Rathenau Instituut

Knowledge of the Future

A foresight study for science policy

Report

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Water wheel at the NEMO Science Museum in Amsterdam. Kim van Dam / ANP Photo

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Preface

Developments within society – such as digitalisation, climate change, or geopolitical tensions – are having an unmistakable influence on science. Artificial intelligence, for example, is changing the way scientists conduct research. Where the energy transition or climate policy are concerned, the public expect science to come up with solutions. And while geopolitical conflicts raise questions about the shifting direction of relations on the world stage, universities find themselves confronted by strategic interests in the work of researchers. Broad developments within society such as these affect scientific practice and society's expectations of science.

The Rathenau Instituut is constantly engaged in investigating these matters, for example with studies of open science, of what drives researchers, and of trust in science. The present report builds on those studies and outlines how science and its relationship to society may well undergo change over the coming years.

Based on a study of the relevant literature and a scenario workshop with stakeholders, we conclude that developments in science and society call for greater variation in science policy, namely policy aimed at developing new knowledge but also at utilising science to tackle the challenges facing society. Policy must allow scientists to conduct their research freely within the bounds of science, but must also ensure greater openness, aimed, for example, at generating knowledge for and with society.

Such differentiated science policy requires new policy instruments. Just what these might be is a matter that the Rathenau Instituut will be only too happy to discuss with all the relevant stakeholders. This report already provides pointers for an open dialogue about the future of science policy.

Prof. Eefje Cuppen
Director of the Rathenau Instituut

Summary

This report outlines four broad developments that affect the future of society in general and of science in particular. Together, they pose new challenges for science and science policy. These developments affect
(i) the scientific process;
(ii) the way science is organised;
(iii) the relationship between science and society; and
(iv) the international positioning of Dutch science.

Our description of these developments is based on scientific and 'grey' literature, information from interviews, and a scenario workshop.

1. The scientific process
The main structural development that is radically changing scientific research is digitalisation. The use of digital technologies, including artificial intelligence (AI), can make research faster and more efficient and can create opportunities for new kinds of research. It is therefore not only the demand for ICT skills that is increasing in the research context, but also that for know-how about quantitative and statistical methods. At the same time, digitalisation may well lead to the private sector playing an increasing role in public research. Much of the necessary ICT know-how is concentrated, after all, in the big tech companies.

Further digitalisation of the scientific process will offer opportunities, but will also bring risks. For instance, the use of AI raises questions regarding the replicability and reliability of research results. The dominant position of big tech companies as regards ICT expertise and infrastructure calls for rethinking the relationship between the public and private sectors in the development of knowledge.

2. The way science is organised
In recent decades, the pursuit of excellence has increasingly become the central focus within academia. To promote excellence, knowledge institutions and funding bodies have given researchers ample scope to develop their research ideas freely and have relied heavily on competition to select the best ideas and to allocate research resources accordingly.

This hyper-competition has recently met with increasing resistance. An exclusive focus on research excellence comes at the expense of other valuable functions of scientific endeavour, including the valorisation of knowledge. Science policy is therefore increasingly moving more towards collaboration and societal impact. In

the coming years, this will be reflected in new practices such as open science, the new system of 'recognition and rewards', and the promotion of team science and transdisciplinary research.

A key question is how science can be organised more around collaboration and less on the basis of competition for research resources. What will this mean as regards quality and efficiency? Another question concerns specialisation and the profiling of research institutions. Is this desirable, and if so, who should be responsible for it?

3. The relationship between science and society

Society is increasingly calling on science to provide solutions to pressing problems, ranging from climate change and pandemics to social tensions and economic inequality. The Dutch Government has therefore broadened the Top Sector Policy into ‘mission-driven top sectors and innovation policy’, focusing in part on societal goals. When assessing grant applications, the Dutch Research Council (NWO) requests an Impact Outlook or an Impact Plan. And because complex problems require the integration of knowledge from diverse disciplines and from actual practice, there is an increasing focus on interdisciplinary and transdisciplinary collaboration, for example in city labs, living labs, and academic workshops.

Greater public pressure on science to come up with solutions to pressing societal problems will reduce the distance between science on the one hand and politics and society on the other. This raises questions about what society should and should not expect from public knowledge institutions, about what is required in order to meet legitimate expectations, and about what needs to be done, where necessary, to safeguard the independence of science.

4. The international positioning of science

Scientific development has in recent decades taken place within an international framework; scientific knowledge is predominantly a ‘global public good’. Promoting open science will reinforce this shared nature of knowledge. But international relations are changing. A transition is taking place from a US-dominated to a more China-dominated world order. The question is what this means for how the global scientific community functions. The increasing focus on knowledge security suggests that much scientific knowledge is gradually being seen more as a strategic asset to be protected than as a communal asset.

Geopolitical tensions are leading to uncertainty. They prompt us to reflect on what constitutes strategic knowledge that our country must have at its own disposal, and which countries are reliable partners with which to jointly develop scientific know-how.

Challenges for the future

The four developments outlined in this report are likely to lead to fundamental changes and innovations in the way scientific research takes place, in the way science is organised, and in its relationship to society and to science in other countries. These changes will be more pronounced in some scientific fields than in others. On balance, this development is expected to bring about greater diversity in scientific practice, which calls for increased differentiation in policy instruments for guiding science in the right direction.

To characterise such diversity, we distinguish between policy instruments needed for a closed versus an open knowledge system. We also distinguish between instruments for knowledge development to expand the boundaries of knowledge versus instruments for generating knowledge for practical application. Whereas there is a great deal of experience with policy instruments for a kind of science that is relatively closed and that focuses on groundbreaking knowledge development, we still have only limited experience with instruments for an approach to science that is more open, interactive, and application-oriented.

The developments outlined in this report confront science and science policy with the need to make some important choices. Many of these involve finding a new balance, for example between the role of public institutions and private organisations in developing knowledge, between competition and collaboration in the allocation of resources, between fundamental research with a long-term perspective and knowledge development for tackling urgent short-term problems, between openness and knowledge security, and between conducting research for science, for society, and with society.

The purpose of this outline of influential developments is to extend an invitation to engage in an open dialogue about the science of the future and the future of science.

Contents

1 Introduction

A pandemic that few expected held society in its grip for a number of years. And then a war on our own continent took many by surprise, straining global political relationships. Meanwhile, climate change and the loss of biodiversity are increasingly setting the political agenda. These are just a few of the profound developments that have major implications, including for science. They raise numerous scientific questions and challenges.

Meanwhile, a great deal is also going on within science itself. More and more disciplines are utilising artificial intelligence to analyse data and make predictions. Open science is becoming the standard when publishing results and sharing data. Scientists are increasingly involving stakeholders and the general public in their research.

What are the consequences of these developments for the science of the future? What do they mean for the role of science in society? In this publication, the Rathenau Instituut presents a foresight study aimed at clarifying relevant developments for the Dutch science system and identifying tasks for Dutch science policy. We hope this study will help politicians, policymakers, and directors of knowledge institutions and research funding bodies to think about what kind of science we want in our country. What is the significance of science for the Netherlands, what is its desirable position in society, and what kind of policy is needed for it to acquire and strengthen that position?

Mid-2023 saw the appearance of the report *Vandaag is het 2040* [It's already 2040], a foresight study for secondary vocational education, higher education, and science.[1] The present foresight study is limited to scientific research and does not deal with education, but it does build on some observations in that report and places developments in science in a broader framework of current developments within society.

Four perspectives

To give an idea of the developments that are important for the future of science policy, we view Dutch science from four different perspectives, in each case taking a step backwards, so to speak (see Figure 1). We look successively at:

1. the scientific process;

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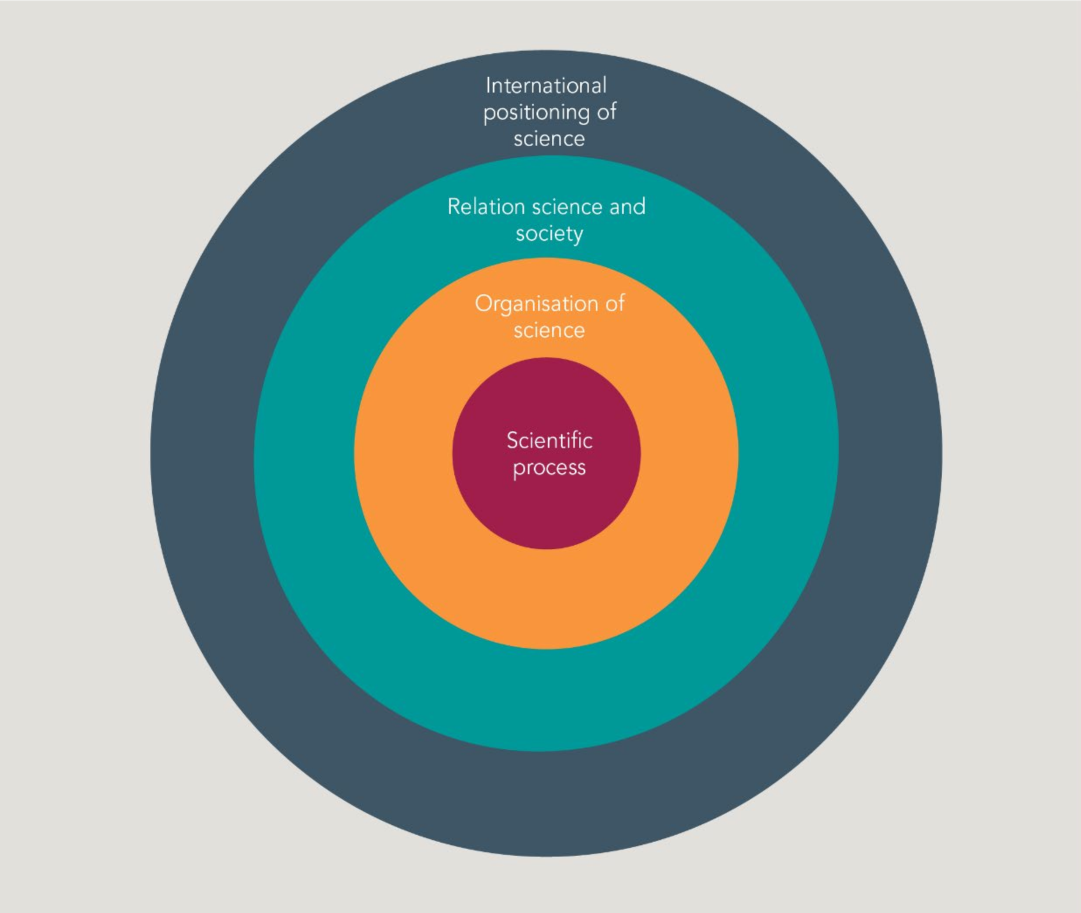
1 Eimers (ed), 2023. The foresight study was conducted by KBA Nijmegen (consortium lead), ResearchNed, Andersson Elffers Felix, CHEPS, and the Kohnstamm Institute.

2. the way science is organised;
3. the relationship between science and society;
4. the international positioning of Dutch science.

In four separate chapters, we describe the main developments currently underway as regards each of these different aspects. We indicate how these developments can be seen as manifestations of broader general developments within society.[2]

Figure 1 Dutch science from four perspectives



Source: Rathenau Instituut

It is not easy to predict how strongly the four developments described will carry over into the science system and into society as a whole in the medium term. In the final section of each chapter, we describe the strategic issues about which policymakers need to keep an open mind in the coming years .

2 This foresight study is largely based on the broad survey, as explained in Appendix 1.

Approach
Our description of developments within science and society is based on scientific and 'grey' literature, information from interviews, and our own expertise and observations. To add depth to our analysis, we held a scenario workshop with stakeholders. For that purpose, we developed a scenario for the future of each aspect. The scenarios were exploratory in nature and are emphatically *not* to be taken as forecasts. They helped, however, to make the consequences for scientific practice more tangible and specific.[3]

The developments in science and society that have been outlined, together with the scenarios, served as the basis for formulating a number of tasks for science policy.

Limits of the foresight study
By science policy we mean here interventions at national level and within knowledge institutions that are aimed at increasing the relevance, effectiveness, and efficiency of Dutch science. Current science policy focuses on
(1) a strong and sound foundation;
(2) giving scope to a diversity of talent; and
(3) increasing the societal impact of higher education and research.[4] Future developments may of course be a reason for modifying these targets.

In our foresight study, we look primarily at research universities, university medical centres, universities of applied sciences, and academic research institutes. These operate within a broader context, which also comprises institutes for applied research (TO2), government knowledge institutions, and other public and private knowledge organisations. Our time horizon for this foresight study is some 10 to 15 years.

Reading guide
Each of the following four chapters describes a line of development within the science system as a manifestation of a broader trend within society:

- Chapter 2 deals with changes in the scientific process, namely as a result of technological development, in particular the use of digital technology.
- Chapter 3 describes changes in the organisation of scientific research, intended to reduce the drawbacks of an overemphasis on competition and individual performance.
- Chapter 4 deals with the changing relationship between science and society, partly as influenced by major societal challenges in such areas as climate, energy, and the environment.

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3 See Appendix 2 for a description of the methodology, a list of workshop participants, and the scenarios used during the process.
4 Ministerie van OCW, 2022.

- Chapter 5 looks at the international positioning of Dutch science in a world where geopolitical tensions are mounting and knowledge security is an increasing concern.

Chapter 6 brings the four lines of development together. We conclude by looking at the consequences of the various developments for science policy.

2 The scientific process

The main structural development that is radically changing scientific research is digitalisation. Digitalisation has consequences for the research process in almost all disciplines, although in different ways. For decades now, the introduction of new applications of digital technology has led to major changes in research, and with the development of artificial intelligence (AI) that trend can be expected to continue in the future. Digital technology can make research faster and more efficient, and it also creates opportunities for new kinds of research.[5] The use of ICT can make researchers' work easier and thus increase their productivity. At the same time, the advance of digital technology in science also raises new questions, for example regarding the reproducibility of research results when they are generated with the aid of AI.

2.1 Digital technology

At various times in the past, access to new technology – for example inventions such as the microscope and telescope – gave a major boost to science. In recent decades, the availability of computers, the internet, and then a whole range of new applications of digital technology have radically altered the research process. Throughout society, digitalisation has greatly simplified and accelerated numerous activities that used to be performed manually or by mechanical means, and the same is true in the world of science. Scientists have been using ICT to collect or analyse data for decades, but the availability of massive quantities of data, expansion of the available computing capacity, and further development of artificial intelligence are currently creating radical new opportunities.[6]

The first consequence of digitalisation is the much greater availability of data that scientists can use to conduct research. The ubiquity of sensors, digital devices, and communication networks creates large flows of data that can be used in research. Human behaviour, developments in our environment, written texts, sounds and images – all these are recorded in digital data that find its way into academic research.

5 This means research with big data files and powerful computers that were not previously available (‘data science’).

6 According to an OECD study, some 40% of all authors of scientific articles now use computer models or simulations in their research, although Dutch researchers still do so slightly less than the average (OECD, 2019).

A second consequence of digitalisation is that scientists can conduct their research more efficiently. Digital technology automates many parts of the research process, including the collection, processing, and analysis of data. Algorithms are getting smarter all the time, and computers can handle more and more data. Recently launched Large Language Models (LLMs) such as ChatGPT offer yet more new possibilities. These can assist researchers with programming, for example, or help them create an overview of relevant literature or historical sources.

A third consequence of digitalisation is the emergence of new forms of academic research. The increasing amount of data available for research and the rise *machine learning* are amplifying the opportunities for *data science*. This is a type of science that is driven primarily by available data, with research following not so much a deductive path – i.e. from theory through verifiable hypotheses to empirical testing – but rather an inductive path, starting from the available data and attempting to discern regularities and structures in it so as to arrive at scientific understanding. Some writers on the philosophy of science envisage a paradigm shift from explaining phenomena to recognising and predicting patterns. This would mean that science will focus more on describing phenomena, without providing insights into their underlying causes. One example is predicting which patients are at risk of a particular condition based on their genetic material, without knowing exactly what physiological mechanisms cause that condition.[7, 8]

2.2 Practical consequences

Greater digitalisation of academic research involves a range of practical consequences. First, there is an increasing need for new digital skills. For example, researchers not only need to be able to deal with more digital resources but also need to have a better understanding of quantitative and statistical methods. New roles are emerging within research, for example that of 'data steward'.[9]

A second consequence is the increasing role of the private sector in public research. Although the government is investing substantially in digital infrastructure for science,[10] the digital research resources utilised by universities are largely in

7 Nordmann, 2020 distinguishes between scientific and techno-scientific research, with the latter necessarily requiring a greater tolerance for what we do not know. Such a knowledge gap is a consequence, among other things, of the increased complexity and scale at which technoscience research operates, leading to more trial and error in the approach adopted. See also Boge and Poznic, 2021.

8 Sarewitz, 2016 has described the overabundance of data as a 'datageddon' that strikes at the very root of a mode of science focused on explanation and understanding.

9 See, for example, TU Delft Data Stewardship (tudelft.nl) and Radboud Datastewards – Research Data Management (ru.nl)..

10 In 2018, 2019 and 2020, for example, €20 million was invested annually in digital infrastructure, mainly for the development of a supercomputer (Ministry of Education, Culture and Science, 2022).

private hands,[11] for example citation management software, research databases, and video-conferencing services. New digital tools are regularly developed at public knowledge institutions, but scaling up and maintaining such tools requires flexible, long-term funding, which is often unavailable from public sources. Researchers and research institutes therefore often decide to make use of a private alternative.[12] The companies that provide the relevant platforms tend to be big monopolist players within their market. Over time, this may also mean that private parties will become more involved in research, thereby also attracting talented individuals who will then pursue private rather than public research.

A third consequence is increasing concern regarding knowledge security. In a digital environment, ensuring the security of information is a complex task, one that will become even more complicated when quantum computers become available. These are expected to be able to circumvent current forms of data security.[13]

The question is to what extent other developments will continue to have their effect, such as the focus on data science and machine learning, further methodological uniformity, the growth of inductive research, and the use of artificial intelligence as a research tool.

2.3 What is at stake?

Further digitalisation of the scientific process offers opportunities. Digital technology is a particularly powerful tool for generating new scientific knowledge and insights, but it can also drastically alter the nature of scientific research. This raises the following questions:

1. What will further digitalisation of scientific research mean for the generalisability and usability of the knowledge that it generates? How will we deal with a changing relationship between explanatory and predictive research?

- If scientific research increasingly takes on the character of data science or is conducted with the aid of artificial intelligence – potentially becoming more data-driven than theory-driven – how can we ensure that the resulting scientific knowledge is understandable, replicable, and reliable?[14]
- Do traditional forms of scientific research – based not on the use of powerful digital tools but, for example, on laboratory experiments, fieldwork, or

11 Rectores magnifici of Dutch Universities, 2019
12 Expert interview.
13 AIVD, 2021b.
14 Horbach et al, 2022; van Noorden, 2022.

document analysis – deserve protection? How can the pluralistic nature of scientific research be preserved?

2. What does further digitalisation mean for the division of tasks and roles between public and private parties?

- What needs to be done to safeguard the public character and independence of science in a world where the (digital) technologies and resources for research are largely in the hands of big international tech companies?
- How should the relationship between public knowledge institutions and private companies be shaped if those companies surpass public organisations in terms of the availability of technology and the capacity to use it for research, and in terms of the resources for attracting talented individuals?

3. Are additional efforts needed to ensure that Dutch science is one of the leaders in exploiting the opportunities offered by digitalisation?

- What strategic choices, knowledge development, and investments are needed for this?

3 The way science is organised

We are emerging from a time when the focus within academia has been increasingly on the pursuit of excellence.[15] The prevailing view is that research is excellent if it is published in the journals that are most highly regarded and most frequently cited. A researcher is excellent if he or she acquires the most prestigious research grants and his or her work is rewarded with prizes. To promote excellence, academia has in recent decades relied on competition as an organising principle. Researchers compete for research grants and for recognition by scientific journals. Scientific institutions compete with one another for the best researchers and students. Currently, however, a shift is apparent in this situation.

3.1 Beyond excellence and competition

In recent decades, universities and scientific institutes worldwide have increasingly been organised along the lines of ‘new public management’ (NPM), as if they were autonomous businesses competing on global markets. As far as their research is concerned, these knowledge institutions are 'judged' primarily according to their earning capacity, publications, and citations. This has fostered a one-dimensional pursuit of research excellence within these institutions. This decades-long focus on excellence in the governance and funding of science has contributed to Dutch research being very highly regarded internationally – that is to say: very widely cited – and to Dutch universities occupying a high position in international rankings.[16]

What has taken place in the organisation and governance of knowledge institutions is part of a broader societal trend. The principles of NPM have left their mark on many public organisations. This fits in with the trends of the past three to four decades whereby our society has become increasingly individualised and mutual interaction is increasingly organised according to market principles. We have moved from a welfare state to a participation society, from a society built on collective facilities to one organised around individual choices.

Increasing resistance to this change would seem to have arisen in recent years. When discussing facilities such as public transport, healthcare or education, by no

15 Cremonini et al, 2017.
16 Seven Dutch universities are in the top 100 most cited universities according to the Leiden Ranking, which examines the proportion of a university's publications that – compared to other publications in the same field and year – are among the top 10% most cited publications. https://www.rathenau.nl/nl/wetenschap-cijfers/werking-van-de-wetenschap/excellentie/ranglijsten-rankings

means everyone finds it obvious to rely on market forces anymore. From different quarters of the political spectrum, there are now calls for societal arrangements that focus less on economic growth and more on ensuring social security and secure livelihood and restoring trust in social solidarity.

The widely felt resistance to ever-increasing individualisation and ever more competition and market forces is also asserting itself in academia,[17] where it is becoming increasingly clear that a form of organisation focusing exclusively on excellence comes at the expense of other valuable functions of scientific endeavour. Promoting measurable excellence does not automatically lead to encouraging research with the greatest value to society: 'not everything that counts can be counted and not everything that can be counted counts.'[18] It also does only limited justice to the ambitions of researchers to make a meaningful contribution to society.[19] It tends, moreover, to promote above all incremental, individually oriented, discipline-focussed, and risk-averse research.[20]

But there are more undesirable developments associated with the current organisation and governance of science. Constant competition loads a great deal of publication pressure onto researchers' shoulders, with a heavy toll on their mental well-being. The limited career opportunities that are available, especially for early-career researchers, also contribute to mental problems.[21] Mutual competition has also led to a major concentration of research resources among a limited number of top scientists, the 'Matthew effect'.[22] Moreover, the system used for allocating research budgets in the context of competition is expensive and time-consuming.23 Much of the funding for research is channelled to a wide spectrum of relatively small, individual projects. All those projects are based on voluminous project proposals, which are then subjected to labour-intensive assessment procedures. The award rate of projects funded by NWO has since 2018 been about 20%. Since 2021, it seems to be increasing somewhat, particularly within the Dutch Research Agenda (NWA).24 NWO already began taking steps in 2017 to reduce the number of applications received. In the new NWO Strategy (2023–2026), the success rates for the Open Competition and Talent Programmes are also a key focus.

Strong competitive pressure in research is partly to blame for what has come to be referred to as the 'replication crisis'. Since the turn of the century, there have been all kinds of projects in various disciplines – including psychology, biology,

17 See, for example, International Science Council. 2023
18 A statement attributed to Einstein.
19 Rathenau Instituut, 2022a.
20 Moore et al., 2017; Chu and Evans, 2021.
21 See for example Levecque et al., 2017 and Van der Weijden & Teelken, 2023.
22 Rathenau Instituut, 2018a.
23 Ibid.; Moore et al., 2017; Rathenau Instituut, 2018a.
24 That is less so with the Open Competition and the Talent Programme. See Rathenau Instituut, 2023a.

pharmacology, and biomedical research – that seek to replicate results published in scientific journals. In many cases, replication has proved impossible. What emerges from the scientific literature as solid knowledge does not always turn out to be so on closer inspection. In 2015, for example, an international replication project in psychology found that the number of statistically significant results in replication studies was only 39%, whereas in the original set of studies it was 97%.[25, 26] An article in *The Lancet* in 2009 estimated that as much as 85% of the medical research started amounted to *'research waste'* i.e. research of insufficient scientific quality.[27] A major cause of the replication crisis lies in the pressure to report positive results in empirical research. This involves statistical relationships that confirm a hypothesis or theory. Articles that fail to find statistically significant relationships are difficult to get published. This leads to researchers searching for positive relationships and in doing so tending to stretch methodological standards (*'questionable research practices'* or QRPs) and interpreting random patterns in data as statistically significant relationships.[28]

The heavy emphasis on competition in research leads not only to QRPs, quality problems, and high 'system costs'; it also comes at the expense of a focus on the university's other core tasks, namely education and the transfer of knowledge for societal impact. This is particularly problematic given that student numbers are increasing and funding bodies and policymakers are increasingly pushing for such societal impact.[29]

The perceived limitations of the NMP-style approach to scientific research are leading to a search – in science too – for a new balance between individual freedom and collectivity, between competition and collaboration, between excellence (here: publications and citations) and equality, and between knowledge production and valorisation in science. In that context, for example, the Dutch knowledge institutions have in recent years set up a programme to reform the approach to 'recognising and rewarding'.[30] It is possible that forces in society will continue to increase pressure on knowledge institutions to take further steps in such directions..

25 Open Science Collaboration, 2015.
26 See Sarewitz, 2016 for more such examples.
27 Chalmers, I., & Glasziou, P., 2009.
28 Jerak-Zuiderent et al, 2021.
29 Rathenau Instituut, 2022a.
30 See the Recognition and Rewards Programme, https://www.nwo.nl/en/recognition-and-rewards; https://www.universiteitenvannederland.nl/onderwerpen/personeel/erkennen-en-waarderen-van-wetenschappers; https://www.knaw.nl/en/publications/recognition-and-rewards-agenda-2022-2025.

3.2 Practical consequences

Greater awareness of the downsides of an overly competitive regime of ‘publish or perish’ – combined with society's changing demands on science in terms of transparency, responsiveness, and accountability – is leading to the way science is organised and functions gradually being grafted onto a wider range of principles.[31] Besides competition, collaboration is becoming increasingly important; besides implementing a scientific agenda, meeting society’s needs; and besides scientific publishing, generating societal impact. All this is reflected in new forms of organisation and governance such as open science, broader facilitation of interdisciplinary and transdisciplinary research, promotion and funding of team science, and the new system of ‘recognition and rewards’. Under the banner of the latter, universities and research institutes are experimenting with new incentives and rewards for scientific performance, based on a broader view of what constitutes scientific quality.[32]

Various priorities of open science are gradually finding their way into actual practice. For the time being, there is a strong focus on making scientific publications freely accessible (‘open access’) and on curating and sharing data (‘open data’). The number of open access publications by authors with a Dutch affiliation increased from 44% in 2016 to 78% in 2021.[33] Large-scale repositories are being set up for sharing data, but awareness of the possibilities among researchers and the skills to use them are still limited.[34]

The next few years will need to show to what extent these new forms of organisation and governance meet current needs and whether they can form a viable alternative to the established primarily competition-based arrangements. The question is what effect they will have on the productivity and quality of Dutch science, on how it links up with the needs of society, on the attractiveness of the career prospects that it offers, and on its position on the global playing field.

3.3 What is at stake?

The way science is organised – based on mechanisms of competition for funding, publications, and talent – has led to a fragmented scientific landscape, the embedding of which within society is open to improvement. Full professors have a dominant position. They acquire research resources and publication opportunities

31 In the next chapter, we address society's changing demands on science.
32 VSNU (now : UNL) et al., 2019.
33 Rathenau Instituut, 2022b.
34 Hessels et al, 2021.

by means of complex procedures while at other times allocating them to colleagues as members of review or assessment committees. The result is a broad, diverse palette of scientific production that is very much driven by the initiative of individual scientists, with little actual coordination at system level. This competition-based organisational structure imposes a heavy burden on researchers, particularly early-career researchers who have yet to acquire a permanent position.

Among advisers, there are calls for a clearer direction in public research, a greater division of labour between research institutes, and thus more specialisation. A lengthy series of reports have recommended clearer strategic decisions as to what research should and should not be undertaken, more profiling of institutions, and more coordination of research efforts at national level.[35] Although these calls have been ongoing for some considerable time, universities still regularly launch initiatives that lead to more rather than less overlap.[36] Moreover, there is a need to address the high workload and career prospects of researchers.[37] The desire to organise science differently raises the following questions:

1. How and to what extent can the way science is organised be oriented more towards promoting collaboration, rather than competition for research resources?

- Competition for funding is meant to ensure that the best research proposals are given ample scope, with poorer proposals not receiving funding. If research funding is allocated by means of a different mechanism – one based less on competition between specific project proposals – what can be done to ensure effective and efficient use of the funds?
- How can quality be defined and measured, otherwise than as success in terms of publications and citations?

2. Is it desirable for research institutions to raise their profiles and coordinate their research more among themselves? If so, who should ensure this?

- What should form the basis for decisions on the deployment of resources if the process is to be less bottom-up, i.e. initiated less by researchers themselves? What processes are needed for arriving at decisions on thematic research priorities, both nationally and at institutional level?
- Should the task of profiling and coordination lie with the knowledge institutions themselves, or should an external party play a role in this, for example the Royal Netherlands Academy of Arts and Sciences (KNAW) or the Dutch Research Council (NWO)?

35 Veerman Committee, 2010; AWTI, 2003; AWTI, 2019.
36 For example, the number of bachelor programmes at Dutch universities continues to increase each year: https://www.universiteitenvannederland.nl/onderwerpen/onderwijs/opleidingsaanbod-universiteiten.
37 OECD, 2021; van der Weijden & Teelken, 2023

- What role should government play, and what knowledge, expertise, capabilities, and powers are required for it to do so?

4 The relationship between science and society

The attention currently being paid to a different way of recognising and rewarding research efforts and attempts to alter the emphases within the funding system that were described in the previous chapter have been prompted not only by tensions within science itself, but also by developments in society's expectations and demands regarding science. In the second half of the previous century, the dominant idea was that science functions best when scientists and scientific institutions can operate as autonomously as possible. Scientific progress results when scientists are free to follow their curiosity: 'Scientific progress on a broad front results from the free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for exploration of the unknown.'[38] *Seen from this perspective, science is essentially about generating knowledge, about discovering how the world works.*[39] This view has long defined the position of science within society throughout the entire Western world.[40]

Alongside the view that science is essentially about generating knowledge there is the view that it should focus on practical problems. This view of the nature of science has always played a role in the medical and technical sciences, but in recent years it has also gained currency in the more fundamental disciplines: science should provide the knowledge needed to address major societal challenges. The ultimate goal of research is then societal impact. From that perspective, 'the free play of free intellects' is not enough. To achieve this societal impact, science would need to connect with society more than in the past, or do so in a different way. Developments in the organisation and governance of science in recent years can be seen as a search for opportunities to establish new connections and to make them productive.

4.1 Contributing to society

In recent years it has become increasingly clear that with the way we now live we are coming up against a range of physical limits. Exceeding the limits of our planet's carrying capacity is leading to climate change, loss of biodiversity, and ultimately to

38 Bush, 1945.
39 This applies more to science at research universities [Dutch *universiteiten*] than at universities of applied sciences [*hogescholen*], which is organised, directed, and assessed differently.
40 Sarewitz, 2016; Kwa, 2007.

erosion of the conditions for human life.[41] We are also putting the social sustainability of society to the test. Social inequalities and social fragmentation are leading to conflicts over wealth distribution, political polarisation, belief in 'alternative facts', erosion of democracy, and ultimately social disintegration.[42, 43]

The lack of physical and social sustainability has a direct impact on science. Society appeals to science not only to understand the emerging problems in all their facets and to place them on the political agenda, but also to provide solutions to them, for instance in the framework of the Dutch Research Agenda (NWA) or the Horizon Europe programme. As the problems become more acute, this appeal to science is becoming more insistent. In some areas, such as our food supply and fossil-based industry, society also sees science as itself a source of problems.[44] There is a growing realisation that science and technology are co-creators of various systemic problems.[45] Science is consequently under pressure not only to help address existing problems but also to prevent the emergence of new ones.

Where solutions are concerned, people generally look first to the technical and medical sciences. Many have pinned their hopes on technological innovations to meet challenges such as the nitrogen crisis, contamination of the soil with PFAS, or global warming.[46] But for these problems, a technical solution is usually insufficient, assuming such a solution even exists. It is often institutional arrangements and established behavioural routines that form the bottleneck preventing actual change. The need to address this bottleneck brings the social sciences and humanities into play, once more increasing the urgency of interdisciplinary collaboration.[47]

Against this background, the view has gained force in recent years that science has a responsibility to contribute to solving societal problems.[48] Not only does society demand this, but many scientists themselves feel called on to make a positive contribution to tackling the challenges facing society.[49] This requires new ways to interact with society.

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41 Richardson, 2023
42 The term ‘alternative facts’ refers to politically motivated views that are not related, or only very selectively related, to objective reality. This term came into vogue after being used by a supporter of Donald Trump, who presented an untrue claim as alternative fact.
43 See, for example, SCP, 2023; see also De Voogd and Cuperus, 2021.
44 See, for example, Van der Ploeg, 2023. See also Pew Research Centre, 2023, which also shows that members of the public have become more critical of science since the COVID-19 pandemic.
45 Turnhout, 2022.
46 Among Dutch farmers, for example, the slogan 'don't halve [the livestock], innovate' is popular: See https://nos.nl/nieuwsuur/collectie/13901/artikel/2472069-innovaties-die-stikstof-beperken-blijven-juridische-puzzel.
47 PBL, 2021.
48 International Science Council, 2023.
49 Gardner et al., 2021; Wassenius et al., 2023.

Many of the developments in how science is organised are nowadays grouped together under the label 'open science'. At its core, this is about opening up, sharing, and collaborating. It primarily concerns relationships between researchers, as discussed in Chapter 3. It is expected that being more open about one's methods and sharing data and results will not only accelerate research processes and make them more efficient, but also make results more replicable and therefore more reliable.[50] Secondly - and this is the focus of the present chapter - it concerns the relationships of researchers to their surroundings.[51] Here, the expectation is that if science is more open vis-à-vis society, it will be more responsive to society's needs. In this regard, open science is in line with Responsible Research and Innovation (RRI), which has been defined as: 'The on-going process of aligning research and innovation to the values, needs and expectations of society, whereby all stakeholders including civil society are responsive to each other and take shared responsibility for the processes and outcomes of research and innovation.'[52] RRI was introduced from within the European Commission (EC) to counterbalance the autonomy of science or a one-sided orientation towards the commercial sector, and to steer research towards the needs of society.

4.2 Practical consequences

The view that science has a social responsibility and should be responsive to society has found its way into procedures and processes in various places. As a body that funds research, NWO is developing its policy on societal impact so that that aspect becomes equal to scientific impact.[53] When assessing grant applications, NWO already requires (almost) all applicants to submit a detailed vision – in the form of an Impact Outlook or Impact Plan – for how the intended impact will be achieved.

A greater focus on societal challenges in science, technology, and innovation (STI) policy is also leading to more attention being paid to interdisciplinary and transdisciplinary collaboration. Because of their complexity, the climate transition or the energy transition, for example, require the integration of knowledge from a variety of disciplines. Moreover, the practical and experience-based know-how of professionals and other stakeholders, including members of the public, will also be needed. Active participation by users, consumers, or members of the public in research and innovation processes helps to monitor the relevance of the research and also strengthens support and commitment for transitions (OECD 2020).

50 European Commission, 2016; Ministerie van OCW, 2017.
51 Rathenau Instituut, 2021a.
52 Rome Declaration on Responsible Research and Innovation in Europe, 2014.
53 NWO, 2022

Given the need to deliver greater impact, many new transdisciplinary research practices have already emerged recently; these include city labs, living labs and academic workshops, within which researchers work closely with professionals from the relevant fields.[54] Universities of applied sciences are often well represented in this regard because their research activities focus specifically on linking up research and actual practice. These partnerships sometimes arise not only from scientific needs but also from initiatives by members of the public, local authorities, or interest groups.[55] The new (Dutch) Climate Research Initiative (KIN) is also based on the principles of transdisciplinary collaboration.[56] We note an increasing awareness of knowledge ecosystems, within which parties invest in sustainable networks and relationships for shared knowledge development.[57]

Involvement of non-researchers (professionals, stakeholders, interested parties, or other individuals) in scientific research is less central to open science than to RRI, the European policy goal that preceded it. In the OS context, it is often reduced to 'citizen science'. The most familiar examples involve members of the public assisting with data collection, but members of the public are nowadays increasingly involved in actively formulating research questions, analysing data ,or formulating conclusions.[58] In many fields, however, meaningful, active involvement by members of the public in all phases of the research process has yet to be achieved.[59]

In other areas, research is linking up with society to a greater extent. The Top Sectors policy – aimed primarily at promoting knowledge development to strengthen the competitiveness of the Dutch economy – featured a leading role for representatives of the private sector in the programming of research.[60] When that policy was introduced, for example, the Top Sectors were given a voice in allocation of part of the NWO budget through the Knowledge and Innovation Agreement (in 2024-2027, this amounts to €138 million per year). Companies themselves also invest in projects that have been allocated funding. The number of companies on university campuses increased by 30 per cent from 2014 to 2018.[61] The third Dutch Government led by Mark Rutte broadened the scope of the Top Sectors Policy. The current 'Mission-driven Top Sectors and Innovation Policy' encourages not only knowledge development to support innovation in the private sector, but also

54 Transdisciplinary research is a form of knowledge development whereby researchers go beyond disciplinary boundaries and also involve knowledge and expertise from non-scientists such as professionals from the relevant fields, policymakers, or members of the public. See Lang et al., 2012.
55 Deuten and Jansen, 2021.
56 See link for more information.
57 Rathenau Instituut, 2021b; Dialogic, 2020.
58 Schade et al, 2020.
59 Rathenau Instituut, 2021c.
60 Ministerie van EL&I, 2011.
61 Rathenau Instituut, 2020.

research to achieve societal goals.[62] In some of the programmes, public authorities act as the 'problem owners' of societal goals.

The *Strategy Evaluation Protocol* (SEP), which is utilised to evaluate research at universities and academic research institutes, applies three criteria for evaluating research groups.[63] One of these is the social relevance of the research concerned, next to its quality and the extent to which the unit is future-proof. A study by the Rathenau Instituut shows that academic researchers recognise knowledge transfer as an important objective of their organisation, but say that they are not yet judged on it.[64] The new 'recognise and reward' system aims to change this.[65]

Finally, it should be noted that increasing attention is being paid to science communication within Dutch knowledge institutions. As part of a different approach to ‘Recognition and Rewards', they are encouraging researchers to engage with the general public.[66] Partly in response to distrust among some of the population regarding its COVID-19 policy, the Dutch government decided to set up a National Centre of Expertise on Science & Society (NEWS).[67]

4.3 What is at stake?

As issues regarding climate, biodiversity, and inequality gain in urgency and impact, public pressure on science to adopt a clearer and more onerous role in addressing them will increase. Science is increasingly being challenged to make a positive impact in society, not only by placing problems on the agenda but also by helping to find solutions to them. This requires a reorientation within science itself – in some disciplines more than in others – and a different, closer involvement of society in science. Greater involvement on the part of science in implementing transitions means that it will also be drawn closer to the political arena. That makes it more important – and probably more difficult – to ensure that research is independent, impartial and objective, and to communicate this effectively. This raises the following questions:

62 Topsectoren, 2023.
63 VSNU (now: UNL) et al., 2020.
64 Rathenau Instituut, 2022a. Many respondents themselves consider 'contributing to knowledge utilisation' to be an important performance indicator, but say that it does not (as yet) play an important role in assessing their performance.
65 UNL, NFU, KNAW, NWO, and ZonMw note in their position paper: ‘Many academics feel there is a one-sided emphasis on research performance, frequently leading to the undervaluation of the other key areas such as education, impact, leadership and (for university medical centres) patient care. This puts strain on the ambitions that exist in these areas. [...].Relying too strongly on such indicators can disrupt diversity and the societal impact of research, as well as impede the practice of open science.’ See VSNU (now: UNL) et al., 2019.
66 VSNU (now: UNL et al.), 2019.
67 Rijksoverheid, 2023.

1. What can society expect from public knowledge institutions when large-scale societal transitions are concerned? How can such institutions meet those expectations?

- Are research universities, universities of applied sciences, and other knowledge institutions adequately equipped to contribute to achieving societal transitions?
- What structures and mechanisms are needed to more effectively translate society's needs into research questions, and to prioritise those questions in individual research agendas?
- What mechanisms and structures are needed to ensure that the results of research are implemented in actual practice?
- How can an attitude of social responsibility be fostered among researchers? What reward mechanisms, support structures, and cultural changes can contribute to this?

2. In this context, what can society *not* expect from public knowledge institutions? What safeguards are needed to enable science to play the desired socially responsible role?

- How can we ensure a proper balance between free and unfettered (curiosity-driven, blue-sky) research on the one hand and application-oriented (often interdisciplinary and transdisciplinary) research on the other?
- Particularly where research becomes more politically charged, how should the relationship between science and politics be structured so that both can fulfil their responsibilities?
- What must be done to prevent science from becoming a 'political football' or being guided too much by short-term objectives?

5 The international positioning of science

In recent decades, science has been predominantly international in nature. Scientific knowledge has for the most part taken on the character of a ‘global public good’: a 'good' that is there for all of us and that no one owns exclusively.[68] This relates to the nature of scientific knowledge as ‘non-rivalrous’, i.e. one person's access to and appropriation of knowledge does not diminish another's ability to also appropriate the same knowledge. Today, this shared nature of scientific knowledge is reinforced by the drive for open science.

5.1 Scientific knowledge as a strategic asset

In recent decades, the Netherlands has focused strongly on 'world-class science', on acquiring and maintaining a leading position within this open, globally organised approach to science. From the mid-20th century, Western countries – in particular the United States – have been dominant in this regard. This international scientific system is based on a number of principles.

Within this system, academic freedom and a high degree of autonomy on the part of scientific institutions are important, for example. Scientific researchers, as a community, largely determine their research agenda. When national government subsidises academic research programmes, their management is usually in the hands of the researchers. The influence of policymakers and funding bodies on how research is tackled has also been curtailed.[69] Quality assurance is in the hands of science itself. With the peer review system, research funding bodies sail according to the compass of the researchers themselves, so to speak.

It is also a basic principle that free competition and collaboration are aimed for in the way science is organised, with researchers interacting and competing on a level playing field and with ideas and scientists being internationally mobile. Free competition and collaboration benefit from a shared culture of openness, fairness, and reciprocity. International science flourishes when it is driven by the common

68 However, governments have often ring-fenced knowledge and technology for defence reasons.
69 The Netherlands Code of Conduct for Research Integrity states that 'Independence means, among other things, not allowing the choice of method, the assessment of data, the weight attributed to alternative statements or the assessment of others’ research or research proposals to be guided by non-scientific or non-scholarly considerations (e.g., those of a commercial or political nature).' See KNAW et al, 2018.

pursuit of greater knowledge for all, with everyone receiving due recognition for the contribution they have made.

International relations in science form part of the general order of international relations as regards politics and economics. This generic rule-based international order developed mainly after the Second World War, and was accompanied by the establishment of all kinds of institutions, ranging from the IMF and the World Bank to the EU and the International Criminal Court.[70] It is characterised by its rule-based nature: confrontation between different interests takes place in accordance with previously agreed rules and procedures, and conflicts are settled by independent third parties.

Since the turn of the century, science has grown enormously, particularly in Asia.[71] With the advent of China on the scientific playing field, centres of scientific dynamism are no longer concentrated solely in Western countries. Competition for and between scientists has intensified, and the market for scientific talent is becoming increasingly global. Between 2003 and 2021, for example, the proportion of foreign researchers at Dutch universities increased from 20% to 45% (in terms of FTEs).[72] Many foreign researchers have only a temporary position, but the majority (83%) are considering remaining in the Netherlands after their current appointment terminates.[73]

As a result of changing power relations – with the rise of China in general and of Chinese science in particular being the most clearly apparent – tensions on the world stage have increased in recent years. These tensions have led not only to war in Europe but also to a transition from a US-dominated world order to one in which the power of China has become more decisive. At the moment, it is unclear what this will mean for the rules-based international order and how, in the light of this, international relations within global science will change. But the first signs of increased nervousness are already apparent. For instance, concerns about knowledge security have recently increased and calls for 'strategic autonomy' – basically meaning having crucial knowledge available ‘in-house’ for ourselves – are becoming more prevalent. As regards the long term, the question is more about what will happen when the international rules of the game are no longer defined so much by the United States but increasingly by China. Will knowledge still be a global public good, or will it become more of a strategic asset?

70 The rules-based international order is also referred to as the ‘liberal international order’. See, for example, Lake et al. (2021). More references can be found at https://en.wikipedia.org/wiki/Liberal_international_order.
71 See, for example, Margison, 2011.
72 Rathenau Instituut, 2023b.
73 Rathenau Instituut, 2018b.

Until about three years ago, the issue of knowledge security hardly figured on the agenda, and collaboration took place within academia without much concern regarding potential interference from state actors, espionage, or covert influence. At Delft University of Technology, for example, dozens of researchers associated with China's *National University of Defense Technology* have written dissertations on topics that are of military relevance.[74] Since then, awareness of the risks regarding knowledge security has increased and various concerns have been raised.[75]

First, there are concerns about the undesirable transfer of sensitive knowledge and technology to hostile parties. The spectrum of dual-use technologies – i.e. technologies with both civilian and military applications – has increased along with the development of ICT, and with it the risk of such undesirable transfer.[76] Foreign powers deploy various methods for extracting knowledge. These may include, for example, espionage and dishonest practices, such as concealing the identity and background of researchers, or their motives for collaborating. In 2020, the Netherlands' General Intelligence and Security Service (AIVD) intervened in the activities of a Russian intelligence officer who had gained access to Dutch know-how through a large network of employees at high-tech companies and an educational institution.[77] In the same year, Iranian hackers targeted Dutch universities. Pressure may also be exerted, for example to transfer intellectual property.

Second, there are concerns that foreign actors are attempting to covertly influence teaching and research. One recent case concerned the Cross Cultural Human Rights Centre at VU University Amsterdam, which was funded by a Chinese university. Appearances by researchers from the centre on Chinese state television seemed to suggest that Dutch researchers were allowing themselves to be used by China to downplay the view that the West is highly critical of China's failure to respect human rights.[78]

Finally, ethical issues may also arise in the context of scientific collaboration and the exchange of knowledge, for example when knowledge is developed or deployed in a way that violates people's fundamental rights. For example, researchers at the Erasmus University Medical Centre in Rotterdam worked with Chinese scientists on a study using DNA taken from Uighurs, although they had reportedly not provided it voluntarily. The study involved forensic research into the possibilities for using DNA

74 De Bruijn et al, 2022a and 2022b.
75 This definition can be found in both the Dutch government's National Knowledge Security Guidelines and in the Knowledge Safety Framework adopted by the Universities of the Netherlands. See VSNU (now: UNL), 2021.
76 Rathenau Instituut, 2019.
77 AIVD, 2021a.
78 Commissie Onderzoek Cross-cultureel Mensenrechtencentrum VU, 2020.

to predict external features such as people's height or the thickness of their eyebrows.[79]

5.2 Practical consequences

Over the past few years, a number of parties have implemented measures to counter the undesirable transfer of knowledge, for example the Universities of the Netherlands (UNL), which has developed a Knowledge Safety Framework.[80] Subsequently, the Dutch central government and public knowledge institutions jointly published the National Knowledge Security Guidelines and established the National Contact Point for Knowledge Security, which is hosted by the Netherlands Enterprise Agency (RVO).[81] With the aid of these facilities, researchers and knowledge institutions must assess the risk of undesirable knowledge transfer when collaborating and sharing knowledge. The Ministry of Education, Culture and Science is also drafting a parliamentary bill for a Knowledge Security Screening Act.[82]

Overall, it is striking that in the context of international science there is not only growth and development in emerging countries, but also a change in expectations. In an international academic world in which cultural backgrounds increasingly differ and interests increasingly diverge, the assumption of openness, fairness, and reciprocity is diminishing.[83] Scientific knowledge will then increasingly be understood as a strategic asset of national importance, particularly when application possibilities come within reach.[84] Calls for strategic autonomy at European level are becoming more forceful. For Europe, the latter implies that it is choosing to keep important knowledge development to itself and relying less on specialisation and international collaboration.[85] This has led to the development of policy instruments such as the European Defence Fund within Horizon Europe – where European framework programmes were previously strictly civil in nature – and the European Chips Act.

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79 Eikelenboom et al, 2021.
80 VSNU (now: UNL), 2021.
81 See https://www.rijksoverheid.nl/documenten/rapporten/2022/01/14/nationale-leidraad-kennisveiligheid for more information.
82 See https://open.overheid.nl/documenten/ronl-dd0a321e0aa198dfc248fb656e7c0035343c6c18/pdf (it seems unlikely that the time frame outlined will in fact be kept to).
83 There are increasing concerns regarding knowledge security and increasing initiatives, both at the EU level and within Member States, to protect knowledge more effectively. For the Netherlands, see for example the RVO's National Contact Point for Knowledge Security, link.
84 See, for example, the issue regarding ASML exporting high technology to China.
85 See, for example, European Commission, 2024.

In other contexts too, there is currently debate regarding the position of Dutch academic institutions internationally. For example, the Minister of Education, Culture and Science has drafted a proposal for limiting the number of English-language programmes at Dutch universities. The House of Representatives' request for such limitation was prompted by the overstretched market for student accommodation and the cost to the treasury. But the underlying issue concerns what role the Netherlands sees for itself within the international academic community. Is it desirable for the Netherlands to play a role within the global academic vanguard, or is it above all important for a university to be a nationally oriented facility? Is it important to be firmly embedded in and contribute to the international academic community, or is the point to meet local demand for knowledge, expertise, and research capacity? The degree of internationalisation of universities has direct consequences for the attractiveness of Dutch universities for top foreign researchers and thus for the quality of research itself. Internationalisation also has an impact on the availability of foreign knowledge workers for the Dutch private sector. That availability partly determines the attractiveness of the Netherlands for companies to establish themselves and thus also job opportunities.

5.3 What is at stake?

Geopolitical tension puts pressure on a number of fundamental principles of scientific research, for example international knowledge sharing and academic freedom. If knowledge development becomes more an issue of political strategy, that will hamper knowledge exchange and mutual collaboration, prompting defensive behaviour. It will encourage the development of strategic 'knowledge buffers' in case internationally available knowledge becomes less accessible. This raises the following questions:

1. What constitutes strategic knowledge where the Netherlands is concerned: what knowledge must the country have at its own disposal for economic and societal reasons?

- What is the right assessment framework for determining which public knowledge the country should protect or shield, from the point of view of security, for economic reasons, or in view of other considerations?
- What is necessary to safeguard access to this strategic knowledge?

2. What should increasing geopolitical tensions mean as regards Dutch 'science diplomacy'?

- Given geopolitical developments, what cooperative scientific partnerships should the Netherlands cultivate, both within and beyond Europe?

- What implications does fragmentation of the global scientific landscape have for quality assurance in science? What must be done to monitor scientific developments within competing geopolitical blocs and to assess their significance?

6 Challenges for the future

The world is always changing, but it currently seems to be changing more drastically than we have become accustomed to in recent decades. Climate change, disruptive technological developments, political landslides, and even a war in Europe's backyard are making their mark on our future. In this report, we have outlined how these major developments can also affect science – and probably will. In the first section of this concluding chapter, we provide a brief synthesis of the developments we identified in the previous chapters. We then consider what these developments may mean as regards policy.

6.1 Synthesis

This foresight study shows that a number of important developments are underway that will have profound consequences for the nature of scientific research. We have described those developments from four perspectives: the scientific process, the way science is organised, the relationship between science and society, and the international positioning of science. We summarise these four perspectives below, including the questions that they raise for science, for science policy, and for politics.

In Chapter 2, we discussed the impact of digital technology on ***the scientific process***. Where research is concerned, digital technology offers radical new possibilities, in particular through much wider data availability and extremely powerful new tools for analysing data. This is changing the nature of research, making it more data-driven and thus potentially less theory-based. But with more digitalisation come more risks, among them increased reliance on the private sector within public research, risks regarding knowledge security, and the potential demise of science based on traditional approaches and methodologies. All this raises the question of the extent to which science, policy, and politicians will embrace and support digitalisation of the scientific process and how they will guide it in the right direction. How do they intend dealing with the changing nature of scientific research and the risks we have referred to?

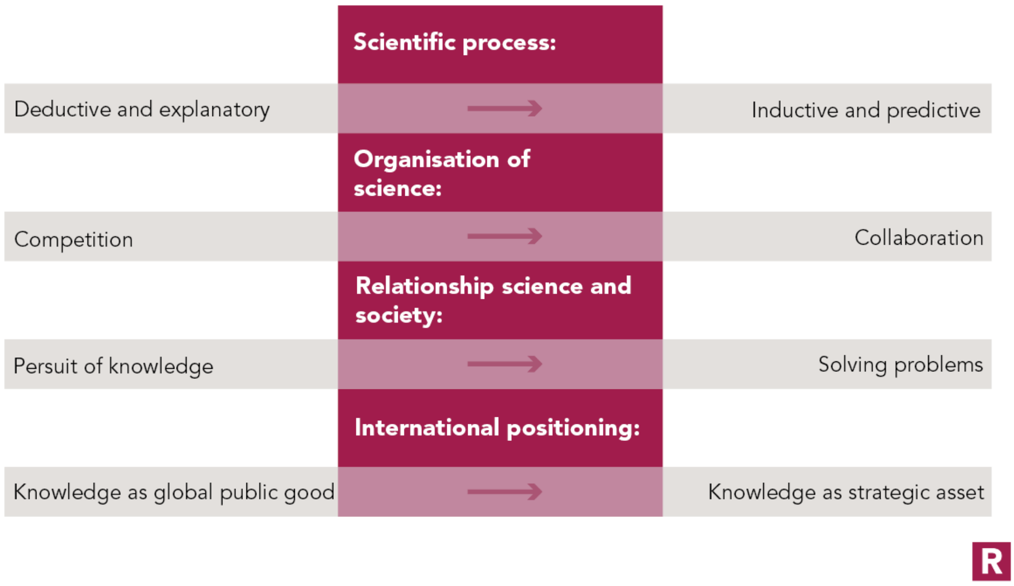
In Chapter 3, we considered changes in ***the way science is organised***, with competition decreasing and collaboration becoming more central. The focus on academic excellence has produced science that is well regarded worldwide, but that focus has also contributed to 'questionable research practices', high ‘system costs' and mental health complaints among researchers. A counter-reaction is now discernible in which the focus is more on collaboration, for example in the attention being paid to open science and reframing of the processes of recognition and rewards. The question for science, policy, and politicians is to what extent a process of changing the organisation and governance of science from a primarily competition-based closed model to a more collaboration-based open model, is currently opportune – and what that process should look like.

In Chapter 4, we looked at the changing ***relationship between science and society***, and we noted that the call for science not only to develop new knowledge but, above all, to contribute to solving problems is becoming stronger. Society's urgent need for solutions to various sustainability crises expresses itself as a different set of expectations vis-à-vis science. This can already be seen in the case of a number of research funding bodies, which are focussing increased attention on transdisciplinary collaboration and the societal impact of research. Many scientists feel motivated to contribute to this. For science, policy and politicians, the question is to what extent the urgency of societal challenges should lead to a shift away from a focus on generating new knowledge per se to assuming more (shared) responsibility for addressing societal issues. A greater emphasis on societal orientation and responsiveness may perhaps necessitate limiting scientific autonomy.

Finally, in Chapter 5, we discussed the ***international positioning of science*** and zoomed in on the impact that increasing geopolitical tensions have on science. Whereas in recent decades science had an open character when it came to international partnerships and there was an assumption of fairness and reciprocity, in times of increasing tensions this is no longer a matter of course. There is a range of fields in which knowledge can change from being a global public good into a strategic asset that needs to be properly protected. The question for science, policy, and politicians as regards science policy is what scientific knowledge we should continue to treat as a public good and what we should in future classify as a strategic asset.

The diagram below gives a simplified version of the developments we discussed in the previous chapters:

Figure 2 Developments in science from four perspectives



Source: Rathenau Instituut

Looking at the four developments in the diagram, we can say that science policy is well equipped to respond to the features of the science system in the left-hand column. These, after all, are the features of science as we know it from recent decades. Competition between researchers plays a central role in the allocation of resources. Research excellence is the main criterion for funding. Scientists and academic institutions enjoy a high degree of autonomy in setting their research agenda. Direct and indirect public funding is predominantly allocated by researchers among themselves. International collaboration and mobility are important as regards career prospects. Dutch science policy is well able to deal with such matters. Dutch science therefore performs very well by international standards.[86]

The question is now what would be needed to draw up a science policy that is just as well prepared for the system features in the right-hand column of the diagram. These features are not entirely new, but a system dominated by them does have a different character to the current one. We do not expect the features on the left to be entirely disregarded. Preparing for the features on the right does not therefore imply neglecting the achievements on the left.

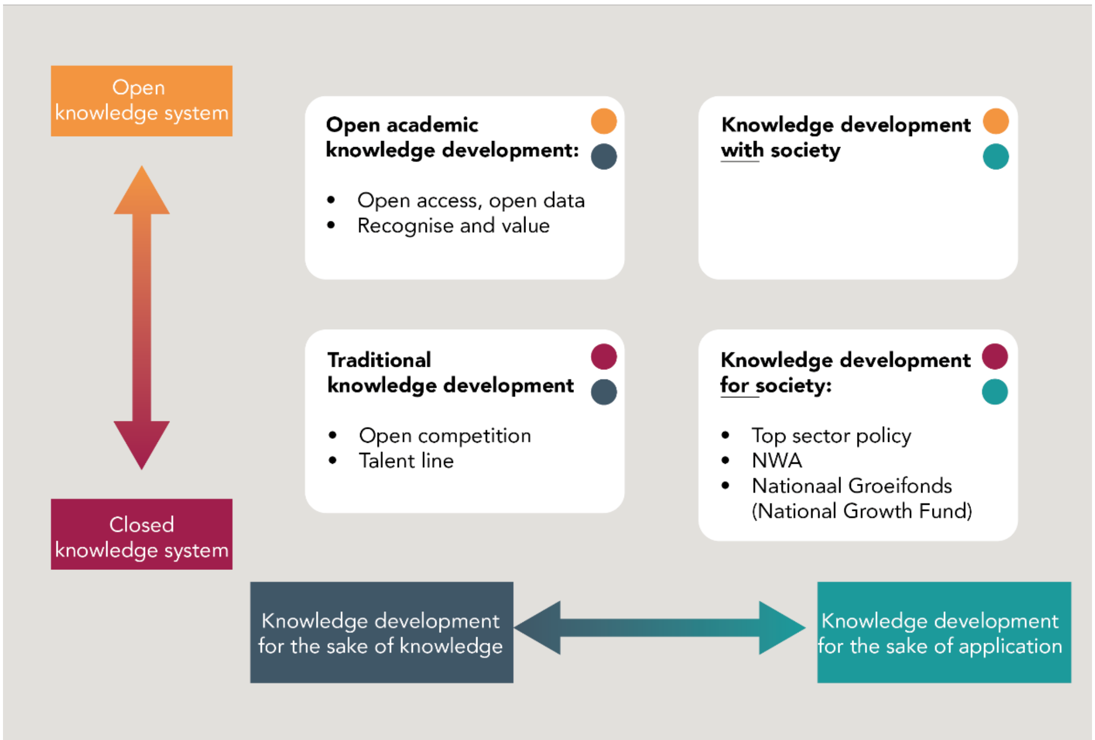
86 Adjusted for the number of researchers in a country (expressed in terms of FTEs), Dutch researchers are the most successful recipients of funding from H2020 (https://www.rathenau.nl/nl/wetenschap-cijfers/geld/europese-financiering/de-positie-van-nederland-de-eu-kaderprogrammas) and publications from Dutch universities are cited particularly frequently (https://www.rathenau.nl/nl/wetenschap-cijfers/werking-van-de-wetenschap/excellentie/ranglijsten-rankings)

6.2 Towards a differentiated science policy

This report shows that in the coming years science will find itself caught within a complex interplay of forces. The developments we have outlined potentially have major consequences for scientific practice. They will not all steer science in the same direction, however; they also exert opposing forces. Changes in the way science is organised will lead to a greater emphasis on openness and collaboration, but perhaps not everywhere, for example because geopolitical developments as regards strategic themes may actually call for a more closed set-up. Developments in society's relationship with science place a heavier emphasis on knowledge valorisation so as to address societal problems, but that does not alter the fact that there will also continue to be a need for free, curiosity-driven research.

A greater diversity of societal needs calls for a greater diversity of science policy instruments. This is set out in the diagram below. In it, we distinguish between instruments for a closed versus an open knowledge system, and instruments for knowledge development so as to expand the boundaries of knowledge versus instruments for generating knowledge for practical application.

Figure 3 Instruments for four types of science policy



Source: Rathenau Instituut

Traditional knowledge development (bottom left in the figure) takes place within a relatively closed knowledge system with the primary focus being on knowledge for its own sake. This approach to science became dominant in the Netherlands especially in the final decades of the last century (see Section 3.1). That includes excellence-oriented policy instruments such as NWO's Open Competition and the Talent Line (Veni, Vidi and Vici). Since the beginning of the 21st century, some areas of knowledge development have placed a greater emphasis on application, on valorisation, i.e. a shift in the figure to the right, towards knowledge development demanded by society through various channels. This shift was expressed by new policy instruments such as the Top Sector Policy, which allowed companies to drive the agenda of research institutions, and the Dutch Research Agenda (NWA), which did the same for civil-society organisations and individual citizens. Initially, this happened without any substantial change in the way science is organised. This change only really took off with the push towards open science*,* a shift in the matrix upwards (see Section 4.1), towards different organisational principles for science. The push for open science came from both national and European policy initiatives. These are reflected in policy aimed at open access and open data and in new approaches to recognition and rewards within academic institutions.

Currently, developments are underway in science that combine the movement towards a more application-focused orientation with greater organisational openness. These are developments towards more knowledge generation not only ***for*** but also ***with*** society, towards more transdisciplinarity and more co-creation. These developments take us very far away from the knowledge generation with which we are familiar from the past and on which the established instruments of policy were focused. While the areas at the bottom and on the left-hand side of the figure have become well stocked with policy instruments, the area at the top right still lags somewhat behind. There are relatively new policy initiatives for the top right-hand area, including incentives for citizen science, academic workshops, and knowledge workshops. And there is the new (Dutch) Climate Research Initiative (KIN), a taskforce under NWO, designed to bring about close collaboration between scientists and civil-society actors to prevent the worst effects of climate change.[87] Experience with this is still at a very early stage, however. NWO is considering establishing a Knowledge Platform for Interdisciplinary and Transdisciplinary Research. The increasing attention and funding for practice-oriented research at universities of applied sciences, which is often of an interactive nature, is also evidence of an increasing emphasis on knowledge development *together with* society.

87 European framework programmes have also increasingly focused on interaction with society. For example, Horizon 2020 had a specific Science With And For Society (SWAFS) component. In the case of *Horizon Europe*, this is integrated into the basic structure of the programme.

6.3 In conclusion

The world is changing. In this report, we have outlined developments that will determine the future of science, such as digitalisation, the need for sustainability transitions, and geopolitical uncertainty. These developments confront science policy with the need for fundamental choices. Many of them involve finding a new balance, for example between the role of public institutions and private organisations in developing knowledge, between competition and collaboration in the allocation of resources, between fundamental research with a long-term perspective and knowledge development for tackling urgent short-term problems, between openness and knowledge security, and between conducting research for science, for society, and with society.

This report is intended to initiate an open dialogue on the science of the future and the future of science. The core question is how science, supported by science policy, can develop as effectively as possible so as to serve society to the full. We will be only too happy to engage in that dialogue with you.

Literature

AIVD, 2021a. *Jaarverslag 2020*.
AIVD, 2021b. *Bereid je voor op de dreiging van quantumcomputers*.
AWTI, 2003. *Backing winners*.
AWTI, 2019. *Het stelsel op scherp gezet*.
Boge, F.J. & Poznic, M., 2021. *Machine Learning and the Future of Scientific Explanation*. J Gen Philos Sci 52: 171–176.
Bruijn, A. de, Booij, D., Emanuel, H., Sys, M. & Eikelenboom, S., 2022a. *Europese universiteiten helpen China om 's werelds modernste leger op te bouwen.* Follow the Money.
Bruijn, A. de, Booij, D., Emanuel, H., Sys, M. & Eikelenboom, S., 2022b. *China stuurt gericht tientallen militaire onderzoekers naar Nederland om gevoelige kennis te vergaren.* Follow the Money.
Bush, V., 1945. *Science, the endless frontier*. Geciteerd door Sarewitz, 2016.
Chalmers, I., & Glasziou, P., 2009. *Avoidable waste in the production and reporting of research evidence*. The Lancet, 374 (9683): 86-89.
Commissie Veerman, 2010. *Differentiëren in drievoud*.
Commissie Onderzoek Cross-cultureel Mensenrechtencentrum Vrije Universiteit Amsterdam, 2020. *Onafhankelijkheid gewogen*.
Cremonini, L., Horlings E. & Hessels, L., 2017. *Different recipes for the same dish: comparing policies for scientific excellence across different countries*. Science and Public Policy, 45: 232-45.
Deuten, J. & Jansen, J., 2021. *Living Labs in VerDuS SURF: een synthesestudie*.
De Voogd, J., Cuperus, R., 2021, *Atlas van Afgehaakt Nederland – Over buitenstaanders en gevestigden*.
Dialogic, 2020. *Onderzoeks- en innovatie-ecosystemen in Nederland*. Dialogic, Utrecht.
Eikelenboom, S., Bruijn, A. de & Booij, D., 2021. *Hoe Nederlandse onderzoeksinstituten de Chinese politiestaat helpen.* Follow the Money.
Eimers, T. (red.), 2023. *Vandaag is het 2040: toekomstverkenning voor het middelbaar beroepsonderwijs, hoger onderwijs en wetenschap*. KBA, Nijmegen.
Europese Commissie, 2016. *Open Innovation, Open Science, Open to the World – a vision for Europe*.
Europese Commissie, 2024. *Strategic Autonomy and European Economic and Research Security*.
Gardner, C.J., Thierry, A., Rowlandson, W. et al., 2021. *From publications to public actions: the role of universities in facilitating academic advocacy and*

activism in the climate and ecological emergency. Frontiers in Sustainability, 2.

Hessels, L., Koens, L., & Diederen, P., 2021. *Perspectives on the future of Open Science: Effects of global variation in open science practices on the European research system*.

Hoffmann, S., Deutsch, L., Thompson Klein, J. et al., 2022. *Integrate the integrators! A call for establishing academic careers for integration experts. Humanities & Social Sciences Communications*. 9: 147

Horbach, S.P.J.M., Oude Maatman, F.J.W., Halffman, W. et al., 2022. *Automated citation recommendation tools encourage questionable citations*. Research Evaluation, 31 (3): 321-325.

International Science Council, 2023. *Flipping the science model: a roadmap to science missions for sustainability*.

Jerak-Zuiderent, S., Brenninkmeijer, J., M'charek, A. et al., 2021. *Goede wetenschap: Een visie van binnenuit*. Amsterdam UMC / Universiteit van Amsterdam: Amsterdam.

Kuhlmann, S. & Rip, A. 2018. *Next-Generation Innovation Policy and Grand Challenges.* Science and Public Policy 45(4): 448–454.

Kwa, C., 2007. *Onderzoek aan de universiteiten: Een geschiedenis van de academische autonomie*. Krisis, 4: 36-51.

Lake, D.A., Martin, L.L., Risse, T., 2021. Challenges to the Liberal Order: Reflections on International Organization, *International Organization* 75, Spring 2021, pp. 225–57.

Lang, D.J., Wiek, A., Bergmann, M., et al., 2012. *Transdisciplinary research in sustainability science: practice, principles, and challenges*. Sustainability science, 7: 25-43.

Levecque, K., Anseel, F., De Beuckelaer, A., Van der Heyden, J., Gisle, L., 2017. *Work organization and mental health problems in PhD Students.* Research Policy, 46: 868-879.

Loorbach, D.A. & Wittmayer, J., 2024. *Transforming universities:*
Mobilizing research and education for sustainability transitions at Erasmus University. Sustainability Science, 19: 19-33
Rotterdam, The Netherlands

Marginson, S., 2011. *Higher education in East Asia and Singapore: rise of the Confucian Model*. High Educ 61: 587–611.

Ministerie van EL&I (Economische Zaken, Landbouw en Innovatie), 2011. *Naar de top – hoofdlijnen van het nieuw bedrijvenbeleid*, Kamerstuk 32 637, nr. 1.

Ministerie van OCW, 2017. *National Plan Open Science.* doi: 10.4233/uuid:9e9fa82e-06c1-4d0d-9e20-5620259a6c65

Ministerie van OCW, 2022. *Beleidsbrief hoger onderwijs en wetenschap*.

Moore, S., Neylon, C., Eve, M.P. et al., 2017. *“Excellence R Us”: university research and the fetishisation of excellence*. Palgrave Communications, 3: 16105.

Nordmann, A., 2020. *The Advancement of Ignorance*. In Maasen, S., Dickel, S., Schneider, C. (eds.) *TechnoScienceSociety: Technological Reconfigurations of Science and Society, Sociology of the Sciences Yearbook*. Springer, 2020: 21-33.

NWO, 2022. *Wetenschap werkt! NWO-Strategie 2023-2026.* NWO, Den Haag.

OECD, 2019. *Charting the digital transformation of science: Findings from the new OECD International Survey of Scientific Authors*. OECD, Parijs.

OECD, 2020. *Addressing societal challenges using transdisciplinary research*. OECD, Parijs.

OECD, 2021. *Reducing the precarity of academic careers.* OECD STI policy papers no. 113

Open Science Collaboration, 2015. *Estimating the reproducibility of psychological science*. Science, 349: 6251.

PBL, 2021. *Hoofdlijnen Werkprogramma PBL 2022-2023*. PBL, Den Haag

Pew Research Centre, 2023. *Americans’ Trust in Scientists, Positive Views of Science Continue to Decline*.

Rathenau Instituut 2018a, *Excellent is niet gewoon: Dertig jaar focus op excellentie in het Nederlandse wetenschapsbeleid*. Rathenau Instituut, Den Haag.

Rathenau Instituut, 2018b. *Drijfveren van onderzoekers: goed onderzoek staat nog steeds voorop* Rathenau Instituut, Den Haag.

Rathenau Instituut, 2019. *Kennis in het vizier – De gevolgen van de digitale wapenwedloop voor de publieke kennisinfrastructuur*. Rathenau Instituut, Den Haag.

Rathenau Instituut, 2020. *Balans van de wetenschap 2020*. Rathenau Instituut, Den Haag.

Rathenau Instituut, 2021a. *Samen verder met open science – op weg naar een betekenisvolle publieke betrokkenheid bij onderzoek.* Rathenau Instituut, Den Haag.

Rathenau Instituut, 2021b. *Onderzoeksprogramma's met een missie: lessen voor opgavegericht innovatiebeleid*. Rathenau Instituut, Den Haag.

Rathenau Instituut, 2021c. *Samen verder met open science: Op weg naar betekenisvolle publieke betrokkenheid bij onderzoek*. Rathenau Instituut, Den Haag.

Rathenau Instituut, 2022a. *Drijfveren van onderzoekers en docenten 2022*. Rathenau Instituut, Den Haag.

Rathenau Instituut, 2022b. *Wetenschappelijke publicaties via open access*. Rathenau Instituut, Den Haag.

Rathenau Instituut, 2023a. *Excellentie in de wetenschap*. Rathenau Instituut, Den Haag.

Rathenau Instituut, 2023b. *Ontwikkeling buitenlands personeel en herkomstlanden.* Rathenau Instituut, Den Haag.

Rectores magnifici van de Nederlandse universiteiten, 2019. *Digitalisering bedreigt onze universiteit. Het is tijd om een grens te trekken.* Volkskrant Opinie, 22 december.

Richardson, J., Steffen W., Lucht, W., Bendtsen, J., Cornell, S.E., et.al. 2023. *Earth beyond six of nine Planetary Boundaries.* Science Advances, 9, 37.

Rijksoverheid, 2023. *Nationaal expertisecentrum voor wetenschap en samenleving (NEWS) wordt opgericht*. Via: link.

Rome Declaration on Responsible Research and Innovation in Europe, 2014.

Sarewitz, D., 2016. *Saving science*. The New Atlantis: 7-40.

Schade, S., Tsinaraki, C., Manzoni, M. et al., 2020. *Activity Report on Citizen Science – discoveries from a five year journey*. ISBN 978-92-76-28369-0.

Schot, J. & Steinmueller, W. E. 2018. *Three frames for innovation policy: R&D, systems of innovation and transformative change*. Research Policy 47: 1554–1567.

SCP, 2023. *Eigentijdse ongelijkheid – De postindustriële klassenstructuur op basis van vier typen kapitaal, Verschil in Nederland 2023*.

Topsectoren, 2023. *Herijkte missies en scherpere keuzes missiegedreven innovatiebeleid*. Via: link.

Turnhout, E., 2022. *Betere kennis is mogelijk*. Via: link.

UNL, KNAW, Vereniging Hogescholen, NFU, TO2-federatie, Rijksoverheid & NWO, 2022. *Nationale leidraad kennisveiligheid – Veilig internationaal samenwerken.*

Van der Ploeg, J.D., 2023. *Gesloten vanwege stikstof.* ISBN 9789464711370. Uitgeverij Noordboek, Gorredijk.

Van der Weijden, I., & Teelken, C., 2023. *Precarious careers: Postdoctoral Researchers and Wellbeing at work*. Studies in Higher Education, 48: 1-13.

Van Noorden, R., 2022. *How language-generation AIs could transform science*. Nature, 605: 21-21.

VSNU (nu: UNL), NFU, KNAW, NWO & ZonMw, 2019. *Ruimte voor ieders talent: naar een nieuwe balans in het erkennen en waarderen van wetenschappers*.

VSNU (nu: UNL), KNAW & NWO, 2020. *Strategy evaluation protocol 2021 – 2027*.

VSNU (nu: UNL), 2021. *Kader Kennisveiligheid Universiteiten.*

Wassénius, E., Bunge, A.C., Scheuermann, M.K. et al., 2023. *Creative destruction in academia: a time to reimagine practices in alignment with sustainability values*. Sustain Sci, 18: 2769–2775.

Appendix 1: Broad exploration

The first step in our foresight study involved an inventory of relevant developments within and outside science. Based on various sources (see below), we identified 29 trends. We have categorised these below according to three levels (1 to 3) and the four main lines (a to d) in this foresight study:

1. Societal developments affecting science:

a. Developments affecting the scientific process:
   - Digitalisation, AI, quantum technology, and blockchain: the meteoric development of digital technologies, with far-reaching applications in the public domain, work, education, entertainment, and healthcare.

b. Developments affecting the way science is organised:
   - Decentralisation of policy and local solutions to complex problems: a shift in responsibilities from central government to the provinces and municipalities, as well as local initiatives to tackle global challenges.

c. Developments affecting the relationship between science and society:
   - Democratic representation and social trust under pressure: coarsening of public debate, with part of the population feeling unheard or unrepresented in political decision-making.
   - Inclusiveness as a public value: the need to allow divergent voices to participate in discussions, activities and decision-making, thereby doing justice to diversity in terms of demographics, religious orientation and perception, skin colour, culture, gender/gender identity, sexual orientation, appearance, political affiliation, level of education, and income.
   - Interest in science is increasing and trust remains high: members of the public show increasing interest in science through news consumption, museum visits and volunteering, and trust in Dutch science is stable.

d. Developments affecting the international position of Dutch science:
   - Geopolitical uncertainty: the international balance of power is currently highly dynamic and unpredictable.

e. Other:
   - Transitions regarding food, healthcare, mobility, security, sustainability, and energy: growing awareness that a number of

major societal challenges can only be tackled through systemic changes, in conjunction with one another.
- Overall well-being is becoming more important than economic growth: a cultural trend whereby people define social progress not only in terms of economic growth or purchasing power, but also in terms of health, education, work, living environment, or social relations.
- COVID-19 pandemic: this caused a great deal of disruption in scientific production in the short term, but at the same time greatly accelerated the adoption of digital communication technologies.

2. Developments within the field of science, technology, and innovation:

a. Developments affecting the scientific process:
   - …

b. Developments affecting the way science is organised:
   - Consideration of the concept of excellence: after becoming increasingly central to many countries' science policy in recent decades, the concept of excellence has been increasingly called into question in recent years.
   - Discussions about integrity and responsible research practices: concerns about the reproducibility of research and discussions about methodological quality, especially in quantitative social science and biomedical science.
   - Low award rates for indirect public funding: due to the pressure on individual researchers to secure external funding and NWO's limited budget, NWO's average award rate has fallen to around 25% in recent years.
   - Open science: the rise of open access publishing of research results, making research data openly available, and involving societal stakeholders in the research process.

c. Developments affecting the relationship between science and society:
   - Many partnerships with and funding from companies: the increasing importance of third-party funding for universities, increasing presence of companies on university campuses, and the emergence of more exclusive strategic partnerships between companies and knowledge institutions.
   - Collaboration within knowledge ecosystems: the growth of new transdisciplinary research practices, such as city labs and living labs, within which researchers work closely with professionals from the relevant fields, and an increasing awareness of

  knowledge ecosystems within which a variety of parties jointly develop knowledge.
  - Attention to public engagement: fuelled in part by European policy, increasing interest in involving individual members of the public and civil-society organisations in research and innovation.
  - Attention to the societal impact of science: increasing interest in the social and economic value of scientific research, and an increasing need to map it with indicators and evaluations.

d. Developments affecting the international position of Dutch science:
  - Global competition for talent: the attractiveness of China and other Asian countries for talented researchers is increasing, with consequences for the availability of highly qualified staff in the Netherlands.
  - International orientation: the increasing proportion of foreign scientists at Dutch universities, the high level of participation of Dutch researchers in Horizon 2020, and the collaboration with foreign researchers in publishing articles.
  - Greater use of EU grants: the share of funding from the European Framework Programmes for total research funding in the Netherlands is increasing.
  - Large-scale research infrastructure: participation in various large-scale research infrastructures which require major long-term public investment.

e. Other:
  - Increasing student numbers: the number of students enrolled at research universities and universities of applied sciences continues to rise.
  - Increasing number of PhDs: an increase in the number of PhDs in all fields of study, leading to a relatively larger number of PhDs working outside the field of academic science.

3. Developments in policy for science, technology, and innovation:

a. Developments affecting the scientific process:
  - Increasing attention to R&D competencies: a growing call for investment in competencies that are needed (including among non-researchers) to leverage research and innovation so as to generate value for society and tackle societal challenges.

b. Developments affecting the way science is organised:
  - Broader recognition and rewards: a movement among Dutch universities, research funding bodies, and the Royal Netherlands Academy of Arts and Sciences (KNAW) to reward a broader set of qualities and achievements than solely measurable research

performance in the context of decisions on careers and research funding, such as teamwork, societal impact, and teaching.
- Due to an increasing share of project funding at universities and university medical centres, an increasing share of the state contribution is spent on matching. This is at the expense of untied research. The current caretaker government has set up a €5bn fund to invest in free and untied research and development over 10 years.
- Policy on high-risk research: there are calls in various countries to reform research funding to create more room for high-risk/high-reward research.

c. Developments affecting the relationship between science and society:
   - Orientation towards societal challenges: National governments and also the EU are increasingly orienting their STI policy towards addressing societal challenges, for example by formulating missions or promoting transdisciplinary collaboration.

d. Developments affecting the international position of Dutch science:
   - New incentive for the European Research Area (ERA): the European Commission aims to further integrate the science policies of the different Member States by forming a revamped ERA.

e. Other:
   - …

Sources used

Recent policy reports, advisory reports, and analyses of Dutch science policy

- AWTI 2020, Versterk de rol van wetenschap, technologie en innovatie in maatschappelijke transities.
- Beleidsdoorlichting Dialogic: https://www.dialogic.nl/projecten/beleidsdoorlichting-onderzoeks-en-wetenschapsbeleid/.
- CPB Position paper digitalisering (2019).
- Eimers, T. (red.) (2023) Vandaag is het 2040. Toekomstverkenning voor middelbaar beroepsonderwijs, hoger onderwijs en wetenschap. Nijmegen/Utrecht/Enschede/Amsterdam: KBA Nijmegen, ResearchNed, Andersson Elffers Felix, CHEPS, Kohnstamm Instituut.
- KNAW 2018, Maatschappelijke impact in kaart.
- KNAW 2019, Evenwicht in het wetenschapssysteem – De verhouding tussen ongebonden en strategisch onderzoek.
- KNAW 2020, Het rolling-grantfonds – Kloppend hart voor ongebonden onderzoek.

- KNAW 2021, Storage and availability of data for research.
- NWO evaluatie 2020 en kabinetsreactie.
- PBL werkprogramma 2022-2023.
- PwC bekostiging hoger onderwijs: https://www.strategyand.pwc.com/nl/en/press-releases/2021/management-samenvatting.html
- Rabobank: https://economie.rabobank.com/publicaties/2021/november/nut-en-noodzaak-van-publieke-kennisinvesteringen/
- Roland Berger ‘valorisatie ontketend’, https://www.rolandberger.com/nl/Insights/Publications/Van-technologietransfer-naar-samen-innoveren.html?btc=NL
- SCP Meerjarenplan 2021-2025
- VSNU 2019 ruimte voor ieders talent
- VSNU 2020 Werkdruk universiteiten

Recent publications by the Rathenau Instituut

- Balans van de wetenschap (2020)
- Bedrijf zoekt universiteit (2018)
- De impact van grootschalige onderzoeksinfrastructuren (2019)
- De zin van promoveren (2018)
- Drijfveren van onderzoekers en docenten (2022)
- Eieren voor het onderzoek (2019)
- Excellent is niet gewoon (2018)
- Factsheet AI-onderzoek (2021)
- Factsheet De opkomst van China als R&D-supermacht (2021)
- Factsheet Tijdelijke contracten (2021)
- Onderzoeksprogramma’s met een missie (2021)
- Ontwikkeling derde geldstroom en beïnvloeding van wetenschappelijk onderzoek (2020)
- Samen verder met open science (2021)
- Stad zoekt toga (2020)
- TWIN-cijfers 2019-2025 (2021)
- Vertrouwen in de wetenschap (2021)
- Wetenschap in cijfers: https://www.rathenau.nl/nl/wetenschap-cijfers

‘Grey’ literature on science systems and science policy from an international perspective

- European Commission, Communication on a European strategy for universities: https://education.ec.europa.eu/document/commission-communication-on-a-european-strategy-for-universities
- Issues in Science and Technology, sectie over ‘The next 75 years of science policy’: https://issues.org/next-75-years-science-policy/

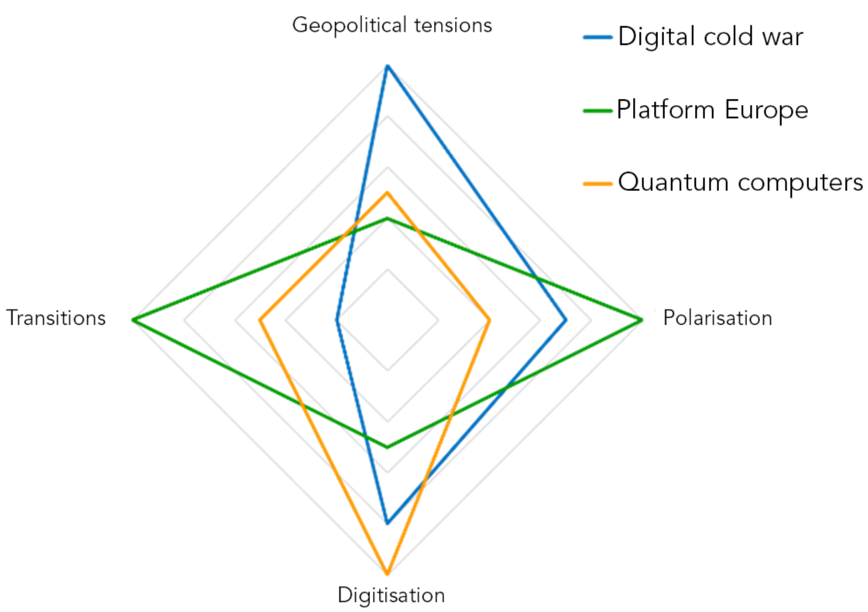
- NSF, Strategic plan 2018-2022: https://www.nsf.gov/pubs/2018/nsf18045/nsf18045.pdf
- NSF, Strategic plan 2022-2026: https://www.nsf.gov/about/performance/strategic_plan.jsp
- OECD STIP policy papers (divers): https://www.oecd-ilibrary.org/docserver/de9eb127-en.pdf?expires=1640269334&id=id&accname=guest&checksum=2AB38F439A574C85F09578C9DF25F17C
- OECD, STI Outlook 2018 & 2021: https://www.oecd.org/sti/science-technology-innovation-outlook/
- SFI, Strategy 2025: https://www.sfi.ie/strategy/
- Swedish Research Council, Future Choices for the Swedish Research System: https://www.vr.se/english/analysis/reports/our-reports/2019-12-13-future-choices-for-the-swedish-research-system.html
- The British Academy, Lessons from the History of UK Science Policy: https://www.thebritishacademy.ac.uk/documents/243/Lessons-History-UK-science-policy.pdf

Appendix 2: The scenario workshop

On 14 July 2022, we held a workshop with stakeholders. The aim was to refine our picture of key developments, explore their potential impact on various stakeholders, and identify dilemmas for science policy based on participants' knowledge and experience.

To make future developments more tangible, we prepared three scenarios. These are based on a number of external developments, outside science or outside the Netherlands. Based on a broad exploration (see Appendix 1), four key trends were selected: digitalisation, geopolitical tensions, transitions, and polarisation. In the scenarios, these trends each continue with different intensity or in different forms.

By viewing the trends as axes, we created a four-dimensional space within which our three scenarios are placed. We commenced each scenario at a single point within this space and then looked for a coherent narrative on the other axes. The scenarios are shown below in the form of a spider diagram.



The intention was not to outline the three most likely futures but rather to properly cover the four-dimensional space.

The workshop was held according to the design principles of the World Café methodology. After a plenary explanation of the project and an introduction about the three scenarios, participants engaged in discussion at four tables. There were two rounds of about 40 minutes. Each round began by completing a short questionnaire. This was followed by a discussion that participants documented themselves on flip-over sheets on their table. The afternoon ended with a plenary exchange between the various discussion tables and a tentative identification of dilemmas and tasks for science policy.

Participants

People were approached personally for the workshop, with the option of being replaced by a colleague. This made for a good spread of relevant parties in and around the science system. There were some 20 participants in the workshop (see table below).

First name	Surname	Organisation
Annelien	de Dijn	WOinActie
John	Doove	SURF
Marissa	Herder	Ministry of Education, Culture and Science
Channah	Herschberg	Dutch Research Council (NWO)
Anja	Hezemans	Ministry of Economic Affairs (EZK)
Darco	Janssen	Universities of the Netherlands (UNL)
Anneke	Kastelein	PhD Network Netherlands (PNN)
Hamilcar	Knops	Advisory Council for Science, Technology and Innovation (AWTI)
Vincent	Lagendijk	Rathenau Instituut

Wendy	Reijmerink	Netherlands Organisation for Health Research and Development (ZonMw)
Luc	Rietveld	Dutch Cancer Society (KWF)
Frans	Spierings	Rotterdam University of Applied Sciences
Loek	Stokx	National Institute for Public Health and the Environment (RIVM)
Hanneke	Takkenberg	Dutch Network of Women Professors (LNVH)
Reineke	Timmermans	Confederation of Netherlands Industry and Employers (VNO-NCW)
Martje	van Ankeren	Netherlands Association of Universities of Applied Sciences (VH)
Peter	van den Berg	Deltares
Annelieke	van der Giessen	Advisory Council for Science, Technology and Innovation (AWTI)
Alex	Verkade	Taskforce for Applied Research SIA
Ruud	Verschuur	Ministry of Infrastructure and Water Management (I&W)

The scenario workshop gave us a clearer picture of the implications of the four central developments. We documented what opportunities and concerns participants saw in the various scenarios, what consequences they expected for science (in terms of priorities, social interaction, and organisation), and what challenges and dilemmas these pose for science policy. We shared a report of the workshop with participants for validation.

The scenarios used
We used the following scenarios to fill in how we see potential future developments. These are only tools: they are speculative in nature and emphatically *not* predictions.

Scenario 1: Eclipsed by big foreign companies
In 2030, Amazon makes a new generation of cloud services available, Google manages most of the available research data, and Microsoft launches a perfected version of its GPT artificial intelligence (AI) system. These companies are among the handful of US and Chinese companies that dominate the entire digital market. Not only do they provide services to companies, governments and consumers, they have also invested in data science universities where fundamental research is performed and which are considered the best places in the world to conduct data-driven research in a wide range of disciplines. It is virtually impossible for traditional universities to compete with them in these disciplines. Not only do public universities have less comprehensive access to data, they also do not have the resources to develop sufficient computing power themselves, and they therefore rely on the services provided by the tech companies.

The meteoric development of AI within the tech giants' universities and the overwhelming availability of data has shifted the emphasis in science from explaining to predicting. Although AI can recognise patterns in data, it cannot develop theories or explain phenomena.

The dominant role of big companies in science jeopardises the independence of academic research. It is possible that business interests will take priority over the public interest. Innovative solutions to major problems, for example, are sought mainly in what digital technologies can offer. Investment in radically different solutions is much more cautious. In order not to undermine existing revenue models, for example, the emphasis in tackling climate change is therefore more on adaptation than on prevention. Self-regulation has turned out to be inadequate for safeguarding independence.

Scenario 2: The divided Netherlands[88]
In 2030, some 40 per cent of voters will vote for populist parties that oppose the ‘administrative elite’ and claim to champion the interests of the people. Those who vote for these parties have lost trust in politics and public institutions. They believe that the government does not listen to them, does not acknowledge their interests, and does not respect their identity. The number of people who believe in conspiracy theories is approaching half a million.

88 This scenario was not used during the workshop but only developed afterwards.

The result has been a hardening of social relationships, the demise of open political communication, and a withdrawal into groupings of like-minded people. Political conviction is a factor that defines one's identity, and political opponents have become one another's enemies. The pragmatic political midfield has thinned out considerably, administrative compromise is widely perceived as defeat, and the Dutch ‘polder model’ of consensus-based decision-making is more or less defunct. This development is hacking at the roots of democracy. After heated verbal altercations, political debates degenerate into indecision, deadlock, and overall inertia.

This situation is particularly problematic in the light of the crises that society is facing. Effective policymaking on climate, energy, health, agriculture, migration, and housing is not taking effect sufficiently. Social and political ossification within the Netherlands is weakening the country’s position within Europe and the EU's position in the world. This plays into the hands of authoritarian regimes like those of China and Russia, as well as big commercial interests like those of foreign tech companies.

Large sections of the population see science as in essence a self-absorbed institution belonging to the elite, in the same way as they see politics and journalism. This fuels distrust of researchers and doubt about research findings. Many researchers are also increasingly struggling in the endless battle for research funding and the constant pressure to publish, and are looking for better ways to help solve specific societal problems. This is leading to the widespread draining away of talent from academia.

Scenario 3: Climate disruption

In 2030, it has become clear that the predictions generated by the climate models used up until then have been far too optimistic. In recent years, numerous records have been shattered in terms of melting polar icecaps, overflowing rivers, forest fires, warming oceans, hurricanes, thawing tundra, methane release, and rising temperatures. All this means significant detriment to food production and threatens more and more residents of low-lying and vulnerable areas.

The ensuing havoc has been seized upon by European governments to drastically change course and finally get serious about sustainability transitions. The European Commission plays a coordinating role in that regard. The Horizon Europe framework programme has been succeeded by Transition Europe, with an unprecedented budget of €200 billion.

Society, however, has great difficulty with the transition policy. The total cost of all the sustainability measures combined is enormous, and leads on balance to substantial impoverishment. Land use and spatial planning are changing radically. Many people's jobs are changing drastically or even disappearing altogether. By contrast, other people see new opportunities. This is creating tensions between different groups within society. Many people feel they are at the mercy of superior powers and are losing control of their own existence. This is putting pressure on democracy.

Climate disruption also puts international relations under enormous stress. From countries in Africa, Asia and South America, the demand is growing louder for the countries of North America and Europe – which have largely caused the climate crisis – to come up with solutions, and namely solutions that will not be at the expense of improved living standards and development opportunities in the global south.

These developments are putting heavy pressure on the academic community. Even where technology is already available, the world is looking to science to help politicians implement the available solutions effectively.

Scenario 4: Digital warfare

In 2030, eight years after Russia invaded Ukraine, tensions in the geopolitical arena have not subsided. In the meantime, an economically and politically weakened Russia has fallen entirely within China's sphere of influence. China has carried out a military landing on Taiwan and is struggling to keep up Taiwan's production of strategic goods (specifically advanced chips). China's relationship with the United States is extremely tense. Europe seeks security in its alliance with the United States while trying to stay out of conflicts by pursuing an autonomous course. Within the United States, however, the commitment to NATO is constantly being questioned.

We can now speak of a new 'Cold War', with various power blocs distrustfully opposing one another. All this is not only at the expense of international trade and economic development, but also of a joint approach to tackling global problems such as climate change, nature and biodiversity loss, and deterioration of essential conditions for human existence such as healthy food production, ample clean water, and sustainable energy sources. Fragmentation of the global economy into separate blocs means that production chains need to be reorganised and reduces access to crucial minerals and natural resources. This is leading to a decline in productivity and national impoverishment, making it more difficult to muster the funds needed to tackle climate change, population ageing, and threats to national security.

Geopolitical developments have been an incentive for European collaboration, for example in the military field. European research potential is being harnessed to achieve greater strategic autonomy in the economic sphere and greater resilience as regards defence. Within the EU’s new Reinforcement Europe framework programme, the position of defence research is firmly established.

But while physical combat has reached an impasse, conflict on the digital front is steadily proceeding. Hackers from all quarters are constantly probing the vulnerabilities of digital infrastructure, and thus trying to knock down physical infrastructure as well.

Digital technology, in particular artificial intelligence (AI), is the ‘key enabling technology’ on which the world depends. Whoever is ahead in AI holds the key to knowledge, wealth, and power. It is awareness of this that drives not only China – which has set itself the goal of winning this race by 2049 – but also the US and Europe, which are increasingly mindful of what they have to lose. All parties are therefore investing not only in further development of their digital capabilities, but also in ring-fencing their knowledge and technology. However, keeping foreign ‘tech giants’ out of European markets for digital services and disentangling industrial structures that have been built up over decades is a difficult matter.

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