental physics research. The IPP aims to reconnect academic and industrial research in physics. Intensive collaboration between FOM researchers and researchers from industry is at the core of the IPPs. One of the pillars of the IPP is regular personal contact between the researchers, preferably involving internships and/or research activities on site. (http://www.fom.nl/live/english/valorisation_and_industry/collaboration_with_companies/ipp/ipp.pag).

96 The Technology Foundation STW is part of the research council of NWO and funds technical sciences. (<http://www.stw.nl/en/financieringsinstrumenten/partnership-eng>).

97 See OECD Innovation Review of the Netherlands 2014 (OECD 2014c), and also indicators on co-publication and co-inventorship in patents.

technology-based firms we interviewed found this a strong feature of the Dutch knowledge infrastructure.

As we have discussed in the previous section, firms – especially large technology-based MNCs – have varied knowledge needs. To meet these needs, firms need varied modes of knowledge sourcing. With regard to knowledge sourcing from research universities (and other public research institutes), various modalities of public-private collaboration can be used. For research that is close to the core technological assets of a firm, bilateral or small, closed consortia can be appropriate. Broad and open consortia can be appropriate for precompetitive research. For collaboration in explorative basic research, the involvement of firms may be limited to membership of steering committees or programming boards. In the case of more applied research, industry involvement may be more intensive in terms of financial contribution and the (joint) execution of research.

What we learnt from our interviews with technology-based MNCs in the Netherlands is that the mode of strategic public-private partnership can be particularly effective in anchoring the research labs of MNCs to the national economy. Such partnerships are usually based on joint multiannual research and innovation programmes or long-term roadmaps. Typically it involves facility sharing, exchange of research staff and joint projects. Proximity or co-location facilitates such in-depth collaboration. Therefore, MNCs seek to locate their research centres nearby universities (e.g. on university campuses)⁹⁸, or attract research groups to co-locate with them (e.g. on technology campuses).⁹⁹ Unilever, for example, seeks partnerships with carefully selected leading academic centres around each of Unilever's six global strategic sites to form a dedicated innovation ecosystem. Universities and institutes are chosen for their expertise and capability in fields of science that complement Unilever's scientific priorities.¹⁰⁰

For some knowledge needs, bilateral public-private partnerships or programmatic research collaboration in consortia are not sufficient. To address complex technological problems, mission-oriented research institutes with sufficient mass and long-term perspective are needed. Guided by a clear mission, these types of institute allow for in-depth collaboration between various disciplines and can connect long-term basic research to shorter-term applied research and development activities. Such institutes do not suffer from the typical problems that may hamper industry-university collaboration, including differences in research cultures, organisation and incentives structures. We learnt from our interviews that the disciplinary organisation within university faculties and the bias in the academic incentive structure towards scientific publications, are considered bottlenecks for more intensive collaboration. When firms face complex innovation challenges that need complex solutions and require multidisciplinary approaches, universities are usually not able to meet such demands from industry. Mission-oriented research institutes are better suited for that purpose.

98 Examples are Danone (University of Utrecht) and FrieslandCampina (Wageningen UR).

99 An example is a research group of the Dutch Foundation for Fundamental Research on Matter (FOM) that have co-located themselves with Philips Research on the High Tech Campus in Eindhoven to facilitate close cooperation. See "Philips and Foundation for Fundamental Research on Matter renew successful LED research partnership" (<http://www.newscenter.philips.com/main/standard/news/press/2014/20140122-successful-led-research-partnership-from-the-foundation-for-fundamental-research-on-matter-and-philips-to-be-continued.wpd#.U-DyTHbN00k>).

100 "Unilever in partnership with UK universities: working together in pursuit of sustainable scientific progress" (<http://www.ncub.co.uk/sor14/unilever-sor.html>)

Textbox 12 Two examples of mission-oriented research institutes in the Netherlands

ARCNL, Amsterdam Science Park

A good example of a new strategic form of industry-university collaboration is the Advanced Research Center for Nanolithography (ARCNL) in the Netherlands. It is an initiative of the semiconductor equipment manufacturer ASML together with: the research council NWO; the Foundation for Fundamental Research on Matter (FOM, part of NWO); two universities in Amsterdam (UvA and VU); and the City of Amsterdam. The new centre was located on the Science Park in Amsterdam where a lot of knowledge production in science and engineering is already concentrated. In the Dutch research landscape, it is a new type of mission-oriented research organisation. It has deliberately not been set up as a 'virtual' institute – a common feature of the Dutch system – but as a physical institute with its own staff. The ambition is to perform world-leading basic research on the fundamental physics involved in current and future key technologies in nanolithography. Based on its scientific quality and the attractive conditions for research, it aims to attract the best scientists in the field.

QuTech

QuTech is the quantum institute of TU Delft and the Netherlands Organisation for Applied Scientific Research (TNO). It was founded in 2013. The primary focus of QuTech is the development of quantum technology, such as inherently secure quantum network connections and quantum computers. The institute managed to attract substantial investments from Microsoft and Intel. In September 2015 Intel announced a 10-year collaborative relationship and an investment of US\$ 50 million. Intel will provide engineering resources both on-site and at Intel, as well as technical support.¹⁰¹ Because QuTech needs great students with the drive and talent to help them accelerate the effort to build a quantum computer and a large-scale quantum Internet, the QuTech Academy was established. It is the first in mainland Europe to offer a targeted programme in the area of Quantum Technology and Quantum Information.

Textbox 13 Wyss Institute, Harvard: mission-oriented research institute (USA)

An international example of a new model in mission-oriented research is the Wyss Institute at Harvard.¹⁰² The Institute focuses its research and development efforts on six enabling technology platforms to create new bio-inspired materials and devices, and to translate them into products. The mission is to develop biologically inspired materials and devices that will solve critical medical and environmental problems and to translate these transformative technologies into products that have an impact on society and the world. The Wyss model is based on high-risk groundbreaking research, transdisciplinary research in so-called 'collaboratories', and translating the most promising ideas into

101 See http://newsroom.intel.com/community/intel_newsroom/blog/2015/09/03/intel-invests-us50-million-to-advance-quantum-computing.

102 See <http://wyss.harvard.edu/>.

transformative products by validating them against market needs, and developing product prototypes through collaborations with clinical champions, corporate alliances, and new start-ups. The ambition of the Institute is to break down disciplinary barriers by bringing together world-leading researchers, theoreticians, and technical staff with clinicians and industrial collaborators, creating an environment that facilitates synergy among these investigators.

The connectivity of the knowledge infrastructure is a key competitive asset in retaining and attracting business investments in research. Companies have different knowledge needs and need various modes to link up with the knowledge infrastructure. While the Netherlands has a rich history of promoting and organising public-private collaboration in research and innovation, the challenge is to remain innovative and distinctive in enabling and fostering these public-private connections. Strategic partnerships and mission-oriented research institutes can be a key element in this because they fit with contemporary innovation strategies of MNCs. Such modes of collaboration go beyond co-funding of research projects under a shared programme or in a temporary virtual research institute (as, for instance, in the current 'top consortia for knowledge and innovation' (TKIs)).

The strategic asset of knowledge structure connectivity can be strengthened if the governance system is changed in such a way as to afford and induce mission-oriented research and strategic partnerships with industry. For example, technology-based firms perceive the career paths and incentive structures currently within universities as barriers to strategic connection. Conventional approaches to the evaluation of research quality and academic career development over emphasise the importance of publications in scientific journals and their citation impact. This creates a bias towards disciplinary research, because it offers the best prospects for publication in high-impact journals. It creates a disincentive for multidisciplinary and application-inspired research, because this type of research is more difficult to get published in leading journals. Therefore, to foster strategic connections with industry, more appreciation is needed for research that is oriented at solving problems of industry and society.¹⁰³

6.3 Knowledge infrastructure: the many sides of attractiveness in a global R&D investment perspective

The attractiveness of the knowledge infrastructure in the eyes of business R&D investors is not only determined by the quality of the knowledge it produces and its connectivity, there are additional dimensions.

103 It is therefore a positive sign that The Science Vision 2025 of the Dutch cabinet recognises that a more balanced approach to research evaluation is needed to reduce the bias towards publications in high impact scientific journals and create more incentives for other products and contributions of scientific research. (<https://www.government.nl/documents/reports/2014/12/08/2025-vision-for-science-choices-for-the-future>).

Firstly, the capacity to generate technology-based start-up companies. Young innovative firms have become increasingly important as a source of innovation and industry renewal. They tend to attract the attention of MNCs looking for opportunities to collaborate or invest. Many MNCs have become active in corporate venturing. The Dutch science-based company DSM, for example, actively invests in start-up companies creating innovative products and services in health, nutrition and materials. They collaborate with start-ups in order to explore emerging markets and technologies.¹⁰⁴

These young innovative firms also contribute to the vitality and attractiveness of innovation ecosystems as they challenge existing businesses and business models. They may grow into large multinational companies, or they can remain relatively small and become highly specialised knowledge-intensive service providers that support other firms in the innovation ecosystem.

Universities can – and are expected to – play a valuable role in this dynamic. They can be the source or incubator of start-up companies that are based on intellectual property that has resulted from university research. In particular, ‘entrepreneurial’ universities aim to stimulate an entrepreneurial attitude of students and university staff. Also, through their university campuses, science parks, valorisation centres and innovation labs,¹⁰⁵ they create an attractive climate for investments in research and innovation.

While it is beyond the scope of this report to elaborate on the role of young fast-growing innovative firms in the globalisation of R&D, it is clear that the capacity of the knowledge infrastructure to generate innovative start-ups is a strategic asset in the international competition for investments in research and development. A vibrant entrepreneurial climate contributes to the attractiveness of a country (or region) as a location for business research and innovation. One challenge for policymakers is how to root the new technology-based firms in the home country (or region), especially when foreign investors (large MNCs or venture capitalists) are involved. Moreover, such companies are becoming mobile at a much earlier stage in their life cycle and need presence in international markets in order to grow. Entrepreneurs are looking for the best start-up location from which to grow global businesses. This underpins the need for policy to promote attractive ecosystems that offer access to knowledge, skills, finance, innovative suppliers and customers.

The knowledge infrastructure is an important supplier of attractive talent pools of skilled researchers. Indeed, the researcher training function of universities is very important for firms, especially for firms that rely on research for their innovativeness and competitiveness. They need to scout and recruit the best graduates and therefore enter into various forms of collaboration with universities, including participation in public-private research programmes, funding of chairs in selected universities, participating in curricula, etc. Such arrangements are facilitated by geographical proximity between industry and university. When a national education system cannot deliver sufficient graduates with skills and competences that are relevant from the perspective of industrial research and innovation, the country becomes less

104 See <http://www.dsm.com/corporate/about/innovation-at-dsm/open-innovation.html>.

105 The ‘Innovation Lab’ of the TU Eindhoven, for instance, formulates as its ambition to develop an ecosystem around the university that is aimed at sustainable collaboration with SMEs and industry. (<https://www.tue.nl/innoveren/over-innovation-lab/partnerships/>).

attractive as location for industrial research. If most of the research staff has to be recruited from abroad, the reason to stay in that particular country or region diminishes. Governments that aim to attract and retain industrial research should therefore have policies in place that ensure that university education and training is sufficiently aligned with the needs of (domestic) industrial research both in terms of quality and quantity.

A similar argument can be made with regard to the attractiveness for investments in development. In this case, universities of applied sciences are important suppliers of talent pools of engineers and technical personnel. In order to strengthen this aspect of the knowledge infrastructure, regional actors are key partners.

Universities also act as an access point or portal to relevant knowledge bases and international knowledge networks. Scientific research is a global enterprise and academic researchers operate in international networks. By creating linkages with well-positioned researchers, firms can get access to these global knowledge networks, which helps them to stay informed of relevant developments in science and technology and to identify valuable sources of codified as well as 'embrained' knowledge.

In the agrifood sector, for example, the Wageningen University & Research Centre (WUR) acts as a hub in global knowledge networks. The WUR is well connected to research production that occurs across the globe. The WUR's truly international student population and alumni network obviously helps to develop and maintain these linkages. This makes it attractive for firms to locate their research in the proximity of the WUR, e.g. on its campus.

From the perspective of universities as access points to global knowledge networks, universities should have a strong presence and effective integration into worldwide research networking and transfer.¹⁰⁶ As research and innovation have become globally dispersed, the 'absorptive capacity' of national research and innovation systems has become increasingly important: universities and other public research organisation need to be able to absorb knowledge produced elsewhere and transfer it to domestic firms. Knowledge circulation and absorption are as important as knowledge generation.¹⁰⁷

106 See Frieder Meyer-Krahmer and Reger (1999).

107 See WRR (2013).

7 Acting as one region in Europe

The globalisation of R&D enhances the importance of regions because investments tend to cluster in regional hotspots. Strengthening the location drivers for research and development requires a coordinated policy approach between governments at multiple levels – together with other stakeholders. This chapter first discusses the role of regional and metropolitan governments in the globalisation of R&D. Secondly, we discuss the coordination challenge of creating alignment in the complex policy landscape of the Netherlands.

7.1 The prominent role of regions

Many of the competitive assets in the international competition for business investments in research and development have a spatial dimension. Connections are fundamental for enabling open innovation in global networks, therefore proximity between knowledge partners is advantageous. Agglomeration effects further enhance the importance of proximity. Investments in research and development cluster in regional hotspots underpinned by specialised innovation ecosystems with innovating companies, knowledge institutes and other organisations. Such hotspots are a magnet for investments in research and innovation.¹⁰⁸ Well-known international examples of leading regional innovation ecosystems are Silicon Valley in California, the Boston Area in Massachusetts, Waterloo in Canada, the Paris region and Grenoble High Tech Campus in France, Singapore's Biopolis, etc. Such 'hotspots' play an important role in the global R&D footprint of MNCs, not only for the location of their core research labs (global hubs) but also for their smaller specialised research centres (ports) and development centres.

As a consequence, regional and metropolitan authorities play a prominent role in developing distinctive competitive assets in the international competition for business investments in research and development.

The Netherlands has to compete with the large metropolitan areas around Paris, London, Munich etc. Dutch regions by themselves are usually not large or powerful enough to compete with such large urbanised agglomerations. This suggests that Dutch regions should capitalise on the unique polycentric urban structure and the relatively small geographic distances between regions in order to exploit complementarities.¹⁰⁹ Creating linkages between complementary regional strengths is as important as the regional strengths themselves.¹¹⁰ From a globalisation perspective, it makes sense to bundle regional location strengths and act as a single knowledge region in Europe. This presents a major coordination challenge for policymakers at municipal, provincial and national levels and for other stakeholders in the Dutch innovation system.

108 See also the recent advisory report of the AWTI (2014).

109 See OECD (2014d).

110 See Otto Raspe et al. (2012a).

7.2 A coordination challenge

In the Netherlands, we see a proliferation of regional policies and initiatives that has led to fragmentation.¹¹¹ The increasingly prominent role of regional and metropolitan governments in the Netherlands is backed up by substantial policy budgets.¹¹² In part this is because several provinces sold their shares in energy companies and intend to use these revenues to stimulate knowledge-based economic development in their own regions. Another factor is the European Commission's regional policy and the European Fund for Regional Development (EFRD). This is designed to stimulate regions to develop 'smart specialisation strategies' in which research and innovation play a central role.¹¹³ A result of the increased attention and budgets of regional governments for research and innovation policy is a proliferation of governance structures, policies and measures. It has led to many 'valleys', technology campuses and other regional cluster initiatives that are being promoted individually.¹¹⁴ Some regional and metropolitan governments have become active in setting up new research institutes, for instance the province of Limburg and the city of Amsterdam. Often, however, these initiatives have subcritical mass from a global perspective.¹¹⁵ There is a degree of 'provincialism' as regions nurture their own initiatives. A proliferation of locally defined and demarcated valleys is not conducive to creating internationally distinctive competitive assets in the international competition for business investments in research and development.

It is easy to understand how provincialism without regard for national interests could emerge. The first concern of regional governments is their own region rather than the country as a whole. Moreover, they have a large degree of autonomy and have their own priorities, policy agendas and policy mixes. Regions tend to focus on their own regional strengths within their jurisdictional borders. There is also a level of competition between regions in creating a favourable climate for research and innovation and in attracting business investments.

Central government has a largely decentralised regional economic policy and has refrained from including an explicit spatial strategy, notably in its 'top-sector' policy. National top-sector policy does not have an explicit vision on where innovation clusters should be concentrated and how this should be orchestrated in order to stimulate strong agglomerations and linkages between regional strengths.¹¹⁶

Fortunately, regional and national governments are now recognising there is a need for better coordination. Recently, the Dutch national government and the four EFRD-regions (North, East,

111 This section is based on interviews with policymakers, a desk study of policy documents and on a study by Bodewes Beleidsadvies for this project. (Bodewes Beleidsadvies, 2014).

112 In the annual overview of the 'Total Investment in Research and Innovation' by the Rathenau Instituut, it is estimated that up to EUR 100 million was expended on knowledge and innovation at regional level in 2014. It is added that that amount will increase sharply in the coming years. The most important reason for this is because early 2014 marked the beginning of a new period of European funding for 2014-2020, as a result of which new programmes did not start until late 2014/early 2015. (Van Steen, 2015).

113 Regions need to develop a vision and strategy in which they identify their competitive advantage, set strategic priorities and use policies to maximise the knowledge-based development potential of their region. (See <http://s3platform.jrc.ec.europa.eu/home>).

114 A few examples of such regional valley include the Energy Valley in Groningen, the Food Valley in Wageningen, the Health Valley in Nijmegen, the Maintenance Valley in West- and Mid-Brabant, the Utrecht Science Park and nanotechnology in Twente and Delft.

115 See the inventarisation of campus initiatives by Buck Consultants International for the Dutch Ministry of Economic Affairs (Buck Consultants International, 2014).

116 See OECD (2014d).

South, and West) signed an agenda for collaboration to strengthen the connection between national top-sector policy and the regional policy.¹¹⁷ This may be a first step towards a more productive alignment of national and regional policy initiatives in creating internationally attractive ecosystems. The collaboration is, however, driven more by the need to make the cluttered offering of innovation policy instruments and public services more accessible, transparent and efficient for small and medium-sized companies (SMEs) rather than to create international hotspots.

In addition to a lack of a national spatial strategy, national science and innovation policies tend to suffer from an inward bias. Dutch top-sector policy, for instance, pays considerable attention to stimulating domestic firms to collaborate with national knowledge institutes, but much less attention is paid to stimulating cross-border R&D collaboration and attracting foreign R&D parties. The sectorial perspective reinforces this bias, because it does not capture the reality of fragmented global value chains and the need for cross-sector innovations to address societal challenges.

Dutch top-sector policy focuses on prioritised economic sectors in which the Netherlands has strengths in both science and industry. Nine sectors have been identified: agrifood, horticulture and propagation materials, high-tech, chemistry, water, energy, life sciences, logistics, and the creative industry. For each of these sectors, a specific and integral approach has been developed in order to support them in strengthening their international competitiveness. Stakeholders from the top-sectors (private and public) led the way in developing agendas or roadmaps for research and innovation, human capital and internationalisation.

The focus of top-sector policy is on strengthening connections between domestic firms and the national knowledge infrastructure. In other words, the home country perspective is dominant in top-sector policy. It certainly makes sense to focus on anchoring research centres of domestic (large) firms to the Dutch knowledge infrastructure. But at the same time, we have argued this cannot be the only answer to increasing the R&D intensity of the Dutch economy. There are two other routes to increasing R&D investments in the Dutch economy: via foreign investments, and technology-based start-up companies, but they receive less attention. The inward investment or host country perspective would have to play a more prominent role. Our analysis of the globalisation of research and development suggests that the emphasis should be more on strengthening the international attractiveness of the Netherlands as a location for research and development (in prioritised innovation domains and niches in global value chains), and less on inducing domestic firms to increase their R&D expenditures by aligning the knowledge infrastructure to their needs.

Furthermore, our analysis of globalisation of research and development also suggests that top-sector policy should pay more attention to the spatial dimension. Top-sector policy was developed without much regard for the role spatial clustering plays in R&D investments. In view of the importance of internationally visible hotspots and attractive metropolitan areas as magnets for foreign investments in research, a more explicit spatial dimension and stronger connections between national and regional policies would make sense. In comparison with the main competing countries, the Dutch regions are too small to compete on their own. Promoting

117 Letter to Parliament by the Dutch Minister of Economic Affairs (TK 29697, nr. 18 , 11 December 2014).

the attractiveness of the Netherlands and its hotspots as a location for research and development would benefit from a coordinated strategy of all relevant stakeholders, including the various levels of government.

Stimulating firms – whether domestic or foreign, established or new – to invest in R&D in the Netherlands requires a sharper focus on distinctive strengths from an international perspective. In practice, resources are spread over all business sectors and actors.

Another example of how national policies have not yet fully incorporated the implications of globalisation of research and development can be found in Dutch science policy. Dutch universities are expected to differentiate themselves vis-à-vis other universities in the national science system, rather than to rethink the organisation of the Dutch science system from a globalisation perspective.

The Dutch government has asked universities to develop profiles that help to signal distinctive strengths in research (and education and valorisation) for the various stakeholders, including students, researchers, firms and others. The primary objective of the profiling appears to be to create more differentiation within the Dutch university landscape. In view of the importance of attracting foreign investments, the objective should not be to make Dutch universities more distinctive vis-à-vis each other but to make the Dutch science system as a whole more distinctive and attractive in a European or global landscape. Different solutions would then emerge. The strengths of universities via mergers or alliances could be combined. Should the Netherlands create a few universities that are visible as ‘excellent’ in international university rankings?¹¹⁸ Currently, Dutch universities are in the sub-top rather than among the very best world-wide. Although there is much debate regarding the usefulness and value of such rankings, in practice, they appear to have an influence on location decisions of internationally mobile students, researchers and businesses. It could be argued that in the context of global competition for the location of research investments and the ‘war for talent’, it would be sensible to strive for one or a few universities to become visible as ‘world-class’ in international rankings.¹¹⁹

To enhance the attractiveness of the Netherlands as location for investments in research and development, all stakeholders in the Dutch innovation system should join forces: i.e. ministries and their agencies, regional and metropolitan governments and their agencies, triple-helix organisations, MNCs, SMEs, universities, knowledge institutes and others.

118 Examples of such rankings are the Academic Ranking of World Universities (Shanghai ranking) (with Utrecht University as highest Dutch university at 57th position in 2014), the Times Higher Education World University Rankings (with Leiden University as highest Dutch university at 64th position in 2014-2015), the CWTS Leiden ranking (with Leiden University as highest Dutch university at 53rd position in 2014), the British QS World University Rankings (with University of Amsterdam as highest Dutch university at 50th position in 2014/15).

119 Note that improving the visibility of the quality of the Dutch science system is not the same as improving the quality of it. For instance, virtual integration of several universities would already lead to higher positions in rankings.

A starting point for creating productive coordination arrangements is that regional hotspots are underpinned by innovation ecosystems that spread across provincial jurisdictions.¹²⁰ In the Netherlands, there is no straightforward 1:1 match between ecosystems and regions. Most innovation ecosystems concentrate in more than one region and regions often specialise in more than one ecosystem. A particular ecosystem may thus be important for several regions and several ecosystems may be relevant for one region. Therefore, ecosystems tend to transcend the scale of regional-level decision-making.

The high-tech cluster in the province of North-Brabant, for example, is based upon a high-tech ecosystem with branches in the metropolitan area of Amsterdam, the province of Limburg, the region of Twente, and elsewhere. A second example is the Dutch global hotspot in agriculture and food. It has its centre of gravity in Wageningen (with the Wageningen University & Research Centre). The 'Food Valley' has, however, a hinterland that goes far beyond the region Ede-Wageningen or West-Gelderland, and goes as far as the Randstad, Noord-Brabant and Gelderland.

Collaborative policy arrangements should be based on the underlying flows of knowledge in cross-regional ecosystems, in the same vein as the age-old Dutch Water Boards are based on flow areas or rivers that may span several municipalities and provinces. What seems appropriate, therefore, are (virtual) 'Knowledge Boards' that can offer a platform for various policymakers at multiple levels and other stakeholders to coordinate their policies.

The shared ambition should be to create competitive assets that make a difference in the international arenas for investments in research and development. Different assets matter in different arenas. This should be reflected in the coordination arrangements that are developed and the parties that are involved. To strengthen location drivers for investments in development, for instance, universities of applied sciences and regional triple-helix organisations are important parties.

¹²⁰ An underlying question is: what is the scale of an internationally attractive innovation ecosystem or hotspot? (i.e. how many provincial borders does an ecosystem cross?) While there is no one single answer to this question, a pragmatic rule is that parties have to be able to meet face-to-face on a regular basis to allow for knowledge sharing and in-depth collaboration. This means that maximum distance between parties should not exceed 1 to 2 hours travel time. While the core of an ecosystem may be the size of a campus (where people may meet "around a coffee machine"), the ecosystem may stretch across approximately 100-150 km.

8 Promotion of foreign investments in R&D

The globalisation of R&D enhances the competition for foreign direct investments in research and development between countries and regions. Governments not only have to ensure that their competitive assets in this competition are as strong as possible, but also that they are known and recognised as strong and attractive by potential R&D investors. In this chapter we discuss the challenges for policy in developing and implementing an effective foreign R&D investment attraction policy.

8.1 Together we're strong

Creating internationally attractive hotspots (underpinned by cross-regional innovation ecosystems) requires a coordinated, multilevel approach of various stakeholders. A similar need for coordination and collaboration exists with regard to the promotion of distinctive location strengths in research and innovation abroad.

Investment promotion agencies play an important role in investment promotion and attraction policy. The main functions of these agencies cover the image building of the host country, pre-investment services (advice, information and assistance for potential foreign investors), and post-investment services. Instruments include marketing campaigns, economic missions, seminars and tailored services to foreign investors in R&D. In the Netherlands, the Netherlands Foreign Investment Agency (NFIA) is the investment promotion agency at the national level.¹²¹ At the regional level the Regional Development Agencies (RDAs) play a similar role. Four RDAs have been set up with support from the Ministry of Economic Affairs: the NOM for the three provinces in the North, Oost NV for the two provinces in the East, the BOM for the province of Noord-Brabant, and the LIOF for the province of Limburg.¹²²

National and regional governments play complementary roles. They need each other in developing distinctive propositions. Propositions at the national level have become less and less distinctive vis-à-vis the main competing countries. For instance, many countries now have an attractive fiscal climate for MNCs and/or for innovation, a good infrastructure for transport, a well-educated labour force, etc. Regional strengths (based on agglomeration benefits) can make the difference.

Interregional coordination and/or collaboration are needed for at least two reasons. Firstly, it helps regions to develop propositions that are not only based on their own strengths, but also

121 The NFIA is part of the Netherlands Enterprise Agency RVO, which is part of the ministry of Economic Affairs.

122 Recently, various new RDAs were set up, including Impuls (province of Zeeland); OMFL (province of Flevoland); Innovation Quarter (province of Zuid-Holland); REWIN (Western part of the Province of Noord-Brabant); NHH (Northern part of the province of North-Holland).

on complementary strengths in other regions (also in regions across the border).¹²³ The Dutch top-sectors, for instance, spread across regional boundaries, and it would be unfortunate if regional actors only based their propositions on assets and qualities within their jurisdictional borders. Secondly, go-it-alone strategies could damage the image of the Netherlands abroad. It is not self-evident that provinces and cities coordinate and collaborate in their efforts to attract foreign investments. Indeed, they tend to compete with each other in attracting investments from abroad. To some extent competition is good, because it incites those involved to perform well. However, competition should not prevent parties from paying attention to their common interest.

It is not in the interests of the Netherlands as a whole, for example, that each region, city or municipality organises their own economic mission without any regard to the missions of other parties. It is confusing for foreign investors if they receive various economic missions one after each other, each with a different story and proposition, but also because opportunities to tell a comprehensive story about R&D location strengths in the Netherlands are missed. It is commendable therefore, that the central and regional governments in the Netherlands have decided to develop a joint strategic travel agenda for economic missions. With this joint agenda, the national, provincial, metropolitan and municipal governments have agreed to coordinate their economic missions. The Dutch Trade and Investment Board has developed the agenda together with members from industry (the top-sectors), provinces, municipalities and five large Dutch cities.¹²⁴ The strategic travel agenda is, however, only a first step towards a more coordinated approach in promoting the Netherlands as an attractive location for foreign direct investments.

Below we discuss three functions of investment promotion policy: image building, pre-investment services (lead generation) and post-investment services (investor development).

8.2 Image building

In order to benefit from the globalisation of business research, countries and regions should not only ensure that they are an attractive location for industrial research with internationally distinctive hotspots in science and technology, but also that foreign MNCs are aware of their unique location strengths.¹²⁵

With regard to the Netherlands, numerous international scoreboards, rankings and other lists give plenty of indications that can be used to show that the country performs well in science

123 The PBL Netherlands Environmental Assessment Agency uses the concepts 'borrowed size' and 'borrowed qualities'. Dutch regions lack agglomeration strength in comparison with large metropolitan areas in Europe, such as London and Paris. Dutch regions could increase their agglomeration strength by 'borrowing' strengths of neighbouring regions. Excellent connections between regions are required to make such combination of strengths possible. (Raspe et al. 2012b).

124 Appendix to Letter to Parliament by the Dutch Minister of Economic Affairs (TK 29697, nr. 18, 11 December 2014).

125 The emphasis on distinctive strengths in science and innovation is part of a broader shift in investment promotion policies in OECD countries. A generic approach is replaced by a more targeted approach that focuses on foreign direct investments in specific sectors and high value-added business functions such as R&D. For more information on current trends in international investment in innovation and the attractiveness policies, see OECD (2011). For example, IDA Ireland, a leading investment promotion agency, focuses on research, development and innovation, global business services, advanced manufacturing and high growth companies. (<http://www.idaireland.com/>).

and technology. However, good scores and ranks do not mean that foreign investors automatically think of the Netherlands as the ‘place to be’ when they decide on the location of their industrial research activities. The Netherlands appears to be better known for its attractive geographic location as a gateway to Europe, its well-educated multilingual labour force, its fiscal climate, the quality of the infrastructure, the quality of life, etc. than for its reputation as a powerhouse in science and technology in general.¹²⁶ Thus, the Dutch attraction policy needs to go beyond ‘Holland branding’ in general and highlight its specific location strengths for research and development as well. Policies to promote the Netherlands as a location for research and development should be tightly aligned with science and innovation policies. The Dutch government has taken the first steps towards a better alignment of science and innovation policies with its attraction policy.

Textbox 14 Top-sectors in the attraction policy

The top-sectors are increasingly being used in an attraction policy to raise international awareness of strengths in research and innovation in the Netherlands. The NFIA, for instance, specifically highlights the top-sector Agrifood (as “Holland Food Valley: the agrifood cluster in the Netherlands”) and the top-sector Chemical industry (as “Holland: your chemical portal to Europe”) on its international website. As part of a five-year plan for 2015-2020, the NFIA and the regional development agencies have agreed to increase their focus on acquisition of foreign investment in the Dutch top-sectors under the label ‘Invest in Holland’. Thus, Holland is not only positioned as a trading nation with an international outlook, but also as a country with strengths in knowledge and innovation.¹²⁷

In addition to image-building based on location strengths in science, technology and innovation, investment promotion agencies need to target potential investors in research and development with tailored information, advice and other pre-investment services.

8.3 Pre-investment services

Investment promotion agencies have a package of pre-investment services they offer to potential foreign investors. Such services include provision of general and/or tailored information on the research and innovation system in the host country/region and on the incentive packages that are available. In addition, these agencies offer assistance in organising site visits and meetings with officials and other stakeholders.

¹²⁶ Even in Germany, a neighbouring country of the Netherlands and its most important trading partner, the Netherlands is not known for its reputation in science and innovation. A study by the Dutch Embassy in Berlin shows that Netherlands is not perceived as a country that is noteworthy for science. Scientific performance is perceived as good, but not as leading. Dutch universities were not considered as world-class. Their propensity to collaborate was, however, considered high. The international orientation of Dutch science was also seen as conducive for the capacity for innovation. A negative aspect is that Dutch science was not visible enough, in Germany at least (Gesellschaft für Innovatieve Marktforschung, 2013).

¹²⁷ On the official website for Holland branding (Hollandtrade.com) Dutch solutions to global challenges such as food supply and security, water supply, flood control, climate change, renewable energy, waste management and infrastructure are highlighted.

Traditionally, most investment promotion agencies have acted in a reactive mode. They take action when (generic) promotion activities result in a concrete lead. In recent years, however, a more pro-active or strategic mode has emerged in which they try to target specific investors that have a fit with (regional) strengths in research and innovation in the host country.

The strategic approach to acquisition is still in an early development phase in the Netherlands. The Dutch foreign investment agency NFIA has been developing such a strategic approach in the last decade together with the regional development agencies. The regional development agency of the province Noord-Brabant BOM is a frontrunner in developing a focused proactive strategy to attract high-value added activities that fit its regional strengths in research and innovation.

Coordination and collaboration with regional parties is a key element in this approach. The aim is to operate as one country in finding interesting foreign investors and to bring various skills, competencies and expertise areas together. A first step is to identify and approach foreign firms that match with specific strengths in research and innovation in the Netherlands. The overseas network of NFIA offices plays a facilitating role in this.¹²⁸ The network of Innovation Attachés – based in Dutch Embassies worldwide – plays an important role in getting access to foreign companies and the Chief Technology Officers.¹²⁹ Once there is a lead, the regions can present their tailor-made propositions. Two top-sectors were selected as pilot sectors to develop this strategic track: the Agrifood sector (in particular dairy and crop breeding) and specific parts of the Chemical industry sector.¹³⁰ Initiatives in the strategic track have recently been broadened to the top-sectors High Tech Systems & Materials, Life Sciences & Health and Medical Technology.

Strategic acquisition requires a novel, much more labour and knowledge intensive approach, because it is necessary to use more sophisticated processes for lead generation and client engagement. Potential investors need to be found and approached with tailor-made propositions in an earlier stage of their location selection process. This requires a good understanding of where potential investors can be found and what specific location strengths might appeal to them. The proposition needs to be backed up by credible evidence. The efforts in High Tech Systems & Materials, for example, started with mapping out the value chains and identifying which specific segments and niches could benefit most from a proactive approach to acquisition. Only after such detailed knowledge is available, is a tailored approach deployed to identify and approach high tech firms abroad.

Strategic acquisition therefore requires coordination and collaboration within and between various public and private stakeholders. RDAs have to develop a cross-departmental approach

128 The NFIA has offices in Europe (HQ in The Hague, London, Istanbul), the USA (New York, Boston, Chicago, Atlanta, San Francisco, Washington DC), Asia (Tokyo, Osaka, Taipei, Shanghai, Beijing, Guangzhou, Chongqing, Seoul, New Delhi, Mumbai, Bangkok, Singapore and Kuala Lumpur), the Middle East (Dubai, Tel Aviv) and Brazil (São Paulo). In addition, the NFIA closely cooperates with Dutch embassies, consulates-general and other organisations that represent the Dutch government around the world. (See <http://investinholland.com/contact-us/>).

129 Note that the Innovation Attachés not only bring relevant international trends in science and technology to the attention of Dutch organisations (outside-in perspective), they also bring Dutch knowledge and technology to the attention of relevant parties abroad (inside-out perspective). See <http://www.rvo.nl/onderwerpen/innovatief-ondernemen/topsectoren/ia-netwerk/over-het-ia-netwerk>.

130 That these two sectors were selected is not a coincidence. They represent sectors in which the Netherlands have a particular international profile, also in terms of R&D and innovation.

in which the various departments for foreign investments, business parks, new business development and venture capital collaborate and share information in order to find suitable candidates and approach them with an integral proposition. In addition, collaboration with external partners and consultants that have in-depth understanding of the innovation ecosystem is often needed. Thus, strategic acquisition becomes a public-private partnership, in which investment promotion agencies at national and regional levels collaborate with firms, knowledge institutes and others, in their efforts to attract international investors in research. Such partnerships need to be based on a shared vision on how the regional hotspot and the underpinning innovation ecosystem could benefit from foreign investments. To get domestic firms engaged in attraction strategies, a careful approach is necessary, because they may be reluctant about attracting potential competitors to their home market. Instead, the focus has to be on foreign firms that are complementary and can bring added value to the ecosystem, for instance specialised suppliers of domestic firms.

Universities can potentially play an important role in strategic acquisition. International collaboration networks of scientists can be used as an entry point for identifying potential foreign investors in business research. Strategic acquisition is usually a gradual process. The initial seed may be a connection between a Dutch research group and a research group abroad. Via this connection, a linkage with foreign firms may be made, which in turn may make this firm aware of the opportunities for research in the Netherlands. Eventually, it may decide to develop research activities in the Netherlands, e.g. to get better access sources of knowledge. Thus, foreign (contract) research partners of a university could provide valuable leads. This means that universities should be encouraged (in science policy) to develop internationalisation strategies that not only focus on attracting foreign students and participating in international research programmes, but also on creating links with foreign companies that might be of interest for the vitality of the innovation ecosystem in the region. In their international promotion activities, they should not only present themselves as individual universities, but also as a part of the Dutch knowledge infrastructure and/or as part of regional hotspots. In a more general sense, universities could also contribute to strategic acquisition when they develop a profile in education and research that fits with regional strengths and when they position themselves as key players in regional hotspots. In particular, the campuses and science parks around universities can potentially act as a magnet.¹³¹ Campus organisations can offer expertise that is needed for strategic acquisition, because they know the profile of existing businesses on site, their strengths and their needs. In the province of Limburg, for example, the regional development agency LIOF and the Chemelot Campus collaborate in developing targeted propositions for potential businesses to join the campus.

Strategic acquisition requires a long-term perspective because it takes time to attract carefully selected firms. The incentive structure can be an obstacle for RDAs engaging in strategic

131 Although there are many campuses and science parks in the Netherlands, there are only a few that can act as a magnet on international R&D firms. Buck Consultants International (2012) has made an inventory of such initiatives in the Netherlands, where they looked at both 'Science & research parks' – (often park-like) industrial estates, where R&D is carried out by universities, hospitals, research institutes and companies – and 'Open innovation campuses' – (often former) enterprise campuses where an 'anchor tenant' performs R&D, where other companies can establish themselves, and where interaction and research collaboration is actively stimulated. From the 74 initiatives Buck studied, only 7 can be considered as mature campuses: Kennispark Twente – Enschede, Wageningen UR Campus – Wageningen, Amsterdam Science Park – Amsterdam, TU Delft/ Technopolis (TIC Delft) – Delft, Bio Science Park – Leiden, High Tech Campus – Eindhoven, and Chemelot – Sittard – Geleen.

acquisition. As long as their performance is measured in terms of the number of new projects, new jobs and the size of foreign investments, it is not obvious how RDAs should approach R&D – the most difficult and smallest category of investment. The principals of the RDAs need to be committed. The provincial governments have a dual role in this. On the one hand, they are shareholders of an RDA and as such, should demand measurable contributions to job creation and economic performance in the region. On the other hand, they are political actors involved in attracting firms to strategic areas and/or specific business activities (e.g. R&D). This duality can create mixed signals for an RDA, causing it to be hesitant to fully engage in strategic acquisition.

Furthermore, it is important that adequate funding for strategic foreign investment promotion is mobilised by pooling the resources of various governments. As we discussed, a targeted proactive approach is much more knowledge and labour intensive than a generic reactive approach, and it requires the engagement of all relevant stakeholders, including those from the top-sectors and the regional triple-helix initiatives. It therefore requires strong political commitment of national as well as regional governments. Without such long-term commitment, strategic acquisition is doomed to fail, because it will take time to engage all the relevant stakeholders and to show that such an approach will pay off.¹³²

Textbox 15. Acquisition of R&D as a difficult category

The NFIA annually reports on their results in attracting foreign direct investments. The share of projects that involve R&D investments is below 10% (18 out of 193 projects in 2013; 12 out of 187 projects in 2014).¹³³ One reason for this low share is that the number of R&D-intensive firms looking for a new location is inherently small. In addition, most R&D-intensive firms can be found in science-based industries in which the Netherlands does not have a strong international profile or reputation (e.g. pharmaceuticals, information and communication technologies). As a result, foreign companies in such industries may not always consider the Netherlands as a 'place to be' to develop research activities. Most projects that involve R&D investments concern location decisions after an M&A, when a new foreign owner considers consolidation or relocation of R&D activities.

8.4 Post-investment services

Post-investment services target foreign affiliates that are already present in a host country in order to stimulate them to perform new, more, or higher value-added activities. With regard to foreign investments in R&D, this 'upgrading' is an important mode of internationalisation and globalisation.¹³⁴ A foreign subsidiary may start as an overseas office for Marketing & Sales or

132 Singapore is often mentioned as a pioneer in strategic acquisition of foreign investments in research and innovation. A key success factor is their long-term political (and financial) commitment to the strategy.

133 NFIA Resultaten 2014, downloadable at <https://www.rijksoverheid.nl/documenten/jaarverslagen/2015/03/09/resultaten-nfia-2014>.

134 In section 1 we described the three basic modes of globalisation of R&D: M&A, brownfield investments and greenfield investments.

Distribution & Logistics and eventually evolve into a research and innovation centre. Therefore 'aftercare services' are at least as important as pre-investment services.

In the Netherlands, the investment promotion agencies of the national, regional and local (metropolitan) governments have jointly developed an Investor Relations Programme (until 2014 named the Investor Development programme).¹³⁵ The aim is to retain, strengthen and deepen the embedding of existing foreign affiliates in the Dutch economy by maintaining regular contact with them. In essence, the programme tries to convince 'market seeking' foreign investors to become 'knowledge seeking' investors as well. It is important to not only speak to the affiliates of foreign MNCs, but to their headquarters where the final investment decision is made. The fact that they have a foreign affiliate in the Netherlands does not automatically mean they are aware of the opportunities the Netherlands offers in research and innovation. The programme provides these firms with a platform that they can consult for advice and support, for instance with regard to assistance with new investments and development projects, support in finding and applying for subsidies, help in obtaining visas and work permits for employees, etc. The programme also helps companies to get into contact with the Dutch government at the national, regional and local levels. Various events are organised ranging from seminars and conferences to network dinners, round-table sessions and individual update meetings with representatives from the Dutch government. Finally, the programme offers foreign affiliates the opportunity to make individual arrangements for tailor-made support and advice.

In the Investor Relations programme, the investment promotion agencies of the regions and the large cities take the lead. The NFIA and their overseas network of NFIA offices play a facilitating role. The joint programme is underpinned by a shared web-based account management system which contains >8000 foreign companies. Each year, 500-1000 firms are visited to assess to what extent they could be helped to retain, enlarge or 'deepen' their location in the Netherlands. Leads from overseas NFIA offices are jointly taken up by the RDAs. The balance between interregional cooperation and competition remains precarious, but such initiatives help to develop mutual trust and to work towards a common objective, which is getting foreign companies interested in investing in R&D in the Netherlands in the first place, regardless of which region.

135 See <http://investinholland.com/investor-relations/>.

A note on the methodology

This report is based on a study in which we used a combination of methods and sources.

Desk research

A large body of literature exists on internationalisation and globalisation of business R&D in publications for academic and professional audiences. In the biography we list the sources used to inform our understanding of the globalisation of R&D and its implications.

Interviews

20 interviews took place with R&D leaders of technology companies in the Netherlands. The Top 30 R&D companies from Dutch professional journal *Technisch Weekblad* was used to identify these companies.¹³⁶ The companies are a cross section of Dutch industry. The selection includes firms from the top-sectors Agrifood (Danone/Nutricia, DSM, FrieslandCampina, Unilever); Horticulture and Propagation Materials (Incotec Group, Bayer CropScience/Nunhems, Rijk Zwaan); High-Tech Systems & Materials (ASML, DAF Trucks, Fokker Technologies, Neways Electronics International, NXP Semiconductors, Océ/Canon, Sioux, Vanderlande Industries, Philips, Tata Steel); Chemicals (DSM, Shell); Water (IHC Merwede); Life Sciences & Health (DSM, Philips); and Energy (Shell).

Organisation	Name interviewee (function)
AkzoNobel	Dick van Beelen (Director Innovation Alliances)
ASML	Jos Benschop (Senior Vice-President Technology)
Bayer CropScience Vegetable Seeds	Bert Uijtewaal (Coordinator Special Projects, Nunhems Netherlands)
DAF Trucks	Ron Borsboom (Director Product Development)
Danone (Nutricia)	Hanno Cappon (Vice President R&D Medical Nutrition)
DSM	Marcel Wubbolts (CTO)
Fokker Technologies	Arnt Offringa (Director R&D Fokker Aerostructures)
FrieslandCampina	Emmo Meijer (Corporate Director R&D) ¹³⁷
IHC Merwede	Robert van de Ketterij (Manager Knowledge Development, MTI Holland) ¹³⁸
Incotec Group	Jan Willem Breukink (CEO, President) ¹³⁹
Neways Electronics International	Huub van der Vrande (CEO, COO)
NXP Semiconductors	Hans Rijns (Senior Vice President, CTO)
Océ (Canon)	Anton Schaaf (CEO, Chairman of the Board of Executive Directors)
Philips	Henk van Houten (Executive Vice President & General Manager Philips Research) Jan van den Biesen (Vice President Public R&D Programs Philips Research)

136 Each year, the *Technisch Weekblad* publishes a "Top 30 Bedrijfs-R&D in Nederland" which lists the 30 companies that have the highest expenditures on R&D.

137 Retired from FrieslandCampina in October 2014.

138 Since February 2015 Managing Director.

139 Until March 2014. Since then Senior Executive Member of the Board at INCOTEC Group BV. Since February 2015 Managing Director MTI Holland B.V. at Royal IHC.

Organisation	Name interviewee (function)
Rijk Zwaan	Ben Tax (managing director)
Shell	Roelof Heezen (Vice-President R&D Downstream Technologies) ¹⁴⁰
Sioux Group	Hans Duisters (CEO)
Tata Steel	Debashish Bhattacharjee (Group Director R&D) Wim van der Meer (Director Programmes R&D)
Unilever	Hans Dröge (Senior Vice President Unilever R&D Operations / National Manager Unilever Nederland) ¹⁴¹
Vanderlande Industries	Gert Bossink (Director R&D, COO)

As part of the project, International Top Talent (ITT) undertook a background study on behalf of the Rathenau Instituut. The aim of the background study was to provide insights on the role of China in the globalisation of R&D. ITT interviewed R&D/innovation managers in China about their views on the globalisation of R&D and the changing role of China. ITT performed 15 interviews in total, including 14 interviews with Chinese affiliates of Dutch/Western companies and one interview with an expert from the China Europe International Business School of Zhejiang University.

Organisation	Name interviewee (function)
Aerocore Electronics	Yuri de Klerk (Director of R&D)
AkzoNobel	Fiona van den Brink (RD&I China Operations Manager)
Applikon Biotechnology	Ron de Lahaye (International Technical Project Manager)
China Europe International Business School, Zhejiang University	Mark Greeven (Associate Professor)
Damen Shipyards	Paul Kitzen (Manager Engineering Asia)
DSM	Yi-Bin Huang (R&D Director, Performance Materials Research Center)
General Electric (GE)	Bing Zhang (China Technology Growth Leader)
Jonhson&Johnson Xian Janssen	Oscar Slotboom (BU Head 2 Vaccines and Infectious Diseases)
NXP	Mike Yeh (Managing Director NXP China)
Philips	Klaas Vegter (Head of Philips China R&D & Head of Philips Research China)
Sabic	Yuxian An (Director at SABIC Technology Center at Shanghai)
Shell	Xu-Dong Jing (Director External Research & Innovation)
Teijin Aramid Asia	Danny Wilms Floet (Manager Application Development and Technical Services)
Unilever	Mason Wang (Director Open Innovation North Asia)
Vanderlande Industries	Bart van Kreij (Mechanical Development Engineer)

140 Until November 2014.

141 Until July 2014.

We also conducted interviews with policymakers at the national and regional level.

Organisation	Name interviewee
Brabant Development Agency (BOM)	Eelko Brinkhoff (Director Foreign Investments) Ben Engel (Senior Project Manager)
Ministry of Economic Affairs	Luuk Klomp (Member Management Team of Top-Sectors and Industrial Policy Department) Upton van der Vliet (senior advisor) Nico Schiettekatte (Head of Unit Public Private Programmes, Innovation & Knowledge) ¹⁴¹
Netherlands Foreign Investment Agency NFIA	Bas Pulles (Commissioner for Foreign Investments) ¹⁴¹

A second background study was performed by Bodewes Beleidsadvies on behalf of the Rathenau Instituut. The objective was to map policy initiatives and investments at the regional level in research and innovation. Bodewes Beleidsadvies interviewed several policymakers.

Organisation	Interviewee (function)
Netherlands Enterprise Agency RVO	Maarten van Leeuwen
Ministry of Economic Affairs	Rianne Overeem
NV Industriebank LIOF (regional development and investment company for the province of Limburg)	Jacques Mikx (Director Foreign Investments) Bart de Wit (Head Development & Innovation)
SNN (Northern Netherlands Provinces alliance)	Luc Hulsman (Management and implementation of regional innovation strategies)
Amsterdam Economic Board	Edwin Oskam (Strategic Advisor)
Province of Noord-Brabant	Harmen Bijsterbosch (Senior Policy Advisor Innovatie and Entrepreneurship)

Data analysis

In Chapter 2 we presented various tables and figures on R&D expenditures in the Netherlands.

Data on the funding of R&D performed by companies, higher education institutes (HEI) and research institutes in the Netherlands are from the website 'De Nederlandse Wetenschap' of the Rathenau Instituut which uses data from Statistics Netherlands CBS and OECD. The data are retrieved from http://www.rathenau.nl/fileadmin/user_upload/rathenau/De_Nederlandse_Wetenschap/F-Financiering-uitvoering_van_R_D_vanaf_1990_CBS_.xlsx.

Data on the R&D outsourced abroad by companies in the Netherlands are from CBS StatLine. Data are retrieved from <http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=81244NED&D1=4&D2=1&D3=a&VW=T> (for the period 1999-2009) and <http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=82042NED&D1=a&D2=a&D3=a&VW=T> (for the period 2011-2013).

The figures on the R&D expenditures by eight large technology-based firms in the Netherlands are based on own calculations of data from Technisch Weekblad's annual publication of the Top 30 of R&D investors in the Netherlands. The figures have to be treated with care, because in some cases the Technisch Weekblad had to make an estimation. In addition, companies sometimes change their internal procedures of administrating and reporting R&D expenditure.

¹⁴¹ Until January 2014. Since then Director International Programmes at Netherlands Enterprise Agency RVO.

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Abbreviations

ARCNL	Advanced Research Center for Nanolithography
EFRD	European Fund for Regional Development
EU	European Union
FOM	Foundation for Fundamental Research on Matter
GDP	Gross Domestic Product
HEI	Higher Education Institutes
ICT	Information and communications technology
IPP	FOM Industrial Partnership Programme
ITT	International Top Talent
M&A	Mergers and Acquisitions
MIT	Massachusetts Institute of Technology
MNC	Multinational Corporation
NFIA	Netherlands Foreign Investment Agency
OECD	Organisation for Economic Co-operation and Development
PhD	Philosophiae Doctor (Doctor of Philosophy)
PNP	Private Non-Profit
R&D	Research and Development
RDA	Regional Development Agency
SMEs	Small and medium-sized enterprises
STW	Technology Foundation STW
TKI	Top-consortium for Knowledge and Innovation
TNO	Netherlands Organisation for Applied Scientific Research
USA	United States of America
WUR	Wageningen University and Research Centre

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Who was Rathenau?

The Rathenau Instituut is named after Professor G.W. Rathenau (1911-1989), who was successively professor of experimental physics at the University of Amsterdam, director of the Philips Physics Laboratory in Eindhoven, and a member of the Scientific Advisory Council on Government Policy. He achieved national fame as chairman of the commission formed in 1978 to investigate the societal implications of micro-electronics. One of the commission's recommendations was that there should be ongoing and systematic monitoring of the societal significance of all technological advances. Rathenau's activities led to the foundation of the Netherlands Organization for Technology Assessment (NOTA) in 1986. On 2 June 1994, this organization was renamed 'the Rathenau Instituut'.

The Rathenau Instituut promotes the formation of political and public opinion on science and technology. To this end, the institute studies the organization and development of science systems, publishes about social impact of new technologies, and organizes debates on issues and dilemmas in science and technology.

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