Ministry of Education, Culture and Science

2025 *Vision for Science*

choices for the future

2025

Vision for Science

choices for the future

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Introduction

Netherlands: A strong position

Science makes a significant contribution to our welfare and prosperity. Insights and discoveries of the past, such as the light bulb and penicillin, brought about major improvements to our lives. More recently, advances such as the internet and biofuels have done likewise, providing new insights and revealing new applications. Discoveries in less tangible form also enrich our lives: knowledge about the universe, the functioning of society, and new information about our past, for example. Science will continue to provide new knowledge, insights and practical inventions which will make our lives easier or more pleasant, and which will surprise and challenge us. As yet, we do not know the precise source of this new scientific knowledge. However, we do know that science will inspire, will lead to changes and offer solutions to problems. Its capacity to do so is large and will continue to grow.

The Netherlands can be proud of its science and its scientists. Our country enjoys a prominent position on the world stage.

The conclusions of various national and international studies are unequivocal: Dutch science is of very high quality and represents high productivity.[1] The recent Interdepartmental Policy Review (IBO) concludes that Dutch science has achieved excellent results with moderate investment.[2] The Netherlands ranks among the best in the world in terms of scientific quality and productivity.[3] A study commissioned by the European Commission in relation to the Europe 2020 strategy places the Dutch research system among the very best in terms of openness, excellence and attractiveness, together with the Scandinavian countries, Switzerland and the United Kingdom.[4] Various evaluation reports note the extremely high quality of our universities,

1 In terms of citation scores and the number of publications produced by each researcher, the Netherlands ranks among the very best in the world (Trends Monitor, Ministry of Education, Culture and Science). Similarly, influential international publications such as the CWTS Leiden Ranking, the Shanghai Ranking and the Times Higher Education Supplement place several Dutch universities among the Top 100 in the world. See also the IBO Report (Ambtelijke Commissie Heroverweging, (2014), *IBO Wetenschappelijk onderzoek*. Ministry of Finance, Government of the Netherlands, The Hague).

2 Government expenditure on science and research is slightly higher than the average for all EU member states and OECD countries (Ambtelijke Commissie Heroverweging, (2014), *IBO Wetenschappelijk onderzoek*. Ministry of Finance, Government of the Netherlands, The Hague, pp.21).

3 See www.wti2.nl (Publication productivity and regionally adjusted citation impact scores). According to the IBO, primary funding has fallen in both absolute and relative terms over the past decade.

4 European Commission (2014), *Innovation Union Scoreboard 2014* http://ec.europa.eu/enterprise/policies/innovation/files/ius/ius-2014_en.pdf; pp. 14.

institutes and research organisations.[5][6] Moreover, there is active and close cooperation between government, the private sector, universities and the research institutions in the context of the 'Top Sectors', to promote innovation and the development of new knowledge. The Organisation for Economic Co-operation and Development (OECD) has lauded the Dutch approach towards public-private partnerships and the institutes in which fundamental and applied research is conducted in tandem.[7] The combination of education and research within our universities has also been singled out as a key strength. Although research conducted by the universities of applied sciences (the 'Hogescholen', formerly known as polytechnic colleges) remains on a modest scale at present, they too will play a significant part in applied research and valorisation in the future.

Factors which explain the international success of Dutch science include its external orientation,[8] its non-hierarchical, open culture, the long track record of successful research evaluations, and the high degree of autonomy enjoyed by institutes and individual researchers. In addition, the Netherlands has an excellent research infrastructure. The emergence of new strengths in recent years has served to reinforce the sound reputation established by the traditional areas of focus which owe their existence to various historical and geographic factors. There are many disciplines in which Dutch research is unquestionably among the best in the world.[9] Dutch researchers are known for their openness; they are more than willing to cooperate with others, both within and beyond their own disciplines. As a result, the Netherlands can both 'deliver' and 'collect' knowledge, a process which relies on two-way traffic. Through appropriate cooperation with partners both national and international, we can further strengthen the Netherlands' position and advance science itself. The ability to cooperate effectively is manifest within the various joint research schools, in which universities have joined forces to create a setting which allows young and talented researchers to develop their full potential. The system of open competition applied by Netherlands Organisation for Scientific Research (NWO) offers good preparation for submitting successful applications at the European level. Between 2007 and 2013, the Netherlands received a total amount of research grants which exceeded its contribution to the EU research budget by almost fifty per cent. During the same period, the European Research Council (ERC), which awards personal grants to individual researchers based on the sole criterion of scientific excellence, allocated some nine per cent of its total budget to Dutch researchers. The Netherlands actively supports the concept of the European Research Area (ERA), introduced in 2000 to promote the free movement of

5 Ambtelijke Commissie Heroverweging, (2014), *IBO Wetenschappelijk onderzoek*. Ministry of Finance, Government of the Netherlands, The Hague; Advisory Council for Science and Technology Policy (2014), *Boven het Maaiveld – focus op wetenschappelijke zwaartepunten*. AWT Advisory no. 86, April 2014; OECD (2014), *OECD Reviews of Innovation Policy: Netherlands*. OECD Publishing, DOI: 10.1787/97892642131 59-en.

6 Further to the regular evaluations, the institutes which fall under the auspices of the NWO and KNAW are all rated as 'Excellent'.

7 OECD (2014), *OECD Reviews of Innovation Policy: Netherlands*. OECD Publishing, DOI: 10.1787/9789264213159-en.

8 OECD (2014), *OECD Reviews of Innovation Policy: Netherlands*. OECD Publishing.
DOI: 10.1787/97892642131 59-en; Dutch researchers are responsible for an above-average number of publications, often in co-authorship with international partners (www.wti2.nl: percentage analysis of international co-publications).

9 An example is clinical-medical research at the University Medical Centers. See: Chiong Meza, C.,Van Steen, J., De Jonge, J. (2014), *De Nederlandse universitair medische centra. Feiten en Cijfers* 12, Rathenau Institute, The Hague.

researchers, technology and knowledge. It will enable all Member States to address social challenges more effectively, and to operate at a high international level while ensuring effective and efficient use of public funds.

The IBO report is not alone in noting the strong position of the Netherlands. The Advisory Council for Science, Technology and Innovation (AWTI)[10] does likewise, as does the Scientific Council for Government Policy (WRR). At the same time, these organisations draw attention to the importance of anticipating the global challenges which are likely to emerge, thus maintaining the Netherlands' position as an attractive international partner.

We endorse the AWTI's analysis that leading research requires both a broad base and a number of key focal points.

This combination will enhance the Netherlands' adaptive, innovative and responsive ability. It is important to be able to address the many changes which will be seen in the world around us while also maintaining the links between education, science and society. Similarly, we endorse the WRR's view that it remains necessary to increase our earning capacity, thus ensuring long-term economic well-being. In an advisory report published in late 2013 (*Naar een lerende economie*; 'Towards a learning economy'), the WRR states that responsiveness, absorptive ability and knowledge circulation are crucial factors which will determine the Netherlands' future earning capacity. It is, after all, knowledge which underpins innovation, which in turn provides the solutions to the various societal challenges we face. Innovation will also create new earnings models and will establish the international position of private sector organisations and knowledge institutions alike. Last but not least, the WRR notes that science is essential to the quality of (higher) education and to the development of essential skills such as problem-solving capacity and creative thinking. The indisputable contribution that science makes to knowledge development, welfare and prosperity has also been demonstrated by the 'Value of Research' Committee of the Royal Netherlands Academy of Arts and Sciences (KNAW).[11]

Future challenges

Dutch science enjoys a strong position but that position must not be taken for granted. Looking ahead, we see three major challenges. They must be addressed effectively if we are to avoid any erosion of our current status. The remainder of this chapter examines these challenges and sets out the ambitions for the year 2025. Subsequent chapters describe the ambitions in more detail, together with the action required.

10 Publications issued prior to 29 August 2014 are cited under the former name, the Advisory Council for Science and Technology Policy (AWT).
11 KNAW (2013), *Publieke kennisinvesteringen en de waarde van wetenschap*. Koninklijke Nederlandse Akademie van Wetenschappen, Amsterdam.

Increasing international competition

The past decade has seen a rise in international competition. Investments in science are increasing worldwide[12] and the IBO report notes that the Netherlands is at risk of losing ground.[13] An ever larger number of countries are working to establish a competitive knowledge economy. The resultant growth in scientific knowledge raises new questions and often prompts further research. Between 2001 and 2011, the number of publications in science and engineering disciplines increased from approximately 630,000 to some 830,000.[14] We see new players coming from the emerging economies, new Member States of the European Union (EU) and Asian countries, such as China and South Korea.[15] All such developments provide an impulse to science at the global scale and create opportunities for Dutch researchers, many of whom work alongside partners in other countries and regions. At the same time, the effects of increasing international competition for talent and funding are already clearly visible. The Netherlands' investments threaten to fall behind those of other countries. The Rathenau Institute has warned that direct government funding for research and development (R&D) is likely to fall yet further in future.[16] At the European level, the Netherlands already has a lower level of privately-funded R&D than those countries we wish to compete against. In the Netherlands the private investments in R&D fall behind, while in countries such as Korea and the BRIC countries relative investment levels continue to rise.[17] In 2009, China's investment in R&D showed year-on-year growth of 28%, with a further 15% increase in 2010.[18] International competition makes it more difficult to attract and retain international researchers of the desired calibre.[19]

We need to respond promptly to a rapidly changing world in order for the Netherlands to retain a significant role on the world stage and to derive the benefits of the worldwide growth in scientific endeavour.

This entails monitoring financial and other developments elsewhere, and ensuring that our absorptive capability keeps pace. We like to compare ourselves with countries such as

12 OECD (2013), *OECD Science, Technology and Innovation Scoreboard 2013, Investment in knowledge*, OECD Publishing. DOI: 10.1787/sti_scoreboard-2013-en, pp. 86.
13 In most countries worldwide, including other EU Member States, government investment in research and development (expressed as a percentage of GDP) has risen. However, in the Netherlands investment has fallen, placing the country at risk of losing ground. *Ambtelijke Commissie Heroverweging (2014), IBO Wetenschappelijk onderzoek*, Ministry of Finance, Government of the Netherlands, The Hague, pp. 22.
14 National Science Foundation (2014), *Science and Engineering Indicators 2014*, Arlington VA: National Science Foundation, Table 5-20.
15 Between 2001 and 2011, the European Union's share of worldwide publication output in Science & Engineering fell from approximately 35% to 31%. (National Science Foundation (2014), *Science and Engineering Indicators 2014*, Arlington VA: National Science Foundation, Figure 5-19; Advisory Council for Science and Technology Policy (2014), *Boven Het Maaiveld. Focus op wetenschappelijke zwaartepunten*. AWT Advisory no. 86, April 2014).
16 Van Steen, J. (2014), *Totaal Investeringen in Wetenschap en Innovatie (TWIN) 2012-2018*. Rathenau Institute, The Hague.
17 This can be partly explained in terms of the Netherlands' deliberate focus on economic sectors which attract lower levels of R&D investment elsewhere in the world.
18 Advisory Council for Science and Technology Policy (2014), *Boven het Maaiveld – focus op wetenschappelijke zwaartepunten.* AWT Advisory no. 86, April 2014, pp. 11, 27 and 28.
19 Concerns are expressed in the vision document *Chemistry & Physics: fundamental for our future* (Dijkgraaf Commission, 2013).

Switzerland, Denmark and Germany, which are not sitting still. Both Germany and Denmark have produced a national science agenda which sets out their research priorities. We must now do likewise.

If new and creative interrelationships are to be created, it is essential to allow ample opportunity for free, independent research. This is also a precondition of a responsive system which can address new (international) developments promptly and effectively, and which can absorb new knowledge. The most significant development within science itself is likely to be the growing importance of multidisciplinary research. At the same time, we must maintain a strong strategic focus on those domains in which we wish to be a world leader. If Dutch science is to flourish, it is essential to be at the forefront of scientific development in a number of carefully selected areas. Therefore, choices must be made and effective forms of cooperation must be found.

Closer ties with society and the private sector

Often science focuses on major societal challenges asked by government and society itself. Increasingly, research is conducted alongside private sector organisations and the civil society. Recent examples include the research programmes examining sustainable food production and healthy ageing. The joint efforts of the research field, the private sector, government and other stakeholders are needed in order to increase the impact of science, and to link the strength of science to the major societal challenges.[20] The European Commission has recommended the Netherlands to encourage closer cooperation between research institutions and the private sector, to promote innovation and to facilitate investments in private R&D initiatives.[21]

Knowledge must be shared: With students by means of good education; with society by addressing current issues and encouraging public discussion; with the scientists by discussing ways in which 'cross-pollination' between various disciplines can be further achieved, and between fundamental research and applied research; with the private sector by contributing to the creation of new products. Public interest in science is greater than ever before. Civil society should have more access to the added value which science brings in addressing societal challenges. The controversy which surrounded the vaccination programme against cervical cancer illustrates that scientific evidence is no guarantee of public acceptance.[22] The 'Trust in Science' debates have taught us that closer contact between the scientific field and society is essential.[23] At the same time, we must remember that science is, by definition, a quest for the unknown. It must always be possible to conclude that the quest itself has been interesting but has not produced the desired results.

20 Advisory Council for Science and Technology Policy (2013), *Waarde creëren uit maatschappelijke uitdagingen*. AWT Advisory no. 82; Boon, W., Horlings, E. (red) (2013), *Kenniscoproductie voor de grote maatschappelijke uitdagingen*. Rathenau Institute, The Hague, SciSa report no. 1329.
21 Ambtelijke Commissie Heroverweging (2014), *IBO Wetenschappelijk onderzoek*. Ministry of Finance, Government of the Netherlands, The Hague, pp. 29.
22 Blankesteijn, M., Munnichs, G., Van Drooge, L. (2014), *Wetenschap als strijdtoneel: publieke controversen rond wetenschap en beleid*. Rathenau Institute, The Hague.
23 De Jonge, J. (2014), *Verslag debattenreeks Vertrouwen in de Wetenschap*. Rathenau Institute, The Hague.

The close relationship between research and education is one of the pillars of the Dutch system but it too is under strain.[24] In some disciplines, researchers are under enormous pressure to publish papers and articles; they find it difficult to combine this with other responsibilities such as teaching. Many researchers regard the development of new knowledge as more important than passing on existing knowledge.[25]

In short, Dutch science faces major challenges. Cooperation with the private sector and civil society will be essential in addressing those challenges, as will the close ties between research and education. Only then can Dutch science achieve its full, unique potential.

Our ambition for 2025 is that Dutch science will have achieved maximum impact and that it is more closely interwoven with both society and the private sector.

This calls for cooperation within knowledge 'ecosystems', in which research institutions, universities and other academic organisations pursue knowledge and innovation in association with government and industry. It also calls for a system of 'open science' which serves the interests of society, and for even closer links between research and education.

High demands

Researchers are the cornerstone of science and are of immense importance to society. It is therefore crucial that the Netherlands offers its most talented researchers every opportunity to pursue their professional development and reach the top of their profession. Science can be compared to top-level sport: a competitive undertaking whereby individual researchers attempt to outperform each other. Within the fundamental research field there is currently a discussion about whether the current 'match rules' actually stand in the way of achieving the desired level of performance. As a result of fierce international competition, many researchers feel immense pressure to produce as many publications as possible.[26] The low acceptance rate for NWO funding applications may well stifle creative thinking.[27] Over a third of university researchers feel that they are not able to devote adequate time to research. Many state that they spend significantly less time in the laboratory than originally agreed because they are expected to undertake management, fundraising and educational activities.[28] Rigid career paths prevent many researchers from becoming involved in knowledge valorisation.

24 Ambtelijke Commissie Heroverweging (2014), *IBO Wetenschappelijk onderzoek*. Ministry of Finance, Government of the Netherlands, The Hague pp.31-32: *Balans onderwijs en onderzoek onder druk*; De Goede, M., Hessels, L. (2014), *Feiten en cijfers. Drijfveren van onderzoekers*. Rathenau Institute, The Hague; Scientific Council for Government Policy (2013), Naar een lerende economie. Amsterdam University Press, Amsterdam.
25 De Goede, M., Hessels, L. (2014), *Feiten en cijfers. Drijfveren van onderzoekers*. Rathenau Institute, The Hague.
26 Ambtelijke Commissie Heroverweging (2014), *IBO Wetenschappelijk onderzoek*. Ministry of Finance, Government of the Netherlands, The Hague, pp. 32.
27 Between 2007 and 2011, the percentage of funding applications approved by the NWO fell from 32% to 23% (NWO Evaluation Committee (2013), *Nieuwe dynamiek, passende governance*, May 2013). See also the recent media reports about the NWO's selection of research proposals.
28 De Goede, M., Hessels, L. (2014), *Feiten en cijfers. Drijfveren van onderzoekers*. Rathenau Institute, The Hague.

There is also a risk that certain groups will be overlooked, not because their performance has been anything less than outstanding but because they excel in areas other than those considered by the standard indicators.

Our ambition is that by 2025 Dutch science should be – and be seen as – a seedbed for top talent. Accordingly, we shall create new opportunities for versatile talent, increase the Netherlands' attractiveness as a research location, and ensure that all talent is deployed in the most appropriate way.

Vision for science[29]

The challenges to which we must now rise include the changing position of Dutch science on the world stage, the growing competition for manpower and resources, the major societal challenges, the new role that scientists are expected to fill, career opportunities for top talent, the excessive pressure to publish and the difficulty of securing research funding. If we fail to address these challenges today, the Netherlands' leading international position will inevitably be undermined. The resultant loss of talent and facilities will decrease our ability to absorb knowledge which has been developed elsewhere. Science, knowledge and innovation are the key to ongoing welfare and prosperity. We will therefore continue to focus on the development of a true learning economy.

The following three chapters examine our three main ambitions in more detail:
1. Dutch science is of worldwide significance.
2. Dutch science has even closer ties with society and the private sector; it has maximum impact.
3. Dutch science continues to be a breeding ground for top talent.

In preparing this vision document, we have drawn from various sources to produce an analysis of the current status of Dutch science and the challenges it faces. The Interdepartmental Policy Review (IBO) report and the AWT's advisory report *Boven het maaiveld* have proven particularly valuable. Both confirm the need for greater coordination, for making appropriate choices to support a National Science Agenda, and for matching research activities to the demands raised by current societal issues.

29 This document is primarily concerned with publicly-financed research undertaken by universities (including the universities of applied sciences) and research institutes. The government's 'Top Sector' policy, innovation policy and applied research are considered insofar as they have some relevance to general science policy.

We have consulted numerous reports published by the Rathenau Institute, KNAW, WRR, AWT, OECD, the European Commission and other organisations, all of which have provided valuable information and insights. Needless to say, we have also followed discussions in the media. In recent months, the press has devoted considerable attention to aspects such as public confidence in science and appropriate incentives, prompted partly by the input of the Science in Transition movement.[30]

This vision document has been produced with the assistance of many organisations and individuals, including young researchers, established scientists, university boards, private sector representatives and members of the public. Their contribution has been extremely valuable and once again confirms how dedicated and self-critical the scientific field is.

With the help of the many reports, consultation meetings and interviews, we have been able to produce an ambitious vision document and are aware of the challenges that lie ahead.

It is an ambitious document because science itself is aware of, and open about, those challenges, which include the necessity of coordinating scientific initiatives more effectively and of reflecting the many aspects of 'talent' when appraising a researcher's performance. Two workshops attended by a broad cross-section of researchers, students, private sector representatives and experts helped us to refine the overall picture of international developments, challenges and promising policy interventions.

A further contribution was made by three debates about 'trust in science', organised on our behalf by the Rathenau Institute, KNAW and WRR. These events, held at the NEMO Science Museum in Amsterdam, provided an excellent opportunity to discuss the 'match' between science and practice with an audience made up of researchers, policy-makers and the general public.[31] The prevailing view is that there must be a closer relationship between science and its practical social and economic applications. In other words, science should be more *responsive*. A majority of people feel that science is currently dominated by 'perverse incentives' such as the pressure to publish in scientific journals. Concepts such as co-creation and 'responsible research and innovation' could usefully be applied to involve citizens and other stakeholders in the process of scientific research.

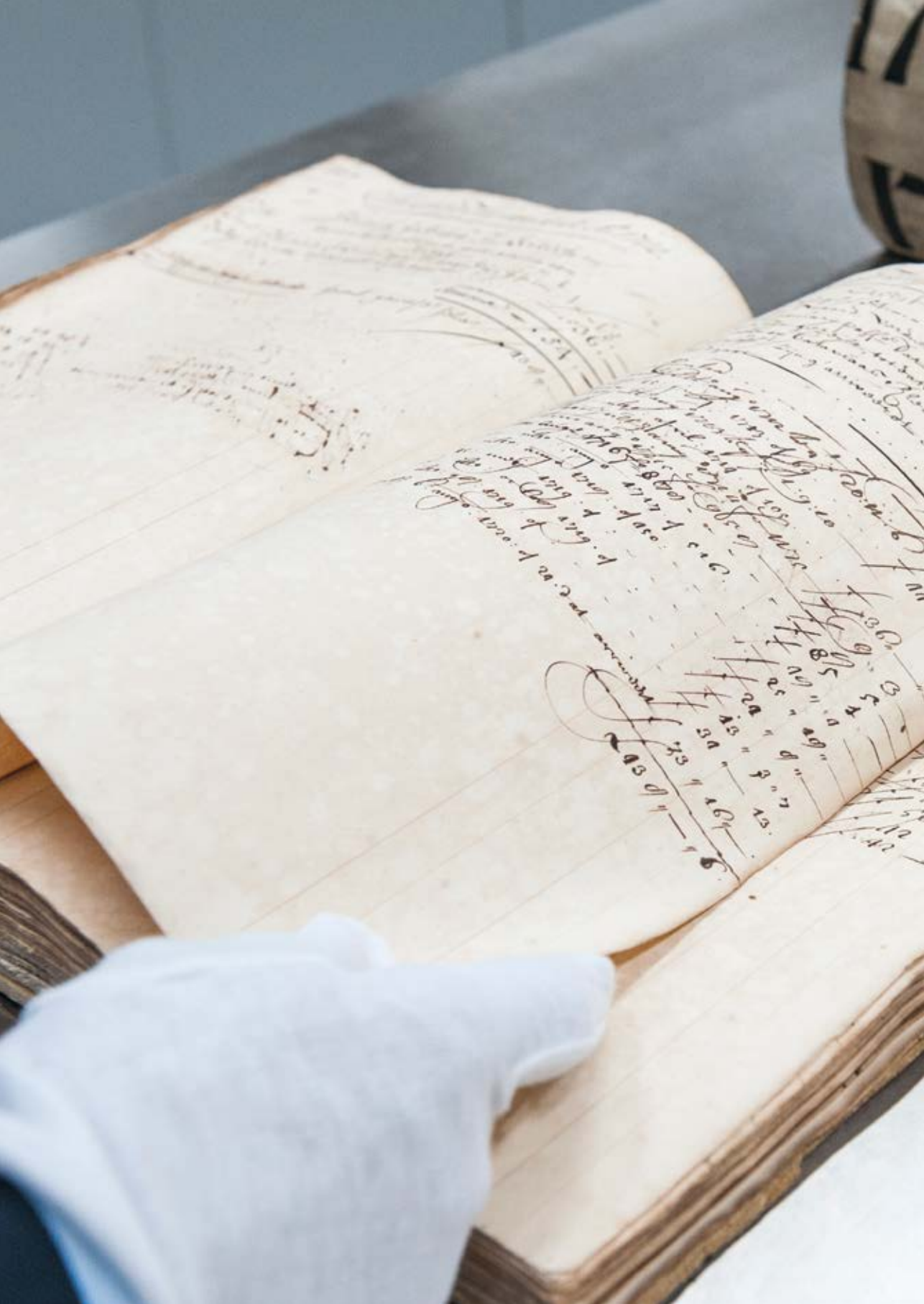
30 In 2013, the Science in Transition platform initiated a large-scale public debate when it issued a position paper considering the effectiveness of Dutch science, higher education in the Netherlands, cooperation with the private sector and the role of science in political decision-making. The group also organised a well-attended conference.
31 Held on 11 and 24 March and 14 April 2014: see De Jonge, J. (2014), *Verslag debatreeks Vertrouwen in de Wetenschap*. Rathenau Institute, The Hague.

This vision document is the first step towards the desired situation. However, a vision alone is not enough. The attainment of our ambitions will demand the commitment of many, engaged in debate, decision-making and action. This document is a precursor to the National Science Agenda, which will set out the priorities and establish the interrelationships between the research programmes of universities, research institutes, private sector companies and other knowledge organisations. There will be an even greater emphasis on the Netherlands' strengths: the areas in which we excel and in which we can stand out from all competitors.

In preparing this vision document, we held numerous discussions with our main stakeholders: the Association of Universities in the Netherlands (VSNU), the Association of Universities of Applied Sciences (VH), the Royal Netherlands Academy of Arts and Sciences (KNAW) and the Netherlands Organisation for Scientific Research (NWO). Interviews were also held with key figures from the 'Top Sectors' and representatives of the VNO-NCW employers' federation, with individual researchers, and with organisations such as the European Commission, The Young Academy, the TO2 alliance (made up of the Netherlands Organisation for Applied Research and four other large technology institutes), Science in Transition, university lecturers, Spinoza Prize winners, our advisory boards and the research executives of various private sector organisations. The government is confident that the scientific field will continue the debate, as will organisations such as KNAW and the Rathenau Institute. At the same time, the government acknowledges that it too must contribute to the debate and, where the public interests so demand, must take appropriate measures to steer developments in the desired direction.

The many meetings and interviews have helped us to formulate the three key challenges outlined above. The following chapters examine these challenges in more detail.

1 Dutch science of worldwide significance



The Netherlands enjoys an excellent position from which it can continue to be a player of international importance. We have a strong basis, with innovative and creative scientists, a well educated population and an excellent science infrastructure. As the IBO report notes, "While other countries show major variation in quality between universities and between research disciplines, all Dutch universities and research institutes can be described as being of high quality."[32] This finding is confirmed by the AWT report which states, "Dutch science shows a series of 'peaks': research groups and institutes which are led by top scientists and which enjoy a worldwide reputation."[33] These peaks stand within a landscape which is itself of high quality: an environment in which talent and creativity can flourish and which provides a firm basis for effective cooperation. These are the key strengths which will enable the Netherlands to claim its place as a world leader.

Creative scientists can flourish in the Netherlands and we wish to retain opportunities for creativity and innovative ideas. This calls for free and independent research.

Leading research is already being conducted in many, extremely diverse areas. Examples include Prof. Leo Kouwenhoven's discovery of the Majorana particle, a breakthrough which may prove of immense importance to the further development of the quantum computer. Prof. Piek Vossen is professor of computational lexicology at VU University Amsterdam. His research will "develop computer models that can assign deeper meaning to language that approximates human understanding and use these models to automatically read and understand text." Prof. Corinne Hofman won the Spinoza Prize 2014 for her research into the colonisation of the Caribbean region, as seen from the perspective of the indigenous population. All three examples support the contention that Dutch research is of global significance. Moreover, many innovative companies owe much of their success to (publicly funded) fundamental research conducted in the Netherlands. Both Bluetooth and WiFi are based on Dutch research.[34] The discovery of the Majorana particle was the result of ten years research, for which Prof. Leo Kouwenhoven and his team at TU Delft were given maximum of freedom and support.

If the Netherlands is to continue performing well at the European and global levels, certain strategic choices must be made and 'smart' connections must be established in order to create synergy between all research initiatives. More than ever, today's complex scientific and societal challenges demand cooperation and a multidisciplinary approach. Cooperation is essential both within the scientific field itself, and between science and private sector organisations and civil society. The result will be a whole which is far greater than the sum of its parts.

32 Ambtelijke Commissie Heroverweging (2014), *IBO Wetenschappelijk onderzoek*. Ministry of Finance, Government of the Netherlands, The Hague.
33 Advisory Council for Science and Technology Policy (2014), *Boven het Maaiveld – focus op wetenschappelijke zwaartepunten*. AWT Advisory no. 86, April 2014.
34 Mazzucato, M. (2013), *The Entrepreneurial State. Debunking Public vs Private Sector Myths*. Anthem Press.

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Free rein for creativity and innovative ideas

We have high expectations of science. In the years ahead, there will be significant advances in the cognitive sciences, robotics and scientific research in the social sciences with large-scale datasets. They could well change society in a manner which is, as yet, unimaginable and unpredictable. We expect that the results of top-level research will enable us to address changing circumstances, whereby we can meet basic human needs such as food, energy, resources, shelter, health, security and education in new ways. Science will contribute to other, less tangible, aspects such as greater contentment and wellbeing, and opportunities for self-development, creativity, learning and critical thinking.

We firmly believe that top-level research demands both a broad basis and focal points, or 'peaks'. The AWT notes that "there can be no peaks without a high plain, and no plain without peaks."[35] This opinion is confirmed by the many interviews and discussions we have held. The combination of a broad basis and a number of focal points will enhance our adaptive, innovative and responsive ability. It will enable us to address the many changes in the world around us, while retaining the close relationship between research and education. For innovation and creative, unexpected interrelationships it is essential that researchers are allowed freedom to pursue their own course.

The scientific strengths of the future will develop from small beginnings. The seeds must be planted; it will be many years before the harvest can be reaped. A free and independent research environment provides the fertile ground in which those seeds will grow, offering the necessary opportunity for renewal and the development of a science system which can respond promptly to new developments. The opportunity to conduct free and independent research is also important in terms of attracting top talent and maintaining the unique combination of education and research for which Dutch universities are renowned. The desired system changes will rely in part on the critical and creative input of young talent.[36]

Dutch science is notable for its broad spectrum of disciplines, with high performance in each. This diversity is a key strength and creates opportunities for cross-pollination between disciplines.

35 'Achieving and maintaining a leading international position is essential. Without clear peaks, the landscape will soon level out, or will develop ever deeper valleys of irrelevant research. The emergence of new players in the global game of knowledge production calls for additional attention for our peaks of global scientific allure. However, the science system as a whole needs more than the peaks alone, and the peaks cannot survive without the underlying basis. Each peak needs input from various allied disciplines together with a supportive ecosystem." (Advisory Council for Science and Technology Policy (2014), *Boven het Maaiveld – focus op wetenschappelijke zwaartepunten*, AWT Advisory no. 86, April 2014).
36 The majority of ground-breaking scientific discoveries are made by researchers in their thirties or forties. See: Jones, B.F. (2010), Age and great invention. *The Review of Economics and Statistics* 92 (1), pp. 1-14.

Cross-pollination between disciplines: SCOOP

The Gravitation Programme proposal SCOOP involves sociologists, historians, psychologists, economists and philosophers who will examine why certain forms of social partnerships survive the test of time while others do not. The programme will consider the implications of change and the form of social partnerships at various levels within society: state, organisation, community and family.

To do full justice to the contributions made by the various disciplines, it is essential that the quality assessment criteria take due account of the differences between them. In the social sciences and humanities, for example, the book is the most prominent form of publication output, while English is not necessarily the language of choice.[37] For this reason, it is important to look beyond the number of publications or the citation impact score to consider other activities in which researchers can excel. For example, social scientists make a significant contribution to public debate and policy development by examining a wide range of issues, from employment to the environment and from health to education.[38]

We believe that allowing researchers full opportunity to express their skills and creativity is an essential precondition in all disciplines. To ensure that this is the case, a number of basic facilities must be in place. A physicist must have access to the data from a particle accelerator, while a biologist might rely on digitised natural history collections. The historian needs time in which to write his monograph. The emergence of new scientific disciplines or societal challenges demands flexibility on the part of researchers. They must be able to anticipate the new circumstances and respond accordingly.[39] The basic facilities are to be financed from the primary (direct) and secondary (indirect) funding flows.[40] There is an ongoing, and extremely relevant, debate about the division of (financial) resources between various disciplines. We regard the National Science Agenda (to which we return later in this document) as an essential instrument in establishing priorities.

37 Commissie Nationaal Plan Toekomst Geesteswetenschappen (2008), *Duurzame Geesteswetenschappen*. Amsterdam University Press, Amsterdam 2008.
38 Commissie Sectorplan Sociale Wetenschappen (2014), *Sociale Wetenschappen: Verantwoord en Verantwoordelijk*. CSSW, Utrecht.
39 The WRR notes the importance of the behavioural sciences to government policy: "In conclusion, the behavioural sciences can make a contribution to better analyses, can help to improve current policy and the use of the underlying instruments, may well open up opportunities for entirely new forms of governance, and imply a more inductive manner of policy development" (Scientific Council for Government Policy (2014), *Met kennis van gedrag beleid maken*. Amsterdam University Press, Amsterdam, 2014).
40 If we examine the current relative activity of the science domains within the primary and secondary funding flows, we see a varied picture. In the primary funding flow, the domains of agriculture, exact sciences and technology have relatively little research capacity, while the humanities and social sciences have relatively high capacity. Within the secondary flow, agricultural sciences, technical sciences, languages and culture all have average research capacity, while natural sciences have relatively high capacity. Cognitive and social sciences have relatively low capacity and economics and law a very low capacity. Figures for medicine and life sciences are incomplete and are therefore not included in this analysis. (OECD MSTI database: Main Science and Technology Indicators: http://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

The recent debates regarding publication pressure demonstrate that it is essential to define the (financial) frameworks for each of the various scientific disciplines.

This is not merely a question of setting priorities, but also one of acknowledging the importance of various forms of scientific output. An article in a journal is one form of output; the incorporation of new insights into educational practice is another. We therefore intend to promote a discussion about how the various forms of output can be compared in a fair and balanced manner. Once again, this will involve taking the differences between disciplines into account.[41]

Although multidisciplinary research is likely to play an increasingly important role in scientific progress, there will still be an important place for monodisciplinary research.[42] Dutch researchers and institutes have already shown the ability to engage in successful multidisciplinary cooperation and this is another key strength of science in the Netherlands. We intend to build upon that strength by seeking new forms of cooperation which will inspire and which will result in unexpected solutions to various problems. The intention is to draw upon the strengths of all disciplines, whether exact sciences, the humanities or social sciences, to create new interrelationships and to examine issues of scientific and societal relevance across the traditional boundaries of those disciplines. The National Science Agenda will provide inspiration, not least by means of the Gravitation Programme (*Zwaartekrachtprogramma*) whereby attention is focused on certain spearhead areas.

Creative cooperation is not confined to the scientific field. There are several inspiring examples of cross-overs between science and other sectors, such as art and design. The University of Twente has established a 'Design Lab' in which the combination of technology, design and the social sciences gives rise to new inspiration and creative ideas. The lab is a meeting place for researchers, students, entrepreneurs, artists and the public sector.

41 A system whereby various forms of scientific talent can be compared and evaluated is described in Paras. 3.1 and 3.2.
42 A comparison against eleven other countries (Australia, Austria, Belgium, Denmark, Finland, Germany, Ireland, Norway, Switzerland, Sweden and the United Kingdom) reveals that the Netherlands has an above-average level of activity in in the social sciences, medical sciences and agricultural sciences, while its activity level in the exact sciences and humanities is below the average for this group. Activity in the technical sciences is average. (OECD MSTI database: Main Science and Technology Indicators: http://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB).

Gravitation Programme (Zwaartekrachtprogramma)

By means of the Gravitation Programme the Dutch government promotes excellent research. It supports the formation of consortia of universities which have the potential to conduct ground-breaking and influential scientific research. The intention is that this research should be of international importance, preferably leading to some breakthrough of global significance. The selection procedure is conducted by NWO on behalf of the Ministry of OCW. The next selection round, in which a total of €131 million will be allocated is expected to be held in 2016.

We intend to maintain direct funding opportunities for independent, 'curiosity-driven' research, in particular through the Innovational Research Incentives Scheme (*Vernieuwingsimpuls*) and the NWO budget for open competition.

The discretion to make their own choices will enable universities to invest in the research lines they regard as having greatest potential. Even high-risk and long-term research will then have a chance.

Two special measures are to be introduced to bolster funding opportunities:

€50 million extra for matching

We shall increase the knowledge institutes' investment ability by contributing towards their matching obligation.[43] Financial resources within the primary funding flow will then remain available for free, independent research. Dutch science has played a prominent role in the most recent European Framework programme, from which it has derived significant (financial) benefit.[44] The budget for the European Horizon 2020 research programme has been substantially increased. In order to build upon past success, the government will reserve an additional €50 million to offset the matching obligation of universities, research institutes (both fundamental and applied) and the universities of applied sciences. This will provide an extra incentive to compete for European projects since institutes will be able to cover part of their matching obligation from this additional €50 million rather than having to call on their primary budget.

43 A European subsidy is usually not enough to cover all costs of a research project. The institute must pay the costs of facilities, support services, etc. which are not covered by the subsidy amount. This is termed 'matching'.
44 See communication to the House of Representatives from the Ministries of OCW and EZ dated 19 June 2014 concerning Netherlands' participation in the Seventh Framework Programme for Research and Technological Development (KP7): Parliamentary Proceedings 2013-2014, 21 501-31, no. 343).

This arrangement will be developed by the Ministry of OCW together with NWO as the administrator, and in coordination with the Ministry of Economic Affairs. A direct relationship with the approval of Horizon 2020 calls is to be established, whereby the payment made by the government will be a fixed percentage of the amount awarded by the European Commission. In keeping with the motion tabled by member A.H. Flierman and adopted by the Senate in March 2014[45], the scheme will be as simple and transparent as possible, with a minimum of 'red tape'.

Greater stability in university funding

We shall increase the stability and predictability of university funding, in line with the recommendations of the IBO. In future, we shall apply three-year averages whereby a significant spike or dip in, say, the number of doctorates awarded in any one year will not have a direct effect on the amount of research funding made available by government. Universities will be able to make more accurate revenue projections.
The number of completed PhD research projects is one of several indicators which determine the amount of direct funding a university receives. A fixed amount is payable in respect of each doctorate awarded. Because there has been a significant increase in the number of PhD awards, the proportion of direct research funding represented by this component has also increased, reaching 24.1% in 2015. This is considered disproportionate and a cap is to be applied. Rather than a fixed amount for each doctorate, universities will receive no more than 20% of their total budget in the form of direct funding based on their output of PhD graduates. Any further increase will therefore have less effect on revenue, which provides greater stability and predictability. These measures will enable institutes to look further ahead in their budget planning and longer-term investment decisions.

1.2
Towards a National Science Agenda, a unifying agenda for research in The Netherlands

Strengthening our strengths

Science and scientists need space and opportunity to work as they see fit. However, this is not enough. The Dutch science system is effective by virtue of its 'smart' combination of freedom, cooperation, competition, concern for quality, good infrastructure and the ability to make sound choices. These strengths are to be safeguarded; they lie at the very roots of the culture of excellence. Competition forms part of that culture and provides an important motor for scientific progress. The Dutch system of competitive funding works well because it is supported by an effective, internationally oriented evaluation system which seeks to safeguard the quality

45 Senate Proceedings 2013-2014, no. 33750 XIII, C.

of all research activities and output. The introduction of 'research evaluations' in the 1990s was an important factor in the development of a competitive culture in which excellence is not only expected but demanded. The Standard Evaluation Protocol (SEP)[46] has made a significant contribution to the quality of fundamental research in the Netherlands and is regarded as an exemplar by the international academic community. The new and improved SEP will ensure that the tradition of effective quality control is not only continued but raised to a new level.[47] There are a number of changes, the most significant of which include ongoing attention for the societal relevance of research alongside its scientific quality. Productivity is no longer an assessment criterion in its own right, whereby the SEP will help to counter the publication culture which has developed within some disciplines.

The new SEP is a major step in the right direction but further action is required if the Netherlands is to maintain its leading international position. There are several areas of research in which we are indeed acknowledged as world leaders. At the same time, we accept that there are certain areas in which we are unlikely to make any significant international impact.[48] In the past decade, scientific output has grown by some thirty per cent.[49]

Given the increasing competition, we cannot be the best in everything. Choices must therefore be made, and we must enter into effective partnerships with colleagues and counterparts at home and abroad.

In doing so, we shall intensify our focus on those areas in which the Netherlands already excels. We shall strive to facilitate international cooperation, and we shall structure our system in such a way that we are flexible enough to respond promptly to social and scientific challenges which have yet to emerge. This will avoid fragmentation and will ensure that Dutch science continues to play a very prominent role on the international stage.

The government therefore intends to formulate a broad-based National Science Agenda (see Para. 1.2.1). The process will give rise to a number of supporting measures, including a new framework agreement with the universities (Para. 1.2.2), a more prominent role for the NWO (Para. 1.2.3), strategic action to create or improve large-scale infrastructure (Para. 1.2.4) and the development of a more responsive and dynamic system of institutions (Para. 1.2.5).

46 The SEP has been jointly produced by VSNU, NWO and KNAW. It forms the basis for the evaluation of all scientific research conducted in the Netherlands.
47 Communication to the House of Representatives dated 21 March 2014 accompanying the revised Standard Evaluation Protocol (Parliamentary Proceedings 2013-2014, 29 338, no. 132).
48 Advisory Council for Science and Technology Policy (2014), *Boven het Maaiveld – focus op wetenschappelijke zwaartepunten*. AWT Advisory no. 86, April 2014.
49 National Science Foundation (2014), *Science and Engineering Indicators 2014*, Arlington VA: National Science Foundation, Table 5-20.

1.2.1
Working together in ground-breaking research

The National Science Agenda is to be a 'co-creation' of researchers, scientists, the private sector, civil society, the government and other stakeholders. The ability to cooperate with others is one of the key strengths of Dutch researchers and institutes, and it is a strength that we wish to exploit to the full through the National Science Agenda. The agenda will include a limited number of themes, selected on the basis of existing scientific strengths, societal challenges and economic opportunities. The research field as a whole will combine its strengths to achieve the greatest possible impact. With its world-class researchers, key expertise, innovative companies and effective social entrepreneurs, the Netherlands is in an excellent position from which to move onwards and upwards. The National Science Agenda will introduce the necessary cross-pollination and cooperation between the various partners, whereby the resultant whole is far greater than the sum of its parts. Science can then excel and, through relevant applied and practical research, will make an even more significant contribution to our quality of life, our society and our economy.

The National Science Agenda will appeal to the imagination; it will inspire and challenge both the research field and society itself to achieve momentous breakthroughs. It will create a better match between research on the one hand, and social and economic needs and opportunities on the other. It will clearly set out those areas in which the Netherlands is to stand out through truly excellent research. By raising the profile of Dutch science with its own agenda, we shall strengthen our position within international partnerships. In specific areas, the Netherlands will take the lead in those partnerships. This is important if we are to attract top talent and safeguard the interests of our knowledge-intensive industry.

International examples of science agendas

Various countries have produced a research agenda which sets out the national research priorities. They include Denmark, Germany, Switzerland, Ireland and the United Kingdom. Denmark's agenda was produced further to an extensive survey among various stakeholders who were invited to suggest its key themes. The resultant RESEARCH2020 'catalogue' is intended as a source of inspiration for the research programmes of universities, national laboratories, private foundations and individual researchers, while it also seeks to involve all parties in finding solutions to the societal challenges at both national and global level. The main themes of RESEARCH2020 are: a society with a green economy, a society with health and quality of life, a high-tech society with innovation capacity, an efficient and competitive society, and a competent, cohesive society.

The production of the National Science Agenda will follow the international trend of 'co-creation', whereby the government guides the joint process of selecting spearhead areas in which researchers and civil society will work alongside each other.

Another good example is the European research and innovation programme Horizon 2020, which sets out a number of 'Grand Challenges' intended to inspire researchers to contribute towards solutions in areas such as healthy ageing, sustainable transport and food security. It is hoped that cooperation between researchers in diverse disciplines, the private sector, social pioneers and government will result in significant breakthroughs and new opportunities, both social and economic.

The National Science Agenda meets a clear requirement[50] and will build upon various existing and successful initiatives such as the 'Top Sector' policy, the current sector plans, the knowledge institutes' profiling plans, (international) alliances, and ongoing research programmes within institutes and regional clusters.

The government will invite the 'knowledge coalition', which currently comprises VSNU, KNAW, NWO, the Association of Universities of Applied Sciences, TO2, VNO-NCW and MKB Nederland, to take the lead and to produce a draft version of the proposed research agenda no later than the autumn of 2015.

They will involve all relevant stakeholders, including The Young Academy, the Netherlands Federation of University Medical Centres (NFU), relevant ministries, regional authorities, key figures in the Top Sectors, and national institutes such as the KNMI and RIVM. It is important that the new agenda does not rely solely on the existing institutional framework. Scientists, researchers and independent creative thinkers will also be invited to contribute. It seems appropriate to approach Spinoza Prize winners, the National Think-tank, Chief Technology Officers, innovative entrepreneurs and key figures in the public sector and civil society organisations. The knowledge coalition's deliberations will have an independent chair, with administrative support at NWO.

Societal themes combined with key areas of scientific interest

Building on the existing 'Top Sector policy', the National Science Agenda will identify a number of societal themes as well as research areas in which the Netherlands wishes to excel.

50 Ambtelijke Commissie Heroverweging (2014), *IBO Wetenschappelijk onderzoek*. Ministry of Finance, Government of the Netherlands, The Hague; Open letter from the Knowledge Coalition to the ministers of OCW and EZ, 23 June 2014. (http://www.vsnu.nl/files/documenten/Nieuwsberichten/Manifest%202014.pdf); Parliamentary proceedings 2013-2014, 2014D18582.

The societal themes will be comparable to the EU's 'Grand Challenges' but with a national focus. They will be selected on the basis of societal and economic relevance in the specific Dutch situation, whereupon they can be aligned with the existing or intended strengths, both scientific and economic. The selection will also take into account the choices made by other countries. As with Horizon 2020, the social sciences and humanities will form an integral component of the agenda, since the societal themes involve complex issues which will often demand knowledge drawn from a wide range of disciplines. NWO has made the first steps toward a full agenda in its most recent (draft) strategy plan, which identifies the following themes: quality of life, the circular economy, a resilient society, the building blocks of life, complexity (dealing with uncertainty) and Big Data.[51]

Cooperation between science and civil society organisations: Nerada

An example of ongoing cooperation between science, the private sector and civil society is the research project led by Prof. Mark van Loosdrecht, professor of Environmental Biotechnology and Water Treatment at TU Delft. He combines fundamental research in microbial ecology with applied concepts in physics, chemistry and bio-engineering. In association with private sector engineering companies, his research group uses the resultant knowledge to produce innovative practical solutions such as the sustainable and efficient water treatment technology 'Nerada'. The first wastewater treatment plant based solely on this technology is in Epe (NL) and became operational in May 2012. It has since been followed by others in the United Kingdom, Portugal, South Africa and Brazil.

Research within the societal themes is thus inspired by the quest for practical solutions in certain domains. In the key areas of scientific interest, it is not necessary to identify the desired solution, or even the domain, beforehand. This research is more fundamental in nature and addresses 'promising' themes, whereby a coordinated national approach could increase the likelihood of arriving at one or more significant breakthroughs. The key areas of scientific interest can therefore be regarded as a seedbed for scientific progress, with the prospect of social or economic applications which will serve to reinforce the Netherlands' competitive position. For this reason, it is essential that the private sector and civil society are fully involved in the process.

51 NWO has consulted over one hundred affiliated researchers in order to identify six themes in which Dutch science can make a significant contribution by virtue of its established strengths. These themes are concerned with various societal challenges (in line with the European Grand Challenges) and the economic Top Sectors. The relevant research will have the potential to arrive at significant breakthroughs.

Strengthening connections, breaking down boundaries

The agenda is not concerned with all research to be conducted in the years ahead but specifically with addressing the selected themes, whereby cooperation and coordination will provide added value. Research which would be less efficient or effective when conducted by a single institute can be included in the agenda. In other words, while everything in the research agenda is important, not everything that is important will necessarily be included in the agenda. The purpose of the National Science Agenda is to inspire and to strengthen the connections between institutes, disciplines and sectors. It must break down the existing boundaries between them and promote cooperation. This will strengthen and revitalise the existing programmes and policies. The National Science Agenda will provide optimum coordination with Horizon 2020, be closely allied to the 'Top Sector' approach, and should increase the involvement of government, regional authorities, the private sector and the TO2 institutes. Its inspirational effect and relevance to actual societal needs will increase the likelihood of securing contract research funding in the priority themes.

The knowledge coalition will develop the National Science Agenda in accordance with the principles set out above. The government will supervise the process and eventually approve the resultant document.

The National Science Agenda in practice

Once the agenda has been finalised and approved, it must be implemented in practice, i.e. in the work of researchers, the private sector and civil society organisations. In principle, each partner is responsible for taking the necessary action. The knowledge coalition will submit an annual progress report. There will be ongoing monitoring to ensure that the measures do not have any unforeseen and undesirable effects, such as creating an imbalance in funding opportunities for researchers and research groups.

The government will oversee the implementation process, provide the necessary assistance to institutes, and encourage the adoption of the agenda through both policy measures and financial measures.

More specifically:

- The National Science Agenda will play a prominent part in the profiling of universities. A proportion of the direct funding, primarily that released by the cap on funding in respect of the number of PhD awards, is to be used to support universities' profiling efforts (see Para. 1.2.2).

- The NWO strategic plan will describe how its existing funding instruments are to be used to support the priorities of the National Science Agenda. As announced in the government's coalition agreement, an annual budget of €275 million has been made available for programmatic research to support the development of the Top Sectors, and the current public-private partnership arrangements for excellent fundamental research are to be maintained. We shall request NWO and the Top Sectors to align the priorities for research receiving indirect funding and the innovation contracts with the contents of the National Science Agenda (see Para. 1.2.3).

- Funding via NWO awards will depend in part on the investments made by the participating partners (matching and co-financing). Proposals will be assessed more favourably where there is cooperation with and between private sector companies and institutes for applied research, possibly in the form of regional alliances (see Para. 2.7). This will leverage the financial commitment of the private partners, civil society and (regional) authorities. By focusing on the science agenda, the Top Sectors and the profiling agreements of the universities, NWO will be able to ensure that both direct and indirect funding flows are more targeted in terms of supporting the national priorities.

- The National Science Agenda will offer greater opportunity to link fundamental research with applied research and valorisation.

- The priorities set out in the National Science Agenda will support investment decisions with regard to infrastructure (see Para. 1.2.4).

- The National Science Agenda will play a part in the evaluation and reform of the institutional system (see Para. 1.2.5).

- In awarding the new Gravitation programme (*Zwaartekrachtprogramma*) grants in 2016, particular attention will be devoted to project proposals which address the spearheads of the National Science Agenda. As always, however, the main assessment criterion for all proposals will be scientific quality, which must be at the highest possible level, i.e. 'excellent'.

Neither science nor society stands still. New societal challenges will emerge, as will new economic opportunities. There may well be significant scientific breakthroughs. It is essential that the National Science Agenda is a living document, able to anticipate and respond to current developments. The entire agenda will therefore be reviewed and updated every seven years.

Midterm review of performance agreements

On 3 November 2014, the Higher Education and Research Review Committee presented its recommendations further to the midterm review of the performance agreements to the Minister for Education, Culture and Sciencen and the State Secretary for Economic Affairs. The Committee had assessed the progress made by universities and universities of applied sciences in implementing their profiling plans, which was adjudged satisfactory. All universities have worked consistently to achieve differentiation in education and to develop focus areas. The Committee noted that the restructuring of both education and research activities is increasingly based on the contents of the profiling plans developed thus far. There have been efforts to achieve clustering and cooperation, while in some instances activities have been discontinued. The Committee also notes that efforts to achieve focus and mass take advantage of internal strengths, while choices are influenced by external opportunities. Finally, the Commission finds the development of Centres of Expertise by the universities of applied sciences in the Top Sectors and the sectors education and healthcare to be satisfactory overall.

1.2.2 Framework agreement with universities

The government wishes to enter into a new framework agreement with the universities in 2015. The National Science Agenda will play a significant part in determining its content. The performance agreements made for the period 2013-2016 have enabled the universities to make significant progress in their profiling activities (see inset).

The new framework agreement will take the process to the next level, as universities produce a strategy plan which clearly states the profile of their research. Their use of direct government funding is expected to make a significant contribution to the attainment of the agenda's objectives.

Financial implications of the framework agreement:

- The purpose of amending the direct funding arrangements is to arrive at measures which will support universities' performance and profiling to the greatest extent possible. The IBO report stresses the importance of achieving greater stability and predictability of revenue and budgets. This is not only relevant in terms of the continuity of longer-term, high-risk research, but it also forms a precondition for multi-year agreements and the production of a long-term policy framework. The manner in which the desired stability will be achieved is described in Para. 1.1.

- Approximately 4% to 5% of research funding[52] will be allocated differently in the future, with the component linked to the number of PhD awards capped at 20%. The surplus made available will then be used to support research which contributes to the objectives of the National Science Agenda. This provides an incentive and support for universities to align their profiling with the priorities of the National Science Agenda, over and above the requirements of the performance agreements.

1.2.3
A new role for NWO

Competition does much to drive scientific progress. Effective competition is supported by NWO's excellence-driven instruments, in which NWO ensures that only the best research proposals, submitted by the best researchers, are selected. This is NWO's primary responsibility.

According to the commission which reviewed NWO's own performance, the organisation fulfils this responsibility admirably, and the excellence of Dutch research is largely the result of NWO's input. NWO enjoys a high international reputation, especially at the European level.[53] Nevertheless, as the 2013 evaluation commission stressed, NWO must move with the times. It must adapt.

ADBTOPconsult[54] has been approached for advice in the change process, which will be based in part on the contents of this vision document and pursued along the following lines:[55]

- In future, NWO will do more to define its position in relation to other organisations, both scientific and societal, including the private sector and the international network. To achieve a more strategic position, in the context of the National Science Agenda for example, NWO must be firmly embedded within the network of organisations. Moreover, the NWO agenda must be more closely aligned with developments in national and European policy. NWO will play a prominent role in implementing the National Science Agenda, but to do so effectively it must become more responsive. It must actively reach out to stakeholders, bringing them together and fostering commitment. This demands greater budgetary flexibility within NWO and throughout the NWO organisation, and it calls for interdisciplinary cooperation.

52 At present, the profiling agreements (which form an important component of the performance agreements with the universities) are directly linked to the funding of education rather to that of research.
53 NWO Evaluation Commission (2013). *Nieuwe dynamiek, passende governance*, May 2013.
54 Van der Steenhoven K., Aalbersberg, M. (2014), *Van lappendeken naar een nationaal discours en centrale programmering - Advies voor een nieuwe governance, werkwijze en organisatiestructuur voor NWO*, ABDTOPConsult, The Hague.
55 Those aspects of the advisory report which are described in this vision document have been subject to consultation with NWO; our position with regard to other elements has yet to be determined.

In future, NWO will work on the basis of a single cohesive programme, taking advice from a large and diverse group of stakeholders such as universities, researchers, ministries, the private sector and civil society.

- The governance structure of NWO is to be revised. We endorse the analysis presented in the evaluation report and the subsequent recommendations. The current NWO organisation is too compartmentalised. In the words of the evaluation commission, it is "a disorderly patchwork." This situation has implications at all levels of NWO.

- To expedite the change process, the authority and responsibility of NWO's central governance apparatus is to be increased, while that of the various institutes, divisions and departments will be gradually reduced. In other words, these units will become less autonomous. Overall management will become the responsibility of an Executive Board, answerable to a Supervisory Board with members drawn from a wide range of disciplines and backgrounds. This will enhance management effectiveness. All decisions with regard to programming, instruments and budget allocation are to be made at Executive Board level. Ongoing contact with the scientific field will remain essential.

- In the interests of adaptability, the underlying administrative organisation is also to be restructured. Organisational ability and best practices, such as close contact with all disciplines in the scientific field and with the societal partners, are to be firmly embedded within the new organisation. The current separate offices and departments will be merged to form a single organisation which is able to respond to new developments promptly and effectively, and which can apply the experience gained in areas such as public-private partnership on a wider scale. The scientists who currently play a vital part in the administrative committees of the various institutes will be given an equally important role within the new organisation, such as membership of the Scientific Council. All parties and organisations which currently have some influence in the governance of NWO will continue to do so in the new situation. The management of the various institutes will fall directly below that of the organisation as a whole, retaining the strict dividing line between the institutes and the allocation of grants and subsidies. The position of ZonMw will also change, as will its relationship with NWO. The necessary preparatory legislation is being drafted by the Minister for Health and Welfare, in close consultation with the State Secretary for Education, Culture and Science.

- The new governance structure includes strong and effective supervision, whereby all decisions with regard to strategy, policy and operational matters are made at the highest level. The arrangements will reduce the management workload, promote effective decision-making and flexibility, while also ensuring that interdisciplinary initiatives are more firmly embedded. Financial resources can be divided among the various areas of scientific interest in a more flexible way. Stakeholders will find the new NWO organisation far more transparent.

The changes demand the amendment of the NWO Act. Until this is accomplished, the new structure and procedures will be adopted to the greatest extent possible within the existing legislative frameworks in a transitional 'as if' phase. Even in this phase, NWO will be able to make an important contribution to the development of the National Science Agenda. With its new governance structure and organization, it will be the most appropriate party to implement the agenda and update it as required.

1.2.4
A more strategic approach to large-scale infrastructure

State-of-the-art facilities do much to attract top research talent. They facilitate and promote cooperation across the traditional boundaries between institutes and disciplines.

Science is increasingly dependent on large-scale research facilities, which are extremely diverse in nature: laboratories with specialised (and expensive) equipment, particle accelerators, large telescopes, high-flux magnets, extensive databases and research collections, to give but a few examples. Ongoing digitisation has created a need for different research infrastructures and new forms of cooperation such as virtual research communities.

Large-scale infrastructure: ELIXIR NL

ELIXIR NL processes biological and biomedical data as part of the international ELIXIR consortium. It uses innovative Big Data IT solutions such as a secure virtual environment, and applies smart solutions to collate and analyse large volumes of data from various sources.

The IT infrastructure warrants special attention. Almost all research domains now call for faster connections, rapid analysis and greater data storage capacity, with that data available 'on demand'. IT is a 'common' technology required by most if not all scientific disciplines. As the possibilities of IT itself grow, a new form of scientific research is emerging which involves the processing of huge volumes of data. This research reveals previously undetected patterns and interactions, thus opening up many new horizons.

The process of establishing a new facility requires coordination at the national level, and often at the international level. Joint usage must be organised and maintenance funding secured. Regardless of the strategic choices which must be made in terms of investment in specific facilities, the ongoing digitisation within all scientific disciplines serves to emphasise the importance of creating and maintaining a high-quality IT infrastructure. Over the past 25 years, the Netherlands has established a leading position in this respect. It has an exceptionally good 'e-infrastructure' developed by the SURF partnership, which enhances the country's ability to attract top researchers and innovative industry. If this position is to be maintained, however, the IT infrastructure must be updated and upgraded in the years ahead, and we must devote greater attention to aspects such as high-performance computing, networks, e-Science, data storage and data analysis.

In many cases, the demand for large-scale facilities already exceeds supply by a significant margin. Individual knowledge institutes are not in a position to purchase the really large facilities outright or to provide the necessary maintenance budget.[56] Participation in the large-scale international infrastructure cannot be financed from the regular direct funding flow or via NWO. The withdrawal of support under the Economic Structure Strengthening Fund (FES) has therefore had a major impact on the large-scale infrastructure and data facilities, particularly in areas such as health and healthcare.[57] The discontinuation of the FES arrangements has also had serious implications for the technological institutes and a large number of ongoing research projects.
There are many international projects which demand careful consideration of whether participation will be useful, and if so, in what form. The Netherlands is an active member of the European Strategy Forum on Research Infrastructures (ESFRI), in which European countries jointly set the agenda for the development and use of large-scale research facilities. Decisions are supported by 'landscape analyses' of the various areas of scientific interest, while the forum also devotes attention to European societal challenges.

Decision-making with regard to investments in large-scale research infrastructure is extremely complex. Universities have generally been successful in making the right choices with regard to new investments and the maintenance of existing facilities. In addition, the *National Roadmap for Large-scale Research Facilities* has proven effective in facilitating new investments. The roadmap was introduced to identify facilities which are of particular importance, whether in terms of fundamental research or ground-breaking scientific research to drive societal and economic innovation, and the manner in which they are to be financed. Further improvements are possible and choices with regard to investments in large-scale scientific infrastructure must now be made.

56 The pressure on the available resources within the first (direct) funding flow raises certain risks in terms of 'the development and maintenance of large-scale infrastructure and data facilities'. There is a general desire to avoid undue fragmentation of the indirect funding flow, also with regard to the large-scale infrastructure and data facilities, which are assessed in combination (Ambtelijke Commissie Heroverweging (2014), *IBO Wetenschappelijk onderzoek*. Ministry of Finance, Government of the Netherlands, The Hague).
57 Ambtelijke Commissie Heroverweging (2014), *IBO Wetenschappelijk onderzoek*. Ministry of Finance, Government of the Netherlands, The Hague, pp. 30.

Permanent Commission for Large-scale Scientific Infrastructure

To ensure that such choices are made in a strategic and coordinated manner, a permanent commission for large-scale scientific infrastructure is to be established within NWO.

This commission will be concerned with facilities used by universities, knowledge institutes, applied research organisations (TO2) and national institutes such as KNMI. It will seek effective coordination in order to avoid imprudent investments and it will promote efficient usage of the facilities. The commission will include representatives of the knowledge coalition partners. In contrast to the current situation, in which investment decisions are made by various ad-hoc committees, the new commission will devote ongoing attention to investment opportunities which will enhance the scientific infrastructure. Resources from the direct and indirect funding flows will be applied in an effective and fully transparent manner, whereby synergy with the investments made by the institutes of applied research will be sought. This approach is based on the recommendations of the AWT's advisory report *Maatwerk in onderzoeksinfrastructuur* ('A custom-made research infrastructure').[58]

We shall request universities and research institutes to provide accountability for their use of infrastructural funding, to follow the recommendations of the roadmap as closely as possible, and to submit regular reports. This will also reveal the exceptional costs incurred in maintaining the (technical) research infrastructure, such as the Reactor Institute in Delft, which will assist the permanent commission in arriving at a fully integrated consideration of the investment requirement.

Financial resources made available in the form of indirect funding are intended to support the upgrading of the scientific infrastructure. They will be allocated by NWO in consultation with the permanent commission. The government intends to examine if and how the *Toekomstfonds* ('Future Fund') can also be used to support investments in facilities for both fundamental and applied research.[59]

There is to be a system of 'pooling', with the national resources allocated in respect of infrastructure linked to the resources at regional level and those of the research institutes, private parties and organisations undertaking applied research. This is in the interests of maximum synergy in both investment and the actual use of the infrastructure. The permanent commission will maintain contact with all parties, seeking their input and informing them of developments.

58 Adviesraad voor Wetenschaps- en Technologiebeleid (2013), *Maatwerk in onderzoeksinfrastructuur, Strategisch investeren in grootschalige onderzoeksfaciliteiten*. AWT Advisory no. 80, April 2013.
59 See letter from the Minister for Economic Affairs regarding the 'Future Fund' (*toekomstfonds*), Parliamentary Proceedings 2014-2015, 34 000 XIII, no. 5.

1.2.5
A more responsive and dynamic system of institutes

The various institutes which fall under the aegis of NWO and KNAW form an integral part of the Dutch science landscape and are acknowledged to be of excellent quality. They complement the universities. We intend to use these organisations as the basis of a responsive and dynamic system, in which each institute is not only 'excellent' but fulfils a specific function within the National Science Agenda.

Where necessary, the institutes will adapt their programmes in line with the agenda in order to maximise their contribution.

They will be subject to a regular evaluation examining their international quality, national function and added value. This evaluation will be concerned not only with each individual institute, but will consider their cohesion and mutual relevance. We shall request NWO and KNAW to conduct a broad-based evaluation at regular intervals, perhaps once every four years. The results may prompt the establishment of new institutes or a revision of the mission of the existing institutes. It is also possible that certain organisations are deemed to have no viable future as an independent, national institute. Options will then include their assimilation into another institute or university structure, or even closure. When allocating funding to the institutes, NWO and KNAW will take the findings of the evaluations into account, as well as the relevance of an institute's work to the National Science Agenda.

2 Science with maximum impact

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Science and research produce structured knowledge of our world. That knowledge is impossible to acquire through any other means. A characteristic of science is that it constantly asks questions: each question and each answer prompts a further question. An important function of Dutch science is to contribute to worldwide knowledge production. However, knowledge leads to relevance to society when it is shared, and when it is applied to create real-life solutions or products.[60] Knowledge co-creation and knowledge circulation ('dissemination') are therefore key concepts underpinning the relationship between science and society.

Science gives much to society. At the same time, it is essential that science is aware of society's needs, and that researchers are inspired by the actual demand for knowledge. The National Science Agenda, in which scientific strengths are directly linked to the societal challenges and opportunities, will form the main source of inspiration for all researchers.

At one time it was held that knowledge circulation and valorisation should take place only when the knowledge is fully mature. This idea is now seen as outdated. We believe that there must be full awareness of the demand for knowledge at the very beginning of the development chain, and that the potential users of that knowledge should be identified at the earliest possible opportunity. According to the principles of co-creation, science and researchers will develop new knowledge of practical relevance in cooperation with the societal partners. Science can then draw on the unique knowledge and skills of the end users.[61]

Smart Urban Regions of the Future

The 'Smart Urban Regions of the Future' project is a joint initiative of NWO, the Ministry of Infrastructure and the Environment and the Ministry of the Interior and Kingdom Relations. It is a prime example of how end users can be involved in a science project in an effective and 'smart' way. The content, structure and focus of the project were initially devised by a panel of scientific experts, whereupon two so-called 'carrefour' meetings were held to discuss the societal challenges faced by urban regions. These meetings were attended by a broad range of participants, including representatives of policy departments, planning agencies, civil society and researchers in various disciplines.

60 The European Horizon 2020 programme distinguishes three funding targets: Excellent Science, Industrial Leadership and Societal Challenges.
61 See Boon, W., Horlings, E. (ed) (2013), *Kenniscoproductie voor de grote maatschappelijke uitdagingen*, SciSa report 1329, Rathenau Institute, The Hague.

There are many forms of valorisation.

At this point it is appropriate to emphasise the very broad definition of valorisation that we apply. It refers not only to the use of knowledge to gain some economic advantage, but also its use with a view to solving societal issues or contributing to the public debate.

It is important that the development of knowledge and the practical application of that knowledge are interlinked within societal sectors such as health and healthcare, safety and security, infrastructure, education and energy.

Impact in education

A good example of research which is of practical relevance to education is that conducted by Prof. Marja van den Heuvel-Panhuizen of Utrecht University. She has shown that the development of numeracy skills in young children is greatly enhanced by the use of age-appropriate picture books, in combination with a teaching style based on prompting, probing, questioning and active participation. Children taught using this approach showed 22% more progress than those taught using the standard early arithmetic methods (without picture books). Prof. Van den Heuvel-Panhuizen's scientific output includes a guide which helps teachers determine the educational value of any given picture book.

The Scientific Council for Government Policy recommends that particular attention should be devoted to the circulation of knowledge and skills in order to strengthen responsiveness yet further. The Council therefore proposes an appropriately ambitious agenda which will promote high-quality education, scientific research of international importance and innovative industry. Effective knowledge circulation demands good connections between research institutes, the private sector and civil society. Those connections will help to increase absorptive ability, i.e. the ability to identify useful (new) knowledge, to locate knowledge developed elsewhere, to adopt that knowledge and to use it in a practical and productive manner.[62] According to the OECD, the strengths of the Dutch science and innovation system lie in the use of public-private partnerships and the presence of institutes which conduct fundamental and applied research in coherence. The success factor is the horizontal and vertical interaction between various knowledge partners who focus on certain niches, thus creating focal points within science and innovation.

62 Scientific Council for Government Policy (2013), *Naar een lerende economie*. Amsterdam University Press, Amsterdam.

Establishing the right kind of connection will achieve the best possible match between science and society. The interaction between science, industry and society is complex and calls for ongoing dialogue.

The dialogue between science and society includes a significant ethical component. Recent controversies such as those surrounding climate science and preventive vaccination for cervical cancer illustrate the importance of engaging in the debate about the societal implications of new solutions and products at the earliest possible opportunity.[63] By involving the (end) users of knowledge and other stakeholders in the research process, whereby all are invited to explore the potential societal impact, the role that research plays in solving the major societal challenges will be enhanced. Within the European context we contribute to 'Responsible Research and Innovation', i.e. research that anticipates and assesses societal expectations and results in responsible and ethical innovations. It is a cross-cutting issue in the Horizon 2020 programme and we call upon the Dutch research community to embrace this principle and be inspired by the principle in other activities as well.[64]

In 2025, the relationship between science and society will have changed. To gain a clear impression of the new situation, the following section examines how the stakeholders will be involved in science in 2025, how they will exert their influence, and how they will use the outputs of science and research. In other words, we examine science from the perspective of these various stakeholders, considering the participative role of the public, the government, the private sector, universities of applied sciences and the educational field. Most importantly, we consider the connections and relationship between these parties and the scientific field.[65]

2.1
Open Access as the catalyst of knowledge sharing

The use of IT facilitates and catalyses interaction between science and society. Information Technology is therefore an important precondition of effective valorisation and knowledge circulation. By ensuring that scientific publications and underlying data are more readily available, we can encourage co-production on the part of the societal partners.[66]

63 Blankesteijn, M., Munnichs, G., Van Drooge, L. (2014), *Wetenschap als strijdtoneel: publieke controversen rond wetenschap en beleid*. Rathenau Institute, The Hague.
64 European Commission (2012), *Responsible Research and Innovation: Europe's ability to respond to societal challenges.* European Union, 2012.
65 The WRR points to the necessity of working towards a 'learning economy' in which knowledge and skills can circulate. It then becomes important to encourage interaction between universities, the universities of applied sciences, TO2 organisations, the private sector, government authorities and civil society. This interaction is a precondition of effective knowledge circulation and of valorisation. The European Commission has recommended the Netherlands to promote investments in private research and development, and to create closer ties between the scientific world and the private sector. (European Commission, (2012), *Recommendation for a Council Recommendation on the Netherlands' 2012 national reform programme and delivering a Council opinion on the Netherlands' stability programme for 2012-2015*. Brussel, May 2012).
66 European Commission (2014), *Background document 'Science 2.0': Science in transition*, pp. 1.

Such developments will fundamentally change the nature of science and research. The terms now current at the European level is 'Open Science'. The European Commission together with the Member States and the scientific world explore the likely implications of Open Science and the most appropriate response. The Netherlands is playing a full part in this process.

Key considerations are 'Open Access' and 'Open Data'. The basic principle is that all information and publications should be available to all members of society, since it is they who have paid for the development of the knowledge concerned. Moreover, access to information is a precondition of effective cooperation between researchers themselves, enhancing both the speed and integrity of research, while access to knowledge is also essential for industry and society. Open Access will promote knowledge circulation because the speed at which knowledge can be passed from one stakeholder to another is significantly increased.

An example of Open Data: DINED

A good example of an open dataset DINED, the winner of the national Data Award 2014. DINED is a database of empirical information about the shape and size of the human body. DINED was originally created for the benefit of industrial designers but has since found several other applications. The knowledge of anatomy and statistics it contains helps to dispel the idea of that mythical creature, the 'average person'. The structure of the dataset is extremely practical whereby it has a high added value to society at large. The extensive body of data, which is clearly described and searchable by means of meta-information, makes the dataset accessible to all. Moreover, the innovative nature of the information invites further research by the scientific field.

The Netherlands has made a start by endorsing the 'Golden Road for Open Access'. The ambition is that sixty per cent of all publicly funded scientific articles will be made available in Open Access by 2016, and all by 2024. In other words, all research that has been funded by the taxpayer will be available instantly and free of charge to anyone who wishes to consult it.[67] Progress will be monitored by the universities and the VSNU. If the interim target is not achieved by 2016, the government will consider introducing a statutory obligation to provide Open Access by means of an amendment to the *Wet Hoger Onderwijs en Onderzoek* (Higher Education and Research Act). NWO will continue to promote Open Access by making funding subject to stringent requirements and by enforcing compliance.

67 Letter to Parliament on Open Access for Publications, 15 November 2013. Parliamentary Proceedings 2013–2014, 31 288, no. 354.

The Netherlands is a front runner in the European and international community and we will aim to connect with like-minded countries. The goal is to work together in ensuring a smooth and rapid transition towards open access.

We shall also take an active role in the development and promotion of international cooperation with regard to the sharing of research data.

The aim is that all scientific data should be securely stored, reliable, and in a form which facilitates ready access and appropriate usage.

In future, proposals submitted to NWO will be required to include a section on data management. In public-private programmes, prior agreements must be made with regard to data management and Open Access arrangements.

2.2
The participative public: Open Dialogue

Given our culture of cooperation, the Netherlands is extremely adept at finding new combinations and opportunities for cross-pollination. We now wish to make even greater use of this strength to establish a leading position in the development of a fully open science system.

By 2025, we wish to be able to make full use of the enormous potential which broad public participation in science offers.

In this era of increasing educational attainment and ready access to information, interest in science is increasing. Put simply, people know more about science. In a recent survey, over two thirds of respondents said that they follow developments in science and technology.[68] This offers clear opportunities for public participation in scientific research, in the formulation of the research questions to be addressed, and in the debate about the potential implications of new technologies. Those implications affect everyone. For example, many people now carry their entire private life about their person in the form of the information stored on their mobile phones. The concept of privacy must therefore be revisited. In 2014, Prof. E.J. Koops of the Tilburg Institute for Law, Technology, and Society (TILT) was awarded a VICI grant for his research examining new ways in which to protect privacy by means of legislation.

68 European Commission (2013), Responsible *Research and Innovation, Science and Technology*, Special Eurobarometer 401, pp. 15.

The huge potential impact that science has on society can place confidence in science under strain. The debates organised by the Rathenau Institute, KNAW and WRR reveal that the interaction between scientists, intermediaries and the general public can indeed be improved.[69] According to the principles of Responsible Research and Innovation, close and frequent interaction with all stakeholders is crucial. By involving the eventual end users of a future technology at the earliest possible opportunity, scientists can tailor their research to address their requirements and concerns. Contact with users forces researchers to reflect on the risks and opportunities of the products which may result from their efforts. It enables them to anticipate problems and objections, whereupon the likelihood of arriving at responsible and desirable innovations becomes that much greater. We firmly believe that effective interaction will not only increase the relevance of scientific research, but also its quality.

Some excellent examples of participation can already be seen. The Rathenau Institute stimulates debate about the implications of new technologies by means of high-profile projects and reports examining a wide range of topics, from fracking to autonomous (driverless) vehicles and synthetic biology. *Zooniverse* is a 'crowdsourcing' web portal operated by the Citizen Science Alliance, based at Oxford University in the United Kingdom. Over 1.2 million volunteers worldwide contribute to various research projects and the analysis of large data sets in various disciplines, including ecology, astronomy and history.[70] The Alliance grew out of the Galaxy Zoo project, in which volunteers were invited to assist in the morphological classification of galaxies. One such volunteer was the Dutch schoolteacher Hanny van Arkel who in 2007 discovered a rare astronomical phenomenon known as a quasar ionization echo. It was named *Hanny's voorwerp* (Dutch for Hanny's object) and the Dutch word *voorwerpje* (little object) has now entered the international astronomical vocabulary. NWO has a successful programme *Maatschappelijk Verantwoord Innoveren* (Socially Responsible Innovation) in which ethical aspects are taken into consideration from the very outset of the design process.
We believe that these developments are just the beginning of a very important transition and we encourage all scientists to conduct an ongoing dialogue with society. They should discuss what can reasonably be expected of science and research, and should talk openly about the potential risks of new technologies as well as the opportunities they present.

More private investors for research

The universities, their alumni associations and foundations such as the Friends of the University Medical Centres face the challenge of moving fundraising and 'friendraising' onto a higher plane. The government is playing its part by publicizing good practices. 'Friendraising' fosters interest and (financial) commitment by showing people the work of researchers and explaining what those researchers hope to achieve.

The contributions of alumni, members of the public, companies and charitable organisations form a valuable supplement to the other sources of research funding.

69 De Jonge, J. (2014), *Verslag debatreeks Vertrouwen in de Wetenschap*. Rathenau Institute, The Hague.
70 www.zooniverse.org.

A gift to science is a gift to society, and hence money well spent. Fundraising to support scientific research (which can include revenue from exhibitions and events related to the research itself) reinforces the relationship between the research institutes and the public.

Non-profit organisations such as the Dutch Cancer Society (KWF), the *Hersenstichting* (Brain Foundation) and the Gak Institute (concerned with employment and welfare) play a very significant role in supporting scientific research. We intend to co-host a number of meetings involving representatives of the research field and the Federation of Philanthropic Organisations (SBF) with a view to promoting communication and cooperation, with joint efforts to promote research and increase its impact.

Private investments in science

An example of private investment in science is the chair of Sexual Orientation Law at Leiden University. It was created in 2011 with an endowment of €1.3 million from the Betsy Brouwer Fund, which now forms part of the Leiden University Fund. This amount ensures the chair's existence for at least the next ten years. The incumbent is Prof. Kees Waaldijk, whose research has included a comparative study of LGBT (lesbian, gay, bisexual and transsexual) rights in Europe.

Dutch knowledge institutes can improve their alumni policy to ensure that former students take an active and lifelong interest in the work of their alma mater. This will strengthen the university and its research, while the alumni networks will enrich the professional and personal lives of their members, who will be encouraged to apply their knowledge in the interests of society.

Crowdfunding by the University of Groningen

In 2013, the University of Groningen launched its first 'crowdfunding' appeal (see *www.rugsteunt.nl*) to support various research projects. One such project is concerned with the distribution and migratory patterns of the Arctic Tern, and could reveal important information about climate change. Response was good and the target achieved very quickly. This fundraising method clearly appeals to alumni, companies and members of the public with an interest in ornithology or the environment, who were approached via the traditional and social media and via the internet.

Promoting science communication

A fascination for science should not be confined to scientists themselves. Appropriate communication about science and technology will keep the general public in touch with the field and abreast of developments. It will promote an understanding of the scientific process. Everyone, young and old, will be well-informed and enthusiastic about all aspects of science and technology. Science must be visible. Maximum visibility can be achieved through various channels: the media, social media, television programmes, science museums, public debates, exhibitions, e-learning (e.g. the 'massive online open courses', or MOOCs) and the 'science shops'.

Science itself will benefit from a broad public debate about the opportunities and risks of ground-breaking new developments. Conversely, the public should have a realistic understanding of how science actually works.

If expectations are too high, they are unlikely to be met whereupon support will dwindle. We shall actively promote science communication to increase public awareness of what science does and how it benefits society. We shall support the National Centre for the Promotion of Science and Technology, we shall assist the further development of the NEMO Science Museum in Amsterdam, and we shall facilitate the network of other science museums and science centres. More airtime will be available for science and technology communication within public service broadcasting, as announced in the policy document on the future of public broadcasting in the Netherlands.[71] Scientists themselves can make a significant contribution to such informative programmes. The knowledge institutions are also active in science communication efforts. We wish to increase both the outreach and impact of science communication. The links between science and education are important in this respect, since not everyone has an innate appreciation of the value of science: it must be instilled. For this reason, we shall ensure that science and technology are firmly embedded in education by means of the 'Dutch Technology Pact 2020'.[72] The existing 'Weekend of Science'[73] is to be expanded to become a large-scale and prestigious event with activities nationwide. All knowledge institutes will open their doors to the general public, whereupon the weekend will become just as well-known and popular as the highly successful Open Monument Day.

71 Parliamentary Proceedings 2014-2015, 32827, no. 67.
72 The Technology Pact (*Techniekpact*) comprises 22 national projects for primary and secondary schools, each with its own objectives, milestones and contact personnel. See: http://techniekpact.nl/acties/.
73 The 'Weekend of Science' (*Weekend van de Wetenschap*) is organised and coordinated by the National Centre for Science for the Promotion of Science and Technology (NCWT) on behalf of the Ministry of OCW.

2.3
The societal partners: inspiration and responsibility

There are at least two dimensions in which the interrelationship between science and society can be seen to be intensifying. On the one hand, the societal demand for scientific knowledge that will help to resolve issues such as climate change and security is increasing. This has inspired the scientific field to examine new topics, one example being Dr Sindy Sumter of the University of Amsterdam, who has conducted research into cyber-bullying.[74] Conversely, it is clear that scientific discoveries will have a significant impact on society in the years ahead, one example being the introduction of 'robotics. However, it cannot be assumed that this impact will necessarily be positive, for which reason it is essential that science and society maintain an ongoing dialogue.

The National Science Agenda will encourage science to devote attention to the societal challenges. As stated in Chapter 1, citizens and stakeholders are to be involved in developing the agenda in a process of co-creation. We intend to draw on the experience of the European Commission, which undertook an extensive public consultation process when preparing the Horizon 2020 programme. Various European agencies, advocacy groups, the private sector, NGOs and the general public were involved in selecting and defining the 'Grand Challenges'. The result is a research programme which addresses the interests and needs of society itself while also establishing an effective administrative structure. Although the process was time-consuming, it ensured that the programme enjoys broad support.

Confidence in science and scientific integrity

Public confidence in science is high.[75] This is something of which we can be justly proud but we must not be complacent. Given the important position that science occupies within society, an active policy to safeguard quality and integrity is essential. A few cases of scientific malpractice have emerged in recent years. The outrage they prompted was no doubt compounded by the rarity of such incidents. Fortunately, the scientific field has a very effective system of self-regulation, as demonstrated by the recently updated Netherlands Code of Scientific Practice. The existing rules on plagiarism have been extended to include self-citation without accreditation, i.e. the 'recycling' of past research data and findings.[76] We note that the field is now engaged in a productive discussion about necessary improvements to the quality assurance mechanisms and how they can best be introduced. Nevertheless, we believe that further action is necessary. One point for attention concerns replication studies: is it possible to replicate the research? Another area of attention is the quality of published research: is it thorough, complete, objective and accurate? We welcome the measures taken thus far, such as the appointment of a Professor of Methodology and Integrity by the VU University Amsterdam

74 http://www.nwo.nl/actueel/nieuws/2013/magw/veel-vooroordelen-over-cyberpesten-kloppen-niet.html
75 Tiemeijer, W., De Jonge, J. (2013), *Hoeveel vertrouwen hebben Nederlanders in wetenschap?* Rathenau Institute and Scientific Council for Government Policy.
76 The Netherlands Code of Scientific Practice, revised version of 31 October 2014 (in Dutch): http://www.vsnu.nl/files/documenten/Domeinen/Onderzoek/Code_wetenschapsbeoefening_2004_(2014).pdf.

and its academic medical centre. The ZonMw 'Prevention of Research Waste' programme, also warrants mention. It is a research programme concerned with research itself, and specifically the avoidance of any questionable practices. It is open to submissions from all disciplines and will support the development of empirical methods to enhance the quality, reliability and practical value of research in the broadest sense of the term.

Measures to avoid selective publication are also appropriate. It is extremely important that publications are not confined to successful research which has led to new, ground-breaking insights. Studies which have failed to produce any interesting outcomes must also be reported and described, not least because this will allow lessons to be drawn when planning future research projects.

We consider it important that knowledge institutes and their researchers should continue to invest in their own self-regulatory ability and pursue further harmonisation of their integrity policy. We are therefore gratified to note that an increasing number of institutes are affiliated with the National Board for Research Integrity (LOWI), whose founder members (VSNU, NWO and KNAW) have been joined by the Sanquin Foundation, RIVM and Kampen Theological University, among others. We shall encourage further institutes to follow suit. The LOWI is the Netherlands' highest advisory body in cases of suspected scientific malpractice. In close consultation with the LOWI and its members, we shall examine how its position and function can be further strengthened. It may be appropriate to formalise that position, establishing a legislative basis whereby the LOWI has statutory authority, in emulation of the approach adopted by various other countries.

2.4
The private sector: working to address the societal challenges

Science and research help to strengthen our country's competitive position. Science can be seen as an investment in our economic growth potential.[77] The knowledge and creativity of the researcher form the key to new breakthroughs.

Scientific advances are often unpredictable, yet they can generate new economic activity or increase productivity and output.

77 In 2017, the Netherlands Bureau for Economic Policy Analysis (CPB) is to publish the study *Kansrijk Wetenschapsbeleid* ('Promising Scientific Policy') setting out the potential returns of effective science policy. See also KNAW (2013), *Publieke kennisinvesteringen en de waarde van wetenschap*.

Many innovations are the result of cooperation within regional 'ecosystems' of knowledge institutes, private sector companies and other stakeholders.[78] If the Netherlands' innovative ability is to be maintained and increased, it is essential to make better use of excellent research and establish a strong profile for science itself. The Top Sectors policy is aimed at a number of economic sectors, that have a knowledge-intensive nature ,export potential, and compete globally. Under the Top Sector policy, government at all levels, the private sector, universities and other knowledge institutes work closely together in the agenda setting of research and innovation. The OECD has acknowledged this approach as an effective way of combining strengths and coordinating strategies with a view to placing the Netherlands among the top five global knowledge economies.[79] Through various instruments and channels, NWO contributes some €275 million per annum to research in the Top Sectors.[80]

The private sector has a particular interest in the exact sciences and technological sciences. These disciplines are of direct relevance to the manufacturing industry and to the societal challenges in areas such as energy, climate and water. The *Science and Technology* sector plan (produced by the 3TU alliance), the *Chemistry and Physics* sector plan and the *Master Plan for the Future of Mathematics* serve to strengthen the structure and profile of these disciplines.[81] The vision documents produced by the field and setting out the desired situation in 2025 also call for attention to be devoted to the exact sciences in (primary and secondary) education. Young people must be encouraged to take an interest in these disciplines. The Breimer Commission, responsible for overseeing the implementation of the Chemistry and Physics sector plan, will make recommendations intended to strengthen the exact sciences at all levels.

Dutch solutions to societal challenges

Cooperation between public and private researchers in the Top Sectors brings solutions to the societal challenges ever closer. This is demonstrated by an analysis of participation in European R&D and by the project portfolio of the Top Consortia for Knowledge and Innovative (TKIs).[82] We shall assist all parties in continuing these successful efforts by introducing a clear focus on the common societal themes, particularly those in which the Netherlands excels in terms of research and innovation. The Dutch contribution to the European societal challenges, as set out in Horizon 2020, will then be clearly visible.

78 We shall also promote cooperation with regard to valorisation, bearing in mind the limitations to which state support is subject. The universities are to be asked to develop a code of conduct to prevent unfair competition with commercial parties.
79 OECD (2014), *OECD Reviews of Innovation Policy: Netherlands*. OECD Publishing: http://dx.doi.org/10.1787/9789264213159-en.
80 The Top Sector policy encourages knowledge institutes and private sector organisations to develop a joint agenda. The approach has been described by the OECD as an effective way of combining strengths and coordinating strategies with a view to placing the Netherlands among the top five global knowledge economies.
81 See the vision documents, *Chemistry and Physics: Fundamental for our Future* (Dijkgraaf Commission, 2013) and *Formulas for Insight and Innovation: Mathematical Sciences in the Netherlands* (Platform Wiskunde Nederland, 2014). Both are available in English.
82 Researchers and businesses in the nine Top Sectors cooperate within the 'Top Consortia for Knowledge and Innovation' (TKIs).

By allocating public resources for knowledge and innovation to societal and economic challenges by means of a demand-led approach, private sector organisations are also willing to make substantial investments in the knowledge economy. As a result the total amount available for research will be greater. In the two-year period 2014/2015, companies will invest some €2 billion euros through the Top Sector organisations.[83] The National Science Agenda will increase the effectiveness of such investments by means of joint programming which takes account of both the challenges and the opportunities. The (research) questions of industry will provide inspiration for science. Cooperation will create an excellent learning environment for public sector researchers who later wish to make a move into the private sector, and *vice versa*.

The global societal challenges open new opportunities for Dutch researchers, institutes of higher education, government bodies and entrepreneurs. NWO has implemented an interesting research programme to examine how companies can make the transition to sustainable business practices. This programme falls within the Social Infrastructure Agenda, which also involves cooperation between the research field, government, the private sector and civil society. It draws upon various disciplines such as business administration, innovation science, psychology and economics.[84] As noted by the OECD, a key strength of the Dutch science system is its public-private partnerships and cooperation with and between institutes which engage in both fundamental and applied research. The success factor here is the horizontal and vertical interaction between the various knowledge partners in certain specific niches, which thus form focal points.[85] We intend to safeguard this strategic flexibility, which is clearly visible in the public-private partnerships within the Top Sectors. The National Science Agenda will reinforce the connective role of the Top Sector policy. Developments to date will be continued, and the societal themes within the Top Sector policy (many of which transcend the boundary lines between traditional policy domains) will be brought into line with the Grand Challenges of the Horizon 2020 programme.

These ambitions can only be achieved if the Netherlands is an integral part in the European Research Area (ERA), which aims to ensure the free movement of researchers, knowledge and technology. The EU Member States have agreed to all work together to establish open, excellent and attractive research systems, to distribute part of their national research budgets together, or to at least coordinate it, to work together on large-scale research infrastructures and to promote the free circulation of scientific knowledge by various means, including Open Access.

83 See the Netherlands Knowledge and Innovation Contract 2014-2015, Parliamentary Proceedings 2013-2014, 32637, no. 82.
84 http://www.nwo.nl/onderzoek-en-resultaten/programmas/duurzaamheid
85 OECD (2014), *OECD Reviews of Innovation Policy: Netherlands*. OECD Publishing: http://dx.doi.org/10.1787/9789264213159-en.

Encouraging entrepreneurship

We intend to increase the impact of knowledge by promoting enterprise and entrepreneurship via education and the valorisation infrastructure.

Universities (including the universities of applied sciences) can profile entrepreneurship as a potential career choice for their graduates. The current performance agreements and the Valorisation programme (€63 million) implemented by the ministries of EZ and OCW make this possible. This also stimulates innovative enterprise by researchers, in the form of start-ups and spin-offs. The results achieved by the *Centres for Entrepreneurship* and the *Technology Transfer Offices* (TTOs) and their mutual cooperation demonstrate that knowledge institutes are actively promoting entrepreneurship, with regional valorisation partners. The Centres of Expertise established by the higher vocational education sector also do much to establish effective interaction between education, research and valorisation.

When translating research results into commercial enterprise, it is important that the 'funding gap' – the difference between the amount of government research funding and the private investment in setting up spin-offs – is bridged. Financial support must also be given to the necessary feasibility studies for start-ups and spin-offs. The *Take Off* programme, a joint initiative of the ministries of OCW and EZ, is specifically concerned with innovative enterprise by researchers. It has an annual budget of 6.65 million euros. In addition, there are several 'incubator' projects which bring start-ups and private investors together.[86]

Building bridges between science, enterprise and society

The FOM Valorisation Prize 2014 was awarded to Prof. Dave Blank and Prof. Guus Rijnders of the MESA+ Institute for Nanotechnology in Twente for their interdisciplinary research which has led to the creation of two successful spin-offs. The professors have also given a number of extremely accessible public lectures about nanotechnology, and were the driving forces behind the 'Universitent' exhibit at the Zwarte Cross festival.

86 A joint programme by NWO, STW and ZonMW.

Better use of patented knowledge by the private sector

To strengthen valorisation and the dissemination of knowledge, we intend to further professionalise the use of intellectual property.

Although the current situation in this regard is satisfactory, improvements are possible, as noted in the recent joint report on the use of patents by KNAW, VSNU, NFU and NWO.[87] Patents which result from scientific research can be of even more use for businesses knowledge institutes and society at large.[88] The incentives to do so must be as close to the work floor as possible. The TTOs will therefore intensify their cooperation, in some cases forming (virtual) TTOs at the national level, and will share best practices with the applied knowledge institutes.

The government's Top Sector policy has introduced a new dynamic to the national economy. To maintain the impetus of the developments to date, it is crucial to ensure that the universities of applied sciences, regional authorities, the small and medium-sized enterprise sector (SMW), and research departments are fully involved in the Top Sector approach.[89] The National Science Agenda will devote attention to this point. The following paragraphs set out the implications for the various parties.

Greening the Cloud

Amsterdam University of Applied Sciences has initiated a large-scale research programme under the title 'Greening the Cloud', in partnership with the Netherlands' largest IT industry federation and ten companies in the SME sector. The institute's physics laboratory is equipped to establish the 'energy footprint' of software with extreme accuracy. This is an example of the formation of regional 'hotspots' in which connections are established between the knowledge institutes, the private sector and regional employment policy. More will follow.

To encourage greater attention for valorisation on the part of individual researchers, NWO will attach greater weight to this aspect in its assessment of research proposals. By taking into account not only planned valorisation activities but those conducted to date (applying a broad definition of valorisation), researchers' efforts and achievements in this area will receive greater recognition (see Chapter 3).

87 Royal Netherlands Academy of Arts and Sciences (2014), *Benutting van octrooien op resultaten van wetenschappelijk onderzoek*. KNAW, Amsterdam.
88 See also the government's response to the report KNAW, VSNU, NFU and NWO, Parliamentary Proceedings, 29 338, no. 138.
89 Advisory Council for Science, Technology and Innovation (2014), *Balans van de topsectoren 2014*. Quantes, The Hague.

2.5
Universities of applied sciences: an integral part of the knowledge system

The universities of applied sciences form a bridge between research and innovation within the professional field. They are knowledge partners to the SME sector and to public sector employers, and are therefore in a position to make a very significant contribution to research projects which pursue innovation or which address societal challenges such as those of Horizon 2020.
They support knowledge circulation by linking innovation with the development of human capital.[90] The OECD has advised the Netherlands to strengthen their research role.[91] NWO must regard the higher vocational education system as a full-fledged research participant and there are clear opportunities to do so. By bringing both the national coordinating body for practical research (NRPO-SIA) and that for research in education (NRO) under the aegis of NWO, applied research will form an integral component of NWO policy and strategy.

Research helping patients with a chronic condition

People are living longer, which means that an increasing number of people find themselves living with a chronic (long-term) condition. Utrecht University of Applied Sciences has established a research department ('lectorate') which examines the problems faced by this group. It seeks ways in which to avoid any loss of function or mobility due to the use of medications or a prolonged hospital admission, for example. The results of its research will enable health professionals to identify risks more promptly, hopefully preventing problems from occurring, and to provide the highest possible standard of care. The department works closely with hospitals, primary care providers, regional domiciliary care organizations, the nursing federation, individual patients and staff at Utrecht University.

To strengthen the knowledge function of the universities of applied sciences, it will be necessary to continue capacity-building efforts, to professionalise the organizational structure of these institutes, and to improve their contact and interaction with the universities and to enhance the capacity to acquire to European grants and subsidies. The Open Access policy described in Section 2.1 of this document will apply equally to publications produced at this level.

90 Advisory Council for Science, Technology and Innovation (2014). *Balans van de topsectoren 2014*. Quantes, The Hague.
91 OECD (2014), *OECD Reviews of Innovation Policy: Netherlands*. OECD Publishing: http://dx.doi.org/10.1787/9789264213159-en.

2.6
Students, pupils and teachers: Education based on the latest scientific insights

Through the development of human capital, science holds the key to a vital knowledge-based society. In today's employment market, knowledge becomes outdated ever more quickly. It is therefore crucial to invest in the combination of new knowledge and human capital. Changing circumstances are forcing the education sector to re-examine what is taught and how it is taught. Science is a *sine qua non* of good higher education. The research activities performed by the staff of universities (and universities of applied sciences) enable them to present the very latest scientific insights to their students. However, it is becoming increasingly difficult for university staff to strike an appropriate balance between research and education, between time in the laboratory and time in the lecture room. Both aspects are under strain due to the significant increase in student numbers.[92] Moreover, it seems that greater weight is attached to a researcher's published output than to his or her performance as an educator.[93]

To redress the balance, we intend to increase investment in higher education and in research which is directly related to education.

This targeted investment will make use of the funds released by the forthcoming amendment to the student financing system, whereby from 2018 it will become possible to link investments to binding quality agreements with the universities. Those quality agreements will include criteria with regard to course differentiation, intensity (contact hours), the quality of teaching staff and pass rates. The Strategic Agenda for Higher Education and Research, to be presented by the Minister of Education in 2015, will devote specific attention to the interrelationship between education and research.

2.7
Closer cooperation between government and science

It is important that central government is able to base its policy on state-of-the-art scientific knowledge. Ministries enjoy the support of various 'scientific advisory councils'. Increasingly, they also maintain direct contact with universities and other knowledge institutes.[94] As noted elsewhere in this chapter, we see opportunities to strengthen the connections between the scientific field and government at all levels. We wish to exploit the responsive and creative attitude of researchers to address the long-term challenges faced by today's society.

92 Between 2008 and 2013, the number of students enrolled at Dutch universities increased from 219,199 to 248,247. (Source: www.vsnu.nl).
93 De Goede, M., Hessels, L. (2014), *Feiten en cijfers. Drijfveren van onderzoekers*. Rathenau Institute, The Hague.
94 Royal Netherlands Academy of Arts and Sciences (2013), *Vertrouwen in de wetenschap*. KNAW, Amsterdam, May 2013.

Ministries need to maintain strong relationships with scientists. Not only must we maintain contact, we must clearly define the questions we wish science to answer. Public sector authorities have a clear responsibility; they must establish priorities and must inspire researchers to apply their creativity and intellect in order to bring solutions to the societal challenges within reach. The National Science Agenda will form their framework.

Central government is mindful that much of the scientific agenda is determined at the international level, and to an increasing degree at the regional level. Alongside the ongoing process of internationalisation, we now see integration, clustering and coordination of efforts within specific regions.

The universities, their medical centres and the universities of applied sciences are taking on the role of regional knowledge centres. There are new Science Parks, campuses and economic clusters with strategic alliances of knowledge institutes, private sector organisations and public sector authorities.[95] Such developments demand good coordination between national and regional science policy.

Amsterdam Science Park

The Amsterdam Science Park, in the city's Watergraafsmeer district, is a location at which education, research and knowledge-intensive enterprise come together and reinforce each other. The Science Park creates a climate in which knowledge-sharing, valorisation and economic activity can flourish. Researchers and students are helped to take their first steps into the world of commercial enterprise. Research results with market potential are developed to maturity, while interested entrepreneurs are given access to the knowledge centres. Science Park Amsterdam has ambition; it wishes to become the heart of a regional network of top business locations and the focal point of knowledge-intensive projects throughout the Province of Noord-Holland. The network and the Science Park itself will attract yet more innovative companies, allowing the ongoing development of new knowledge-intensive economic activities.

In terms of the national interests, creating links with regional policy is one way in which to create added value. Each of the provincial authorities is responsible for developing its own policy with a view to strengthening the regional knowledge infrastructure. Already, policies

95 Advisory Council for Science, Technology and Innovation (2014), *Bloeiende netwerken: hotspots als habitat voor innovatie*. Quantes, The Hague.

of provincial authorities are often aligned with the Top Sectors. These policies can also lead to synergy with the National Science Agenda. In some cases, a province or city has contributed to the creation of new institutes or large-scale research facilities, one notable example being the Advanced Research Centre for Nanolithography in the Amsterdam Science Park. This centre opened on 11 November 2014 and is financed using national, regional and private funds. Through programmes such as Agenda Stad ('The City Agenda') and research initiatives such as *Verbinden van Duurzame Steden* ('Connecting Sustainable Cities'; VerDuS), the government is helping the urban regions to pursue innovation and growth, to enhance the human environment ('liveability') and hence maintain their international position as attractive business and residential locations.

VerDuS

VerDuS stands for Verbinden van Duurzame Steden, or 'Connecting Sustainable Cities'. Within this initiative, researchers are working alongside experts in various disciplines to address challenges in areas such as urbanization, spatial development, mobility and transport. VerDuS is a joint initiative of NWO, the Nicis Institute (now known as Platform31 following the merger with KEI, Nirov and SEV) and various ministries. See: www.verdus.nl.

The activities outlined in this vision document are intended to strengthen the position of Dutch science, which entails making greater use of the region as the locus of interaction and cooperation between science, government authorities, private sector organisations and the societal field. It is at this level that more intensive cooperation within programmes such as *Agenda Stad* can be achieved.

As persuasively argued by the WRR, we must devote particular attention to knowledge circulation. If the Netherlands future earning capacity is to be assured, it is crucial that knowledge and skills are made available to various organisations.[96]

We now see a number of regional specialist clusters. Provincial authorities, knowledge institutes, companies and other stakeholders join forces to create focus and mass within a specific theme.

96 Scientific Council for Government Policy (2013), *Naar een lerende economie*. Amsterdam University Press, Amsterdam.

Researchers from universities work alongside those from universities of applied sciences, professionals from knowledge institutions, institutes of applied research and professionals in Intermediate Vocational Education. Within these alliances, the universities are increasingly taking on the role as knowledge 'hubs' and the drivers of innovation.

The university medical centres have a comparable role in the healthcare domain; their researchers work closely alongside fellow professionals both within and beyond the medical centres themselves.

The involvement of local and regional authorities, industry (the Top Sectors) and the societal field (including knowledge institutes and education sector) is essential to the success of the clusters. In some cases, their cooperation has been formalised within Regional Economic Boards.

In these (regional) ecosystems, the universities, universities of applied sciences, private sector organisations, TO2 institutes and other stakeholders contribute and combine insights drawn from both fundamental and applied research.[97] In the network organization CLICKNL | DESIGN, for example, designers, industry and science work together in pursuit of 'design driven innovation'. We call upon the various parties to do more in terms of joint research programming, and to apply a mix of funding sources such as EFRO, Horizon 2020 and the TKI supplement MIT, the Centres of Expertise programme, regional instruments and the (international) private sector. Here too, the National Science Agenda will provide inspiration and support.

Chemelot Campus

The Chemelot Campus in Geleen is soon to have a new knowledge institute, InSciTe, which will specialise in the development of bio-based and biomedical materials. The partners in the institute are the Province of Limburg, Maastricht University (working in association with Eindhoven University of Technology and RWTH Aachen University), TNO, DSM and a number of start-up companies.
The institute is an example of a regional knowledge 'ecosystem' for research and innovation. Similar ecosystems are emerging in other regions, each in its own stage of development.

97 Scientific Council for Government Policy (2013), *Naar een lerende economie*. Amsterdam University Press, Amsterdam.

Monitoring the effectiveness of the science system

When making decisions regarding science policy, the government requires expert advice. There is a system of institutes and advisory boards in place to answer this requirement. However, we wish to more effective use of this system.[98] Accordingly, we shall take a more active approach to the development of advisory programmes which are based on the actual knowledge requirement of the national government in a coordinated process which will involve various organisations, including but not confined to AWTI, KNAW, the Rathenau Institute and the Netherlands Agency for Economic Policy Assessment (CBP). This will avoid fragmentation or duplication, and will also ensure that the necessary advice is available more promptly. One example of the government's advice requirement concerns the need for a complete overview of the effectiveness of the science system itself. Is it working as it should? With the help of the aforementioned organisations, we intend to conduct a regular assessment of the science system and its functioning. It seems appropriate to do so at two-yearly intervals. The findings will support debate, both political and public, concerning the use of public funds, confidence in science and the impact of science. In 2018 we intend to conduct an evaluation of the advisory system. We also wish to gain a more complete understanding of the economic effects of investments in research. KNAW produced an exploratory report on this topic in 2013.[99] The CPB is currently conducting a study of the macro-economic effects of investment in science.[100] Its initial findings will form the basis of discussions with the CPB and KNAW towards the end of the year about the next stages in the process. At the European level, various models have now been developed in which R&D is examined as a driver of economic growth. The European Commission is supporting the further development of such models, a process in which the Netherlands will participate. The outcomes of the models will help to quantify the effects of our future research investments and activities.

98 The IBO report concludes that there are several aspects in which the performance of the advisory system can be improved. They include the timeliness (and hence currency) of advisory reports, and the volume of work which the various advisory are expected to complete, which is seen as too high.
99 Royal Netherlands Academy of Arts and Sciences (2013), *Publieke kennisinvesteringen en de waarde van wetenschap*. KNAW, Amsterdam.
100 Initial results will become available before the end of 2014. The final report is expected in the first half of 2015.

3 Dutch science as a breeding ground for talent

If science is to have maximum impact and produce real breakthroughs, it must be practised by expert, highly motivated scientists. Maintaining an adequate number of scientific staff is very important for an effective science system, while ensuring the quality of that staff is another. In addition, society and the labour market call for highly-qualified people with good academic skills: people who know how to acquire new knowledge and who are able to assess the value of that knowledge. These are skills which can be acquired by means of a scientific education, and are further developed through active participation in science. The staff of the universities of applied sciences, as well as the applied research organisations, play an essential part in connecting science with practice.

3.1 Opportunities for various forms of talent

Recruiting and developing scientific talent is essential to any strengthening of the science system; attention to these aspects is an investment in the knowledge society and the knowledge-based economy.

Universities, research institutes, research schools and the universities of applied sciences have a clear and prominent role to play in talent (development) policy. Inter-university research schools, graduate schools and other structured forms of cooperation make a significant contribution to research itself and to the training of researchers. Primary responsibility for the design and quality of these research schools rests with their parent institutions. Universities which opt to create and maintain a research school are also responsible for their funding. Effective agreements have been made with the VSNU in this respect.[101]
Universities, technical universities and research institutes are also responsible for taking appropriate care of their staff. However, the government also has a role to play in establishing the framework for an effective talent development policy.

The current situation provides a sound basis. The Netherlands has long history of being attractive to scientific talent from abroad, and we also develop our own 'home-grown' talent. However, there are several challenges. Researchers must contend with competition, peer reviewing, publishing in international journals and other claims on their time and at the same time setting up their research plans. Science can be compared to top-level sport; it involves selection, training and the determination to reach the top. As in sport, we wish to reward those who perform well. One way of doing so is by means of personal grants which allow excellent researchers the financial 'elbow room' to design their own projects and to assemble their own research teams. Such grants do indeed lead to excellent performance.

101 Parliamentary Proceedings 2012-2013, 29338, no. 125.

However, there are other forms of talent which are not yet fully appreciated. As the Science in Transition platform has pointed out, researchers are still largely judged in terms of their publication output and a limited number of forms of valorisation, such as the number of patents they are awarded or the profits their spin-off companies generate.[102 103] Recent research confirms the view that talent selection should not be based solely on published output. This narrow focus can lead to other important academic skills being overlooked: teaching ability, mentoring, leadership, management, entrepreneurship and valorisation, for example.[104] We wish to encourage researchers to develop these valuable skills, which means that due weight must be attached to them in all evaluations and assessments. When assessing quality and excellence, it is also necessary to take the differences between scientific disciplines into consideration.

We therefore wish to ensure that the assessment of research and researchers looks beyond publication output and the citation impact score to take other important academic skills and activities fully into account. This will give the concept of 'excellence' deeper meaning.

Recent decades have seen a very substantial increase in the number of PhD degrees awarded by Dutch universities. The majority of successful PhD students (68%) leave the academic world to take up employment in another sector.[105] This suggests that it will be appropriate to introduce a more differentiated structure for PhD courses in order to achieve a better 'match' with later career requirements. The Netherlands lags behind many other European countries in terms of making good use of female talents in science. Increased international competition is making it more difficult to attract and retain top talent of either gender. All these points can be seen as shortcomings in the current system of talent selection and development. We therefore wish to work with the knowledge institutes to create a science system with a greater number of researchers, all of whom will get the opportunity to develop their talents to their full potential and to pursue their chosen career path, be that in science or elsewhere.

102 "At one time, scientific publications were a means of communicating with other professionals in the field. Today, they have become a sort of universal currency for decisions which determine a researcher's career prospects. Moreover, research and the resultant scientific publications should ultimately have some added value for society. This aspect also goes largely unrecognised in the current system of evaluation." Science in Transition (2014), *Stand van zaken; debat, beweging en aanbevelingen* (here in translation).
103 A large-scale survey among researchers confirmed the impression that individual performance appraisals are seen to be overly reliant on publication output, fundraising ability and educational performance (De Goede, M., Hessels, L. (2014), *Feiten en cijfers. Drijfveren van onderzoekers*. Rathenau Institute, The Hague).
104 Van Arensbergen, P. (2014), *Talent Proof: Selection Processes in Research Funding and Career*. Rathenau Institute, The Hague.
105 De Goede, M., Belder, R., De Jonge, J. (2014), *Promoveren in Nederland. Motivatie en loopbaanverwachtingen van promovendi*. Rathenau Institute, The Hague.

The most important measures are:
- We shall encourage scientific talent to become fully involved in all aspects of research, education and valorisation.
- We shall position the Netherlands as the 'preferred' location in which to pursue a scientific career.
- We shall promote good inflow, throughflow and outflow with equal opportunities for women in research and
- We shall focus on the researcher, offering full opportunity to do what he or she is best at.

3.2 Involvement in research, education and valorisation

We wish to contribute to challenging scientific talent to perform well across the board of academic endeavour. Research results should no longer be the sole criteria on which assessments and rewards are based. It must be possible for scientists to pursue a broad career.

This is in line with the earlier recommendations by The Young Academy which call for all academic career paths to be broadened. Alongside the 'top researcher' model, there must be structured career paths based on excellent performance in other areas, such as education, science communication, policy and governance.[106]

This is part of the HRM policy and as such primarily the responsibility of the institutes themselves. Several positive developments can already be seen, whereby researchers' other talents are being used and appropriately rewarded. Utrecht University, for example, is among the first to open up a full career path in education to its research staff. Nevertheless, further action is necessary.

Diverse career paths

Based on the belief that scientific personnel should be able to pursue a full career based on excellent performance in education, clinical career valorisation, Utrecht University has introduced a 'differentiation framework' which describes various types of professorship, each of equal status but with a different emphasis in terms of activities and responsibilities.

106 The Young Academy (2010), *Rendement van talent – aanbevelingen voor motiverend en stimulerend loopbaanbeleid*. Amsterdam, June 2010.

Acknowledgement of education and valorisation

Good scientists who (also) provide excellent education will get significant career advancement opportunities. This will be part of our talks with the VSNU about the new framework agreement. That agreement may well include other matters relating to strategic personnel policy, such as an updating of the current career paths structure, more opportunities for young talent, more attention for teaching by means of combined career paths, balanced attention for performance in research, education *and* valorisation, preparation of PhD students to pursue career opportunities in other sectors, and the appointment of more women professors.

The proposed amendment of the student grants and loans system will release funds which will be used to improve the quality of higher education, including research activities which are directly related to education. Further measures to strengthen the relationship between research and education will be included in the Strategic Agenda for Higher Education and Research, to be published in 2015.

NWO sets the bar very high when assessing research proposals, the key criterion being 'Excellence'. It also takes plans for valorisation activities into account. NWO will not only consider plans for valorisation but the actual valorisation (in the broadest societal sense) which the applicants have achieved in the past. There are already a few NWO programmes in which teamwork is a precondition of funding. To make full use of the knowledge and qualities of researchers, NWO will restructure its current instruments to allow and encourage more cooperation between researchers and institutes.

3.3
The Netherlands as the 'preferred location' for scientific talent

The past decade has seen burgeoning cooperation between Dutch researchers and their counterparts in other countries.[107] Our country is already very attractive to young international talent. Approximately half of the current PhD students are from other countries. International cooperation is important, and often a *sine qua non* of ground-breaking research at the highest level. The Netherlands is an important player on the world stage. Mobility helps to circulate and disseminate knowledge, it supports the personal development of researchers and it helps in the development of the European Research Area, established by the European Commission with a view to maximizing opportunities for international cooperation and synergy.

Therefore we will continue to further the mobility of researchers.

107 This is also apparent from the increase in the number of Dutch research publications which credit co-authors from other countries. Such publications account for approximately forty per cent of the Netherland's overall contribution to the international scientific literature, a figure which is somewhat above the international average (Netherlands Observatory of Science and Technology (2014): via http://nowt.merit.unu.edu/index.php).

We wish to devote particular attention to attracting international top talent to the Netherlands. Researchers of the highest calibre are needed to produce new insights, develop new knowledge and expertise, and to help in building our networks.

Moreover, talent attracts talent. When top international researchers opt to work in the Netherlands, they create a working environment which encourages younger, talented researchers to flourish. The Netherlands has long been able to attract international researchers, but there is now increasing competition from other countries and there are some indications that it is now becoming more difficult to attract the most established scientists. It would appear that the salary on offer is rarely a decisive factor. Nevertheless, the fact remains that Dutch institutes are not able to compete with some foreign universities in this respect.[108]

Radboud Excellence Initiative

Radboud University and its affiliated medical centre have introduced the Radboud Excellence Initiative, intended to promote international cooperation between top researchers. Each year, the institute will invite some ten to fifteen researchers to Nijmegen; professors will stay for six months, while postdocs will spend up to two years at the university. To date, nineteen international researchers have taken part in the programme, including four professors.

The Netherlands' ability to recruit top talent will therefore remain a point for attention, whereby additional measures are required.

It must be clear to researchers in other countries that the Netherlands offers excellent career opportunities. Dutch science must be placed firmly on the world map. The National Science Agenda and an attractive scientific climate (in terms of aspects such as research facilities) will help to establish the Netherlands' international profile. At the same time, we have to know which top researchers we actually wish to have working here. This will largely be determined by our research focal points. NWO must make an active contribution to the development of the European Research Area, not only by promoting the international mobility of talented researchers but also by cooperating in addressing national priorities. An example in this regard are the Joint Programming Initiatives, which seek to streamline and combine research expertise at the European level. With these initiatives, the European Commission aims to promote the opportunities for international cooperation and synergies as much as possible.

108 Similar concerns are expressed in the vision document *Chemistry & Physics: fundamental for our future* (Dijkgraaf Commission, 2013).

We expect institutions to devote attention to strengthening an attractive environment for international talent since there are clear gains to be had.[109] The options include excellent facilities, dual career structures and a realistic prospect of a permanent position (tenure) during the research project or on its completion. Inter-university cooperation, as in the Gravitation Programme (*Zwaartekrachtprogramma*) creates visible internationally visible peaks. In addition, NOW will bring the Innovative Research Incentive (*Vernieuwingsimpuls*) programme to the attention of selected international researchers. The Innovative Research Incentive provides a personal research grant to creative researchers, awarded further to open competition. Of special interest are those researchers who can bring significant added value to the Netherlands' research landscape by virtue of their focus on the challenges of the National Science Agenda. They will complement the broad-based talent already working here. At present, international researchers make relatively little use of the incentive programme.

Promoting Dutch science abroad

The international position of Dutch science can also be strengthened by involving representatives of Dutch research in overseas missions.

These visits will be even more effective if there is more emphasis on what Dutch universities and Dutch researchers have to offer. It will be important to coordinate the missions undertaken by representatives of universities and knowledge institutes with the (economic) missions of the government. Where joint representation has added value, it will be appropriate for the knowledge institutes and private sector to coordinate their efforts with those of the government, as noted by the VSNU and the VH in their Joint International Vision Document.[110] The knowledge institutes must not only present themselves as individual universities or centres, but as part of the overall science system. A good example has been set by the representatives of knowledge institutes who formed part of the Dutch trade mission to Brazil in November 2012.

The themes of the National Science Agenda must be clearly profiled as our key strengths: the areas in which Dutch research excels. Important partners in this process are NUFFIC, which has nine Education Support Offices outside the European Union, and the Netherlands Enterprise Agency, which has four innovation attachés in Europe and a further thirteen elsewhere. The Netherlands enjoys a particularly high international reputation for research relating to water (management) and food.[111] The UN Climate Summit held in New York in September 2014 saw the inaugural meeting of the Global Alliance for Climate-Smart Agriculture, a Dutch

109 In 2012, Hal Caswell, a leading American researcher in the field of theoretical population modelling, received an Advanced Grant from the European Research Council (ERC). This prestigious award has enabled him to continue his research into individual stochasticity and population heterogeneity in plant and animal demography at the University of Amsterdam's Institute for Biodiversity and Ecosystem Dynamics.
110 VSNU / Association of Universities of Applied Sciences (2014), *Gezamenlijke visie internationaal*. The Hague, May 2014.
111 Dutch research in the field of water management enjoys a very high international reputation. TU Delft leads various projects in countries such as Myanmar and Vietnam, in which research underpins practical applications and consultancy work. Dutch knowledge in water management is also being passed on to organisations in Thailand through training courses and workshops.

initiative which 75 countries have endorsed by now. Its principles were developed and placed firmly on the international scientific agenda by a number of large (international) organisations including Wageningen University.

3.4
A good inflow, throughflow and outflow on the labour market

A steady inflow of young researchers (PhD students and post-doctoral researchers) is essential to maintain the vitality of the science system. At the same time, people with this high level of education are of immense value elsewhere in society. They have acquired the skills needed to develop new knowledge and to assess the value of knowledge.

PhD graduates who opt to continue their career outside the academic setting make a valuable contribution to society. They support the Netherlands' development as a learning economy and strengthen our competitive position. They ensure that we can address the societal challenges of the future.

Accordingly, we wish to achieve greater differentiation within postgraduate education in order to increase diversity. This may also contribute to an increased number of PhDs in the Netherlands.

The number of doctorates awarded by Dutch universities has almost doubled in the last twenty years: from some 1,900 per annum in the early 1990s to over 3,700 today.[112] The proportion of successful female candidates has also increased, from (just under) twenty per cent to over forty per cent. A recent study by the Netherlands Agency for Economic Policy Assessment (CPB) shows that those who hold a PhD degree have better employment prospects than other graduates, although there may be a short period of unemployment (or under-employment) immediately following completion of the PhD programme.[113] Similarly, a comparative study undertaken by the OECD shows that employment participation among those with a doctorate is higher than among other graduates.[114] Partly due to the increase in the number of doctorates awarded, the average educational level of the working population is rising. This leads to a revision of the jobs structure, since productivity is enhanced by a good match between a job and the skills of an employee.[115]

112 Goede, M de., Belder, R., De Jonge, J. (2013), *Feiten en Cijfers Academische carrières en Loopbaanbeleid*. Rathenau Institute, The Hague.
113 Van der Steeg, M., Van der Wiel, K., Wouterse, B. (2014), *Individual Returns to a PhD Education in the Netherlands Income Differences between Masters and PhDs*. CPB Discussion Paper 276, May 2014.
114 OECD (2014), Who are the doctorate holders and where do their qualifications lead them? *Education Indicators in Focus 25, OECD Publishing*. DOI: 10.1787/5jxv8xsvp1g2-en.
115 Pellizari, M., Fichen, A. (2013), A new measure of skills mismatch; theory and evidence from the survey of adult skills (PIAAC). *OECD Social, Employment and Migration Working Papers* 153, Paris.

Given the immense diversity in the career paths followed by PhD graduates, there appears to be a need for greater differentiation in the PhD programmes to ensure a better match between what is taught (and learned) and the student's requirements in later life. Society's requirements must also be taken into account. For example, the quality of education, and particularly that of higher vocational education, will be enhanced by having a greater number of PhDs involved in teaching.

PhDs with teaching qualifications

An interesting initiative to increase the number of PhD graduates in education can be seen in Nijmegen, where twelve postgraduate students were are given the opportunity to spend the final six months of their PhD programme at teacher training college. In a 'conventional' PhD programme they would be expected to spend this period giving lectures to university undergraduates. Instead, they found themselves are teaching in secondary schools among others., and were able to gain the qualifications required to do so on a more permanent basis.

The government's policy statement *Werken aan groei* ('Working on Growth')[116] sets out the demand for more and broader talent in order to ensure the resilience of the national economy. This asks for a greater throughflow of PhD graduates into the private sector and central government positions. In addition, it demands a different kind of doctoral programmes. As the demand for a broader PhD-level education increases, so will the importance of ensuring a good match with the requirements of the employment market.

Greater opportunity for differentiation in PhD-level education

The Dutch system already includes a degree of differentiation. Most PhD students are paid employees of the university. Alongside the research which will form the basis of their dissertations, they generally perform other activities. There are also some external PhD candidates who are not employed by the university itself. They produce a dissertation with the help and guidance of the PhD supervisor, generally a university professor, but have no direct financial relationship with the university itself. In addition, there are PhD candidates – usually international students – who produce their dissertation with financial support from other institutes than the university. An interesting example of long-term strategic cooperation is that between Eindhoven University of Technology and Philips Research. Their joint research programme examines digital innovations in healthcare, lighting and data science. With Philips' support, the university is able to offer an additional seventy PhD research positions.

116 Parliamentary Proceedings 2014-2015, 34000, no. 4.

Such good initiatives aside, the Dutch system has very little differentiation compared to those of our neighbouring countries. The government therefore wishes to create greater opportunity for differentiation.

In addition to the existing arrangements, we wish to facilitate an experiment whereby universities can extend grants from the 'profiling' fund to a PhD student. The PhD student will then complete the third stage of his or her academic education by undertaking a teaching programme. The experiment intends to increase the value of a PhD-level education in the context of the general employment market, and will help to ensure an adequate number of PhDs to meet future demand. The measures are being introduced as a 'limited experiment' because we wish to monitor whether these three objectives are indeed met, and to identify any other effects, before committing to permanent implementation.

In addition, the government will enter into an agreement with the private sector with the objective of increasing the number of people with a doctorate (including the 'industrial doctorates') working in the private sector and in central government by several hundred over the coming ten years (2015-2025). This will achieve more rapid implementation of knowledge within the public and private sectors, and will help to increase the attraction of the Netherlands as a business location. The government will actively support efforts to increase differentiation in PhD-level education. Closer cooperation with the institutes of applied research will establish emphasis on valorisation. One option is to create more part-time professorships, similar to the 52 chairs which are currently shared between TNO and various universities. Another option is to have the PhD students themselves conduct part of their research project within an institute of applied research, which will facilitate a career move into the private sector on completion of their degree. If the match between education and the employment market is improved, and the demand for staff with PhD-level education increases within the public and private sectors increases as expected, the number of doctorates awarded by Dutch universities will continue to rise. This will increase both the responsive and absorptive ability of the national economy, strengthen our competitive position, and help to resolve the societal challenges of the future.

Greater opportunity for a balanced staffing establishment within universities

The 'scientific pyramid' has become broader in recent years, with a relatively high number of postgraduate and postdoctoral research positions and relatively few associate professorships.[117] This shift is largely due to the relative increase in indirect and contract research funding. If an ever larger number of the young talent (PhD and postdoctoral researchers) see no realistic development opportunity, there is a risk that they will decide against pursuing an academic or scientific career altogether. The very existence of universities depends on a constant inflow of young talent. Today's PhD student is tomorrow's top scientist. Of course, not all PhD or

117 De Goede, M., Belder, R., De Jonge, J. (2013), *Feiten en Cijfers Academische carrières en Loopbaanbeleid*. Rathenau Institute, The Hague.

postdoctoral researchers will be able to continue their career within the university but there must be a reasonable opportunity for some – the most talented – to do so. It is therefore important that universities create such opportunities and equip their students with the knowledge and skills required to pursue a full career either within or beyond the university itself. Career opportunities, particularly those outside the academic world, are currently not visible enough, and do not influence the decision to undertake PhD-level education.[118]

The use of resources from the first (direct) funding flow for the purposes of profiling, as proposed within the framework agreement mentioned earlier, will enable universities to implement a more strategic personnel policy and will provide direction in doing so. Moreover, the capping of the amount paid in respect of the number of doctoral awards will reduce the incentive to employ PhD research students rather than postdoctoral staff or analysts. As noted in the IBO report, the current arrangements favour those who have yet to gain a doctorate over those who have already done so.[119] The proposed cap will therefore create a more level playing field and allow the implementation of a more balanced career development policy.

University Executive Boards are to be permitted to assign the *ius promovendi* (the right to supervise and award a doctorate) to associate professors. This is in line with practice in other countries such as Germany, where the system has been shown to work well. This, too, will create a more attractive work setting for international researchers, creating further, more diverse career opportunities while ensuring that PhD students continue to receive adequate guidance and supervision.

3.5
More opportunities for women in science

Dutch science is failing to make full use of female talent, particularly in more senior positions.

In this respect, we are lagging behind most other European member states. In the most recent comparative study, the Netherlands is very near the bottom of the ranking in terms of the percentage of women professors; only Belgium, Cyprus and Luxembourg are lower.[120]

Science can act as a role model in its deployment of female talent.

118 De Goede, M., Belder, R., De Jonge, J. (2014), *Promoveren in Nederland. Motivatie en loopbaanverwachtingen van promovendi*. Rathenau Institute, The Hague.
119 Ambtelijke Commissie Heroverweging (2014), *IBO Wetenschappelijk onderzoek*. Ministry of Finance, Government of the Netherlands, The Hague.
120 In 2010, the percentage of women professors in the Netherlands was 13%, compared to the EU average of 20%. European Commission (2013), *She Figures 2012: Gender in Research and Innovation*. Directorate-General for Research and Innovation, 2013.

Promoting female talents

There are some excellent initiatives, such as the University of Groningen's Rosalind Franklin Fellowship, which seeks to increase the number of women in senior tenured positions. It has been remarkably successful: no fewer than 65% of the Fellows in previous rounds now hold an associate or full professorship. Similarly, the Delft Technology Fellowship at TU Delft offers high-profile, tenure-track positions to female top scientists within the specialist research areas of the university.

A slight increase in the number of women professors can be seen.[121] Nevertheless, if percentage growth remains at the level of the past ten years, an equal male-female balance will not be achieved until 2058.[122] Action is therefore required.

At least part of the current inequality can be explained in terms of 'implicit associations' concerning the qualities of both men and women.[123] [124] NWO is currently conducting a study to examine what is required to ensure that men and women enjoy equal opportunity in competitive tenders. It intends to adopt international best practices to ensure that this is the case within its own assessment procedures.

We consider it essential that no talent goes untapped, in science or elsewhere. The Netherlands will therefore align its policy and action with the European initiatives. The European Commission's Horizon 2020 programme, for example, expressly calls for the creation of a fair balance between men and women in all the various components of the research chain.[125] We shall act in accordance with the Commission's intentions and, together with the institutions, adopt an active policy intended to ensure that the male-female balance is at or above the European average by 2025.[126] In 2010, that average was 20% (i.e. a female-to-male ratio of 20:80).

121 In the two-year period 2011 to 2012, the percentage of women professors in the Netherlands rose from 14.8% to 15.7%. Source: Dutch Network of Women Professors (LNVH) http://www.lnvh.nl/site/News/News/Monitor-Vrouwelijke-Hoogleraren-2013-verschenen.
122 De Goede, M., Belder, R., De Jonge, J. (2013), *Feiten en Cijfers Academische carrières en Loopbaanbeleid*. The Hague, Rathenau Institute.
123 There are numerous scholarly articles describing the use of the Harvard Implicit Association Test (IAT). Almost all confirm that implicit associations ('prejudices') have a significant influence on judgement and behaviour. The test can be taken at implicit.harvard.edu.
124 In a recent editorial, science journalist Dr Margriet van der Heijden (who is also a professor of physics at Amsterdam University College) notes that her female students see very few career opportunities in the Netherlands. "'I would like to continue with physics, but does a woman really have a chance of a scientific career?', one student asked me. Should I tell her that a scientific article with a woman's name at the top is bound to be less favourably received than the same article credited to a man?" (NRC, Saturday 19 July 2014).
125 European Commission (2013), *Factsheet: Gender Equality in Horizon 2020*.
126 A taskforce formed by OCW, LNVH and NWO/VSNU (with VH if appropriate) will produce proposals whereby better use can be made of female talent. This taskforce is primarily concerned with issues surrounding the submission and assessment of research proposals.

By 2025 it is likely to be somewhat higher.[127] This topic will also form part of the new framework agreement with the VSNU. If necessary, firm targets will be included in the Higher Education and Scientific Research Act.

Alongside action intended to create equal opportunity, attention must be devoted to the role that gender differences play within research itself. This too is in line with the intentions of the Horizon 2020 programme, not least because it is a factor which, when ignored, could result in sub-optimum research and output. For example, clinical guidelines for heart disease might be based solely on the male pathophysiology and studies involving only male subjects. As a result, female patients could be misdiagnosed.[128] We support a two-year project by the Gender and Health Alliance, centring on education, research and awareness with regard to gender differences and how they influence the quality of healthcare. The Alliance includes representatives of the healthcare sector, research field, expert organisations, women's advocacy groups and policy departments. The project will result in a National Programme for Gender and Health, produced in association with the Ministry of Health, Welfare and Sport (VWS).

3.6
The researcher at the centre of policy: less pressure to publish and acquire funding

The government wishes to place the researcher himself – or herself – at the centre of its policy. Science relies on people, and science of the highest quality results from the energy and commitment of the very best, talented researchers. Their time is valuable and we wish to see less of it being devoted to the 'red tape' of subsidy applications and the like.[129]

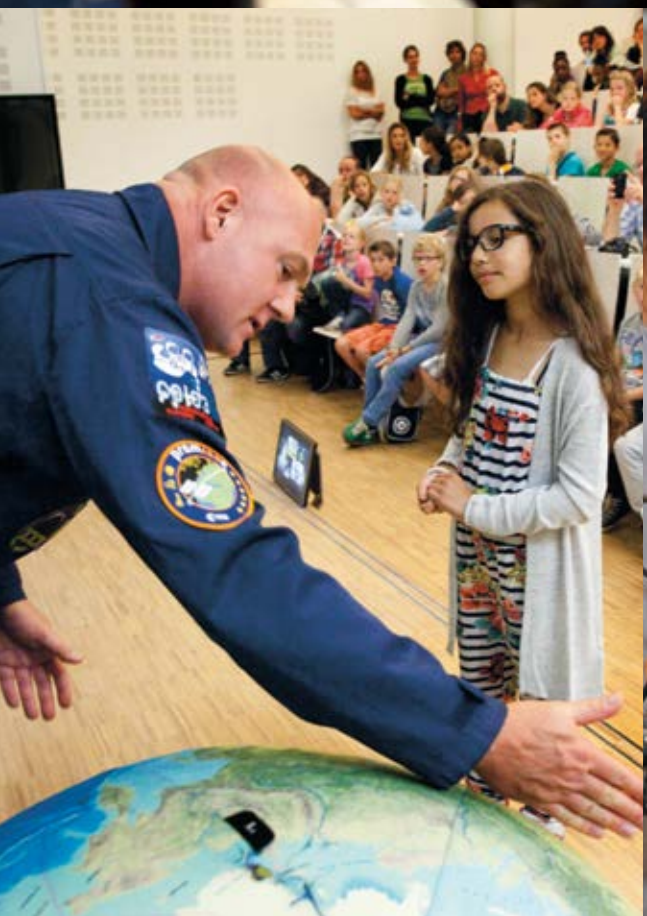
The IBO report notes that the acquisition of indirect funding involves a high workload in preparing detailed research proposals, while the percentage of proposals which are actually approved is relatively low. It makes two recommendations to redress the balance. First, calls for proposals should be more closely aligned with the research spearheads of specific institutions and the sector plans. Second, restrictions should be placed on multiple applications. Although the approval percentage is even lower in some other countries (as is that of the ERC), we believe that the Netherlands' acceptance rate is indeed slightly below the appropriate level. However, the current acceptance rate varies according to the discipline and the individual researcher concerned.

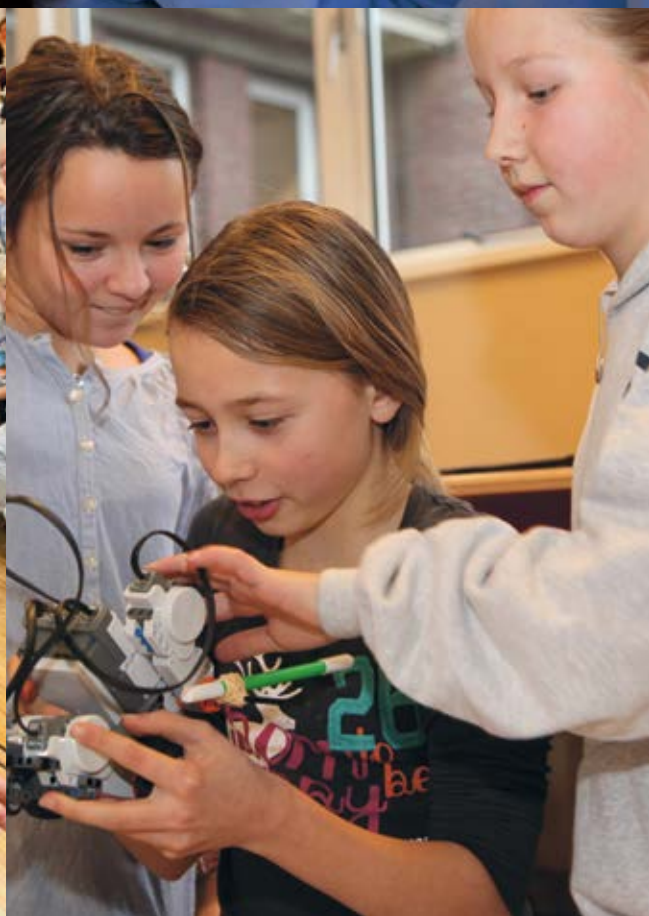
127 European Commission (2013), *She Figures 2012: Gender in Research and Innovation*. Directorate-General for Research and Innovation, 2013.
128 European Commission (2013), *Gendered Innovations - How Gender Analysis Contributes to Research*, Directorate-General for Research and Innovation, 2013.
129 The approval rate for research proposals submitted to the NWO fell from 32% in 2007 to 23% in 2011. Source: NWO Evaluation Commission Report (2013), *Nieuwe dynamiek, passende governance,* May 2013.

The National Science Agenda will introduce greater focus and coordination in research priorities, and this will be reflected by NWO's thematic calls. We shall also encourage universities to devote greater attention to combined career paths, whereby tenure or promotion does not depend solely on publication output. Some of NWO's instruments will be modified in line with the ambitions of the National Science Agenda, whereupon a greater number of researchers will become eligible for funding. In association with the universities, NWO will introduce best practices designed to reduce the workload involved in submitting proposals. Specific attention will be devoted to a good balance between the time and effort expended by applicants, referees and commission members on the one hand, and the likelihood of the application being approved on the other. The universities and institutes will continue to be responsible for submitting carefully selected and well-prepared proposals.

The new Standard Assessment Protocol (SEP) to be applied by KNAW, NWO and the VSNU will go a long way towards reducing the pressure on researchers in terms of publication output.[130] This protocol will apply to every research project or programme conducted by a university or institute which is affiliated with KNAW or NWO. It places the emphasis on the quality of the researcher's work and productivity is no longer a separate assessment criterion. This is in response to criticism that researchers in many disciplines now face excessive pressure to publish. Productivity and speed must no longer be allowed to dominate. The new SEP respects the essence of science and the key motive of its practitioners: the desire to discover the hows and whys of the world around us. In one word, *curiosity*.

130 Communication to the House of Representatives dated 21 March 2014 accompanying the revised Standard Evaluation Protocol (Parliamentary Proceedings 2013-2014, 29 338, no. 132).





Final remarks

Curiosity is innate: every child has an enquiring mind. It is often suggested that adults do not, that curiosity is something one 'grows out of'. While producing this vision document, we have been fortunate enough to meet many people who prove that this is far from the case. We have been helped by people with passion, people who embrace science, people who are just as curious as any three-year-old. The children of today will one day have to decide what to study at university. Some may decide to embark on a scientific career. Hopefully, most will at least wish to read about the latest scientific insights in the newspaper. Children are the scientists of tomorrow. What we can offer them is largely being decided today.

Science shapes our lives, both today and tomorrow. We therefore have a special responsibility to establish a sound position for Dutch science, and to pass on an effective science system to generations yet to come. As a society, we must therefore allow science to develop and to respond to the changes in the world around us. Big Data, large-scale research facilities, the role of IT, political and economic developments, and the cross-pollination between disciplines: all will change the very nature of science and scientific practice for years to come. Science is increasingly based on interaction and dialogue, on the questions and expectations of society. Transparency and accountability are more important than ever; science must be able to demonstrate its relevance, as KNAW has quite rightly noted.[131]

The government wishes to support science in every way possible. New insights and ideas give us a glimpse of what the future may hold; they appeal to our imagination. It is essential that we are able to push back the boundaries of our knowledge. This vision document began by setting out ways in which we shall safeguard that ability. At the same time, increasing international competition and some major societal challenges ask us to concentrate on those areas of science in which The Netherlands can make a real difference. And because it is the scientist himself or herself who is at the forefront of research, he or she must also be the focus of policy. We have high expectations and demand much of our researchers. We are obliged to offer adequate recognition for their efforts. Together, we shall embark on a process in which all the creativity, inspiration, passion and, most importantly, long hours of hard work are brought together to form a science system of the very highest quality. This process will be supported by the National Science Agenda, which will aid in creating the focus and coordination necessary to arrive at truly spectacular scientific breakthroughs. Scientific talent will be given every opportunity to shine, both within the science system itself and beyond.

131 Royal Netherlands Academy of Arts and Sciences (2013), *Vertrouwen in de wetenschap*. KNAW, Amsterdam, mei 2013.

The years ahead will involve much hard work. Today is just the first step towards the future.

This vision document is a call to arms. It invites all the various stakeholders to join forces, rise to the challenges ahead and attain our joint ambitions.

Those stakeholders are poised and ready. We can sense the energy with which they will now set about creating the National Science Agenda and achieving its aims. Responsibility does not rest with government alone, but with all parties. In 2015, we shall enter into a new framework agreement with the universities in which themes such as profiling and strategic personnel policy are given due attention. NWO is about to embark on a process of far-reaching change, redefining its relationship with other organisations and adopting a new governance structure. There is to be a permanent commission responsible for decisions regarding large-scale research facilities. In consultation with the knowledge institutions, it will seek to ensure effective, efficient and coordinated use of the research infrastructure. The universities of applied sciences are to take action so that they too can make a full contribution to the sum of our knowledge. Knowledge institutes and private sector organisations will devise joint programmes to address the important societal themes, particularly in those areas in which Dutch research and innovation already enjoys a strong international reputation. The government intends to enter into a formal agreement with the private sector with a view to increasing the number of PhDs it employs.

The results of these joint efforts will be seen not only in terms of a prominent position on the international scientific stage. They will also be seen on our streets, in the shops, in our schools and in our newspapers. Dutch science will be stronger than ever. It will give us insight and inspiration, bringing about all manner of social advances so that we can pass on an even better world to our children, grandchildren and generations to come. What an exciting prospect!

Appendix

Appendix 1
Glossary of abbreviations

3TU	Federation of the Netherlands' three universities of technology: Delft, Eindhoven and Twente
AWT	Advisory Council for Science and Technology Policy (from 1 August 2014: AWTI)
AWTI	Advisory Council for Science, Technology and Innovation
BRIC	Brazil, Russia, India and China
CPB	Netherlands Bureau for Economic Policy Analysis
EFRD	European Fund for Regional Development
ERA	European Research Area
ERC	European Research Council
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
EZ	(Ministry of) Economic Affairs
FES	Economic Structure Strengthening Fund
FOM	Foundation for Fundamental Research on Matter
IBO	Interdepartmental Policy Review
KNAW	Royal Netherlands Academy of Arts and Sciences
KNMI	Royal Netherlands Meteorological Institute
LOWI	National Board for Research Integrity
NFU	Netherlands Federation of University Medical Centres
NWO	Netherlands Organization for Scientific Research
OCW	(Ministry of) Education, Culture and Science
OECD	Organisation for Economic Cooperation and Development
RIVM	National Institute for Public Health and the Environment
SEP	Standard Evaluation Protocol
SME	Small and medium-sized enterprise (sector)
STW	Technology Foundation STW
TKI	Top Consortia for Knowledge and Innovation
TO2	Alliance of Applied Research Organisations (TNO, Deltares, ECN, MARIN, NLR and DLO)

TTO	Technology Transfer Offices
TU/e	Eindhoven University of Technology
TU Delft	Delft University of Technology
UU	Utrecht University
UvA	University of Amsterdam
VSNU	Association of Universities in the Netherlands
VU	VU University Amsterdam
WRR	Scientific Council for Government Policy
ZonMW	The Netherlands Organisation for Health Research and Development

Appendix 2
Policy options of IBO report in relation to measures in the 2025 Vision for Science

This vision document has been produced in response to the Scientific Research Interdepartmental Policy Review (IBO). The policy options described in the IBO report are summarised below with reference to the contents of the vision document.

	IBO	2025 Vision for Science
Option 1	Improve structure of direct funding flow *Remarks:* To create greater predictability and stability of revenues and to enhance the transparency of the allocation model it is suggested that the structure of the direct funding flow should be adjusted. In practice, this will entail:	The structure of the primary (direct) funding flow is to be amended in accordance with the measures described below.
	• *Fixed base:* the proportion of direct funding represented by the 'fixed base' should be gradually decreased. This will create more opportunity for funding based on other, variable criteria.	We propose no changes to the fixed base at present. However, a number of the proposals outlined below relate to the allocation of funds based on other criteria.
	• *Specific provisions:* - A reduction in the fixed base would suggest that universities should receive a separate amount in respect of the (technical) research infrastructure. - It would also be possible to link a greater proportion of the research funding to the performance and profiling agreements. This would offer greater transparency with regard to why some universities receive more resources, and would be a more rational basis for funding allocation.	A permanent national commission is to be formed within NWO to make all strategic decisions regarding large-scale infrastructure, thus enhancing coordination, effectiveness and efficiency. We shall request universities to account for their expenditure on research infrastructure, as this will help the commission to make fully integrated decisions about the necessary investments in infrastructure. (Para. 1.2.4). Approximately 4% to 5% of the current research funding is to be allocated differently further to a 20% cap on the component payable in respect of the number of doctorates awarded. (Para. 1.2.2). The proposals will be explained in more detail in the Strategic Agenda for Higher Education and Research, to be issued by the Minister of OCW in 2015.

	IBO	2025 Vision for Science
	• *Graduate degrees:* The allocation of research funding based on the number of graduate degrees awarded will be maintained, and can be increased slightly. This will help to safeguard the scientific character of university education.	No change.
	• *Postgraduate (PhD) degrees:* If the current policy is maintained, this indicator will become too dominant and will result in greater volatility in direct funding. Accordingly, a fixed (capped) percentage of the total direct funding allocation is to be based on this indicator rather than a standard amount per doctoral award.	Rather than a fixed amount per successful PhD candidate, universities will receive no more than 20% of their total funding based on the number of doctorates awarded (Para. 1.1).
	• *New indicator:* Further to consultation with the field, it may be appropriate to introduce a new indicator, perhaps based on the amount of EU funding the university has acquired.	Following consultation with the field, it has been decided to allocate some 4% to 5% of direct research funding in a different way. The amount concerned will remain available and will be paid further to agreements with the institutes regarding their contribution to research contributing to the National Science Agenda. (Para. 1.2.2).
	• *Multi-year averages:* Calculation of direct funding based on five-year averages of the various indicators will increase stability and predictability.	We intend to adopt the IBO's recommendation with regard to increasing the stability and predictability of revenue. However, we consider it more appropriate to apply three-year averages. Any variation in, say, the number of degrees awarded in any one year will not cause any major fluctuation in the amount payable in respect of research funding. (Para. 1.1).

	IBO	2025 Vision for Science
Option 2	Improve the structure of the indirect funding flow *Remarks:* This variant requires NWO to adjust the allocation of indirect funding in line with the policy priorities, to reduce the pressure (workload) involved in applying for grants and subsidies, and to take measures to avoid undue fragmentation. In practice, this entails:	
	• *Long-term funding:* Alongside the existing short-term funding arrangements, there is to be greater focus on grants and subsidies covering a period of between four and ten years. This will create greater stability and will support research proposals with a long (or longer) term horizon.	In its (draft) strategy plan, NWO announces funding provisions with a longer-term perspective (of five to ten years) and measures to enhance the funding eligibility of high-risk research.
	• *Support for cooperation:* The assessment criteria will favour proposals submitted by a consortium with a view to encouraging cooperation at the national level.	In some programmes, NWO will consider not only the applicants' plans for valorisation but the researchers' past valorisation activities (in the broader, societal sense). There are already some NWO programmes in which cooperation is either a firm requirement or weighs in an application's favour. The restructuring of the various instruments (removing the strict boundary lines between programmes) will create more opportunity for cooperation between researchers and institutes. (Para 3.2).
	• *Avoiding fragmentation:* Indirect funding should be linked more closely with the institutions' strategy plans, the sector plans and the European research agenda.	The NWO strategy plan sets out how the existing funding instruments of NWO will be used to support the priorities of the National Science Agenda. As announced in the government's coalition agreement, €275 million per annum is to be made available for programmatic research addressing the Top Sectors, and the public-private partnership arrangements for excellent fundamental research are to be continued. We shall request NWO and the Top Sectors to achieve the best possible correlation between the use of funding in respect of the innovation contracts and the ambitions of the National Science Agenda. The NWO's focus on the agenda and the profiling agreements of the universities (which are discussed below) will ensure that both direct and indirect funding will be applied in pursuit of the national priorities (Para. 1.2.1).

	IBO	2025 Vision for Science
	• *Reducing application pressure (workload):* Calls for proposals will in future be more closely aligned with the spearheads of specific institutions and the sector plans. Restrictions on multiple applications will be introduced: this could mean that a researcher or institution will not be permitted to re-submit a proposal which has already been rejected due to inadequate quality.	The National Science Agenda will introduce focus and coordination with regard to the research priorities. This will be reflected by NWO's thematic calls. In addition, we shall encourage universities to devote greater attention to combined career paths, whereby publication output is no longer the sole or main criterion for tenure or promotion. The alignment of some NWO instruments with the priorities of the science agenda will result in a greater number of researchers being eligible for funding. In consultation with the universities, NWO will introduce best practices intended to facilitate application procedures and reduce the workload for applicants, referees and assessors alike. Particular attention will be devoted to achieving a good balance between the time and effort expended in submitting an application and the likelihood of it being accepted, as reflected in the overall approval rate. Universities and institutes will remain responsible for submitting appropriate and well-prepared proposals (Para. 3.6).
	• In addition to the above generic options, the IBO proposes improvements to each of the three main components of the indirect funding flow: - talent and independent research - research concerned with the societal themes - accessibility of large-scale infrastructure and data facilities. The IBO suggests that, assuming that the budget remains unaltered, a political choice must be made. Where one aspect is prioritised, expenditure on one or both of the other aspects must be reduced.	This 2025 Vision for Science adopts an approach which combines elements of the three IBO options. Opportunities for talent development and independent research will be retained; the National Science Agenda addresses a number of the societal themes, and the priorities set out in that agenda will determine investments in the infrastructure (Para. 1.1).

	IBO	2025 Vision for Science
Option 3	Improved governance *Remarks:* Various options are given which are intended to improve the governance of the science system. In practice, this will entail:	
	• *Strategic choices and 'smart' links with a National Science Agenda:* In addition to the strategic profiling of individual institutes, it is desirable to identify a number of spearheads at the national level. The proposal is to develop a National Science Agenda which offers direction and structure to all Dutch research which relies on direct or indirect government funding. That agenda should therefore establish clear priorities. Universities and research institutes should make joint investments in the (future) strengths of Dutch science. Government will oversee the process of arriving at appropriate strategic choices, facilitate cooperation and provide support as necessary. The National Science Agenda will also be used to strengthen the international position of Dutch science across the board.	The National Science Agenda is a 'co-creation', produced jointly by Dutch scientists, entrepreneurs, societal organisations, government and the general public. The government will ask the knowledge coalition, which currently comprises VSNU, KNAW, NWO, the Association of Universities of Applied Sciences, TO2, VNO-NCW and MKB Nederland, to take the lead and produce a draft version of the agenda no later than the autumn of 2015. All other relevant parties will be involved in the process: The Young Academy, the Netherlands Federation of University Medical Centres, (NFU), ministries, provincial and local authorities, key figures from the Top Sectors and national institutes such as the KNMI and RIVM. It is important that the agenda is not based solely on the existing institutional frameworks. Scientists, researchers and independent, creative thinkers will also be invited to contribute (Para. 1.2.1).
	• *Transparency and accountability:* Transparency in decision-making is important to ensure the legitimacy of those decisions and to engender support. The (strategic) considerations which determine how funds are allocated and the results that are achieved must be more apparent. The field has suggested various ways in which transparency can be increased, such as including relevant information in an institute's annual report or creating a web portal. The government should arrive at suitable agreements with the universities, NWO and KNAW.	The 2025 Vision on Science devotes attention to transparency and accountability in the context of the funding of large-scale research infrastructure (Para. 1.2.4).

	IBO	2025 Vision for Science
	• *A dynamic system of institutes:* The institutes which fall under the aegis of NWO and KNAW have an important (national) function within the science system, complementing that of the universities. They manage facilities and collections, provide mass and ensure continuity within the important research domains. They can also initiate new research in emerging areas of interest. There is, at present, little or no room for any new institutes. It is proposed that the current NWO and KNAW institutes are subject to regular evaluation, both individually and in relation to each other, with regard to their national function and excellence. Further to the findings of this evaluation, an institute may be instructed to devote part of its budget to improvement measures. It may also be appropriate to establish new institutes, or to discontinue the activities of any which no longer form a logical part of the overall system. Such measures will create a more dynamic system of institutes. Moreover, should the evaluation show that the 'dual ownership' of the institutes (by NWO and KNAW) prevents the efficient achievement of the objectives, it may be appropriate to consider bringing all under the purview of a single governance body.	Where appropriate, the institutes will align their strategic programmes with the National Science Agenda, to which they can then make a substantial contribution. All institutes will be subject to regular evaluation examining their international quality, national function and added value. Evaluations will no longer focus on each institute separately, but will also consider the interaction between them as a 'system'. NWO and KNAW will therefore be requested to conduct a broad evaluation every four years (or at an interval to be determined). The results of the evaluation may prompt the establishment of new institutes or modifications to the mission of existing institutes. In some cases, the conclusion may be that an institute no longer has a viable future as an independent, national body, whereupon the options include its merger with another institute, its incorporation into a university's organisational structure or outright closure. When allocating funding to the various institutes, the governing bodies of NWO and KNAW will take the results of the evaluations into account, as well as the relationship with (the objectives of) the National Science Agenda (Para. 1.2.5).

	IBO	2025 Vision for Science
	• *Effectiveness of the advisory function:* There should be a reduction in the number of advisory reports on science policy offset by an increase in the practical value of those which remain. This can be achieved by demarcating the roles and responsibilities of each advisory body and by encouraging closer cooperation between them. In some cases, a merger may be the best option.	We wish to improve the advisory system, particularly with regard to its effectiveness. Accordingly, we shall promote the joint development of advisory programmes by AWTI, KNAW, the Rathenau Institute and the CPB, which address the government's current knowledge requirements more closely. This will avoid fragmentation and duplication, while also shortening the advisory process. One example of the government's advice requirement concerns the effectiveness of the science system itself. Is it working as it should? With the help of the aforementioned organisations, we intend to conduct a regular assessment of the science system and its functioning. It seems appropriate to do so at two-yearly intervals. The findings will support debate, both political and public, concerning the use of public funds, confidence in science and the impact of science. In 2018 we intend to conduct an evaluation of the advisory system. We also wish to gain a more complete understanding of the economic effects of investments in research. KNAW produced an exploratory report on this topic in 2013. The CPB is currently examining the macro-economic effects of investment in science. Its initial findings will become available towards the end of the year and will form the basis of discussions with the CPB and KNAW about the next stages in the process (Para. 2.7).

	IBO	2025 Vision for Science
Option 4	Science in support of education *Remarks:* The underlying objective of this policy option is to increase the added value that research brings to scientific education. Presenting the results of recent research to students enhances the quality of education, makes scientific knowledge more widely available and relevant, increases the absorptive ability of Dutch society, and fosters both innovation and economic growth. In real terms this entails:	
	• *Recognition of teaching ability:* Scientific and research staff should be encouraged to take a more active part in the educational process, particularly in those subjects which attract a large number of students. There should be greater recognition for teaching skills as part of the performance appraisal structure, and hence in all aspects of personnel policy including the rewards structure and promotions. Some universities now report that performance appraisals do indeed attach greater weight to educational performance. Their example should be followed.	Good research scientists who (also) provide excellent education will enjoy significant career advancement opportunities. This is something to which attention will be devoted in our talks with the VSNU about the new framework agreement. That agreement may well include other matters relating to strategic personnel policy, such as an updating of the current career paths structure, more opportunities for young talent, more attention for education by means of combined career paths, balanced attention for performance in research, education *and* valorisation, preparation of PhD students to pursue career opportunities in other sectors, and the appointment of more women professors. The proposed amendment of the student grants and loans system will release funds which will be used to improve the quality of higher education, including research activities which are directly related to education. Further measures to strengthen the relationship between research and education will be announced in the Strategic Agenda for Higher Education and Research, to be published in 2015. (Para. 3.2).
	• *External research assessments:* Visiting review committees should attach greater importance to the degree to which a university's research contributes to (the quality of) its education.	

Appendix 3
Undertakings met by the 2025 Vision for Science

I Undertakings made in written communications to the House of Representatives

1. In its communication to the House of 1 October 2014 (Parliamentary Proceedings II, 2014-2015, 31 288, no. 405) the government announced that a vision document on science would be presented in November 2014. The document *Science Vision 2025: choices for the future* fulfils this undertaking.

2. In its response to the KNAW evaluation (letter of 8 September 2014; Parliamentary Proceedings II, 2013-2014, 29 338, no. 139), the government promised that the vision document would devote attention to KNAW's advisory role in relation to that of other advisory bodies. This undertaking, which was also prompted by the findings of the Interdepartmental Policy Review (IBO), is met in Para. 2.7.

3. In its response to the KNAW evaluation, the government promised to devote attention to the development and future of the institutes which fall under the aegis of both KNAW and NWO. This undertaking, which was also prompted in part by the findings of the 2013 evaluation of NWO, is met in Para. 1.2.5.

4. In its response to the NWO evaluation (letter of 14 November 2013, Parliamentary Proceedings II, 2013-2014, 29 338, no. 126), the government undertook to submit to the House a broad-based vision document on the future of the science system, to be produced in association with KNAW, NWO, VSNU and other relevant stakeholders both within and beyond the public sector, most notably researchers themselves. This process would take into account the results of the NWO evaluation, those of the KNAW evaluation, the contents of the advisory report *Optimalisering van het wetenschapsbeleid* ('Optimization of science policy') produced by the AWT and the findings of the Interdepartmental Policy Review (IBO), whereby the promised vision document could also be regarded as the government's response to the IBO report. The 2025 Vision for Science fulfils all these undertakings.

5. In its response to the NWO evaluation, the government promised to devote attention to proposed changes to the organizational structure of NWO in the forthcoming vision document. This undertaking is met in Para. 1.2.3.

6. In its communication to the House (letter of 22 July 2014, Parliamentary Proceedings II, 2013-2014, 21 501, no. 333) on the meeting of the Informal Competitiveness Council in Milan on 21 and 22 July 2014, the government promised that the forthcoming vision document would consider the procedure for any future updating of the Dutch roadmap and its alignment with national policy. This undertaking is met in Para. 1.2.4.

7. In its communication to the House (letter of 15 July 2014, Parliamentary Proceedings II, 2013-2014, 22 452, no. 41) on the international dimension of higher and vocational education, the government promised that the internationalisation of science would be addressed in vision for science. Various sections of the Vision Document 2025 refer to this topic; they include the Introduction and Para. 3.3 which deals with the promotion of the Netherlands abroad and the potential for attracting top international researchers.
8. In its communication to the House (letter of 1 July 2014, Parliamentary Proceedings II, 2013–2014, 27 406, no. 220) on the 2013-2014 funding round for the National Roadmap for Large-Scale Research Facilities, the government promised that the forthcoming vision document would set out concrete action through which the strategic efficiency of investments in large-scale research facilities can be increased, as per the recommendations of the AWT advisory report *Maatwerk in onderzoeksinfrastructuur* ('Custom-made research infrastructure'). This topic is addressed in Para. 1.2.4.
9. In its communication to the House (letter of 23 May 2014, Parliamentary Proceedings II, 2013-2014,29 338, no. 136), which accompanied the report of the Interdepartmental Policy Review, the government undertook that the forthcoming vision document would include a formal response to this report. Appendix 1 of the 2025 Vision for Science sets out how the various policy options listed in the report have been incorporated into the vision document.
10. In its communication to the House (letter of 2 April 2014, Parliamentary Proceedings II, 2013-2014, 29 338, no. 133), accompanying the report *Uitkomsten feitenonderzoek matching-behoefte op (Europese) onderzoeksubsidies* ('Findings of factual investigation of the matching requirement for (European) research subsidies') the government promised that the forthcoming vision document would include a response to the report. This undertaking is met by Para. 1.1.
11. In its written reply dated 25 November 2013 (Parliamentary Proceedings II, 2013-2014, Annex 2013D47296) to questions tabled by Members Van Meenen and Mei Li Vos, the government promised that the forthcoming vision document would address criticism of 'perverse' incentives in the science system. This topic is considered at various points, including the introduction and Para. 3.6.
12. In its communication to the House (letter of 20 November 2013, Parliamentary Proceedings II, 2013-2014, 220338, no. 127) accompanying the report *Verkenning Waarde van Wetenschap* ('An exploration of the value of science'), the government promised that the recommendations of this report would be taken into account in the forthcoming vision document. This undertaking is met by Para. 2.7.
13. In its communication to the House (letter of 15 July 2013, Parliamentary Proceedings II, 2012-2013, 29 338, no. 122) on the subject of research schools, the government promised that the development of the forthcoming vision document would involve consultation with the management, research staff and representatives of research schools (such as SODOLA), graduate school and PhD. All such parties were consulted during the development of the 2025 Vision for Science.

II Undertakings made in written communications to the Senate

In its communication of 1 October 2014 (Senate Proceedings, 2014–2015, 34 000 VIII, A) the government promised that the forthcoming vision document would respond to the motion tabled by Member Flierman during the debate on Innovation of 18 March 2014 (Senate Proceedings, 2013–2014, 33 750 XIII, C) with regard to the use of national budgetary resources in support of the acquisition of European research funds. This matter is addressed in Para. 1.1.

III Undertakings made during parliamentary debates (House of Representatives and Senate)

House of Representatives

1. During the debate on Industrial Policy of 19 November 2013, the government undertook to provide a formal response to the report *Verkenning Waarde van Wetenschap* ('An exploration of the value of science'). An initial response was issued on 24 February 2014 (Parliamentary Proceedings II, 2013-2014, 29338, no. 130). The matter is addressed in further detail in Para. 2.7 of the vision document.

2. During the debate on Science Policy of 4 December 2013, a number of undertakings were given with regard to the vision document:

    1. The vision document would be presented to the House before the summer recess 2014. It would devote attention to the role of the government and its advisory bodies, the e WRR report, provide a response to the IBO report and to other ongoing discussions such as that initiated by the VSNU, to the improvement of educational quality, and to large-scale infrastructure.
    2. A written communication would be submitted to the House prior to the summer recess 2014 describing the added value of science, whereby attention would be devoted to the place that science occupies in the models applied by the Netherlands Bureau for Economic Policy Analysis. This information may also be included in the policy vision document, although no firm undertaking to this effect was given.

In its written communication to the House of 23 May 2014 (Parliamentary Proceedings II, 2013-2014, 29338, no. 136) the government informed the House that the vision document would be presented at some point after the summer recess. A communication of 1 October 2014 (Parliamentary Proceedings II, 2014-2015, 31 288, no. 405) informed both Houses that the vision document on Science would be presented in November 2014.

Paragraph 2.7 of the 2025 Vision for Science examines the role of the government and its advisory bodies, as well as the position of science within the models applied by the Netherlands Bureaus for Economic Policy Analysis. Various sections of the vision document refer to the contents of the WRR report *Naar een lerende economie* ('Towards a learning economy') and the report of the Interdepartmental Policy Review (IBO). Appendix 1 of the vision document sets out the policy options listed in the IBO report in relation to the contents of the vision document itself. The topic of large-scale research infrastructure is examined in Para. 1.2.4. The improvement of educational quality is discussed in brief in Para. 2.6 and shall be further addressed in the Strategic Agenda for Higher Education.

Senate
During the debate on the National Reform Programme of 11 June 2013 (Senate Proceedings, 2012-2013, no. 30), the Minister of Economic Affairs undertook to examine the manner in which national expenditure on education and research is included in the models of the Netherlands Bureaus for Economic Policy Analysis in comparison with European practice and the in the context of the KNAW report Verkenning Waarde van Wetenschap ('An exploration of the value of science'). This matter is addressed in Para. 2.7 of the vision document.

A response to the motion tabled by Member Flierman during the debate on Innovation of 18 March 2014 (Senate Proceedings 2013-2014, 33 750 XIII, C) is given in Para. 1.1.

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