Steering Scientific Research and Reaping its Benefits

Reflections on Dutch Science Policy

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Introduction

Much is expected from scientific research. Governments hope to see solutions for complex policy challenges. Industries and businesses hope for innovations supporting their competitive edge. Society as a whole hopes for a deeper understanding of a complex world and safeguards for welfare and well-being. Last but not least, the community of scholars hopes to be able to understand, reflect, and explore. In the past, society was patiently waiting for results to emerge, trusting that clever scientists would be making new discoveries. Nowadays research is considered too important to be left to its own dynamics and, for that matter, to scientists themselves. The potential of science is to be reinforced, its impact and benefits channelled and increased. As a result, science policies have emerged that also raised an interest, first among politicians and policymakers, and more recently also among the general public.

Science policy is, however, confronted with a fundamental problem. By definition, the results of research projects cannot be predicted. If they could be, the research would be futile. Because of the huge expenses involved – in the Netherlands currently an estimated 4.5-5 billion euros annually[3] – the government and other policy institutions nonetheless hope to steer these investments towards useful, efficient, and targeted outcomes. In other words, science policy hopes to increase the predictability of results. With this in mind, policies are formulated with objectives ranging from nurturing, facilitating, and supporting scientific research to steering, streamlining, and orchestrating its topics and processes. Typically, national science policies

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3 Totale Investeringen in Wetenschap en Innovatie 2014-2020. Rathenau Instituut 2016.

demonstrate a policy mix of measures that can best be explained as a sum of decisions accumulating over time and taken more or less independently at different levels, by successive governments and boards.

In this essay we want to discuss several assumptions underlying science policies and reflect on how, given what is known about systems for research funding and about the effects of policy interventions, the Dutch National Research Agenda (*Nationale Wetenschapsagenda*, or NWA) is embedded in the Dutch academic system. In the course of this paper we will argue that it is not so much the policies themselves that guide or determine the success of science, but the way they add up and shape the environment in which scientists and scholars do the actual work. In order to steer them and reap their benefits, policies should fit the inherent dynamics of the scientific system.

Types of research and funding systems

Is there something like an ideal science policy? And if so, what would it look like? As a start, it should deal, in an effective way, with the diversity in research approaches. A first observation must be that science policy has a tendency to ignore this fundamental point. A lot of the debate on science policy, and also much of the academic literature that contributes to this debate, demonstrates a remarkably narrow view of research. It holds up the natural sciences model as the prototype, or tends to simply reduce scientific research to the natural and life sciences, without further ado. Scientific (including technical) research is usually theory-driven, produces its own data in secluded environments (the 'laboratory'), and results in statements that are thought to be universally applicable. However, this model applies only in certain parts of the research world, and not even in all of the sciences. Mathematics, for example, is not a laboratory science; much technical and engineering research is trial and error rather than theoretically framed. The model is to a large extent not applicable outside the natural and life sciences. Anthropologists, historians, law scholars, or philosophers produce statements and explanations that are context-specific, based on unique observations collected 'in the wild', and they are therefore sceptical of the broad generalisations that we call 'theory'. In disciplines like economics, linguistics, psychology, and sociology we find both types of research. These disciplines are therefore characterized by fierce struggles over methodology, with the 'laboratory' type of scholars berating the poor methodology of their colleagues, who in turn point out that the laboratory produces results that could be irrelevant to the real world. A successful research policy should take these variations into account, or must result in a withering of significant branches of research. This would be a problem not only for the world of research, but for society itself. The success of innovations depends, by and large, as much on its social context as on technology as such (Volberda and Van den Bosch, 2013, p. 44).

As there are different types of research, so we find different types of research funding. Three broad categories have been distinguished, each with its own characteristics (Lepori, 2011, pp. 362-4). In the United States, around eighty percent of public research funding is provided through project subsidies. Ministries, research councils, technological agencies, and other public bodies hand out money to research groups and individuals who have to submit funding applications. YThis is essentially a market model for stimulating research, which has the effect that relatively large amounts of funding go to a limited number of stakeholders ('Matthew effect'). This model still requires a larger pool of competitors, to avoid oligopolistic effects when a small number of research groups stifle the positive effects of competition. It is therefore less suited to smaller systems, where the number of competitors almost by definition will also be smaller. No surprise then that European countries use a different system that channels much of the research funding through universities. In these countries, project funding covers typically between twenty and forty percent of public research. In the Netherlands, the national research council NWO is responsible for about 20 percent of publicly funded research (Koier et al., 2016, p. 38).[4] This structure of funding seems to be especially well-suited for higher education systems with even distributions of research facilities; Switzerland, Norway, Finland, and indeed the Netherlands are usually cited as examples. A third model is the vertically integrated system that was popular in Central and Eastern Europe during the communist era, but also in post-war Southern Europe, including France. In this system, a single, large research facility or institution, usually the Academy of Sciences or national research institution such as the CNRS in France or the CSIC in Spain, is charged with research, while the universities are primarily educational institutions.

In past decades, mixes of these three have evolved, at least in the larger countries in Europe, towards a mix of all three systems, and other European countries are also evolving towards such a mix. In the Western European model, the objective of project funding is to dynamise the research system with the help of strategic incentives. It would therefore be short-sighted to create a funding structure that serves one single purpose.

4 In terms of absolute volume; the indirect effect of NWO funding is considered to be bigger when the total costs associated with the funded research are taken into account.

Impact of academic research

In recent years, the 'impact' of science, in addition to its 'excellence', has become an important issue for policymakers. Politicians argue that excellent science cannot be a goal for its own sake. They want to know how the society they represent can benefit from scientific discoveries and, where possible, increase these benefits. Here, too, policies tend to start from unduly simplistic assumptions. The 'impact' debate has had a tendency so far to focus on economic benefits, and there again on the direct profits that might be reaped from research. However understandable against the backdrop of the recent economic crises, this is an unnecessarily narrow, and in our view ultimately counterproductive, interpretation of the 'impact' of scientific research. Astronomy is not focused on immediate economic benefits but helps to locate us, as humans, in the wider universe. And yet, it gives rise to high-tech innovations taken up by industries. Understanding the marvels and complexity of the living world and its diversity brings us much more than ideas on how to explore or preserve it. The popularity of nature documentaries and their development to include the latest scientific insights can illustrate this. Likewise, understanding how Rembrandt produced his masterpieces does not lead to immediate economic benefits, but enriches our understanding of a unique artistic achievement and can serve as an inspiration for future generations. To be sure, a Rembrandt exhibition, or the Rijksmuseum's presence in Amsterdam, has major economic benefits, and the research underpinning the museum's presentations contributes to those benefits. It is, however, difficult to calculate how cost-effective art history is as a discipline. Likewise, legal scholarship underpins the justice system, sociological research addresses issues with the integration of migrants and refugees, while pedagogy helps to improve our school system. It would be difficult to deny their importance, even if it remains impossible, and is perhaps even morally wrong, to ascribe a precise monetary value to their contribution.

Having said this, scientific research has proven to be fundamental for our economic prosperity, and increasingly so. Even if we stick to economic benefits for the sake of the argument, the literature distinguishes six different dimensions of research impact (Salter and Martin, 2001, pp. 518, 520-26).

a Increasing the stock of useful knowledge: especially publications create opportunities to access new knowledge that firms and organisations can apply in their work processes.

b Training skilled graduates: possibly the most important effect of research is the production of a skilled workforce, to be employed by firms and organisations. Advances in human capital formation are generally seen as the single most important growth factor in advanced economies.

c Creating new instrumentation and methodologies: this is an important result of government-funded (rather than industry-funded) research, but its impact is difficult to measure.

d Forming networks and stimulating knowledge interactions: firms located close to major centres of academic research benefit more from that research than those located at a distance, as a result of social and professional interactions between their employees and academics.

e Increasing the capacity for problem-solving. A Yale survey of 650 R&D directors showed that fundamental scientific knowledge impacts 'through influencing the general understandings and techniques that industrial scientists and engineers, particularly those whose training is recent, bring to their jobs' (Klevorick et al., 1995, quoted in Salter and Martin, 2001, p. 525). This was confirmed by a similar European survey.

f Creating new firms: the most famous example is, of course, the impact of Stanford University on the creation of Silicon Valley in California, but on the East Coast, MIT has had a similar though perhaps less dramatic effect, and in the Netherlands we can see the same effect around Eindhoven University, for example.

Impact, too, is therefore poorly served by a one-size-fits-all approach. Furthermore, it should be noted that these effects are the result of general research, not driven by specific training, and one might even argue that their effect could be jeopardized by too much specialization in a handful of areas. We should also keep in mind that the economic, let alone social, political, or cultural, impact of research will always be difficult to forecast due to the inherently unpredictable character of research (Dasgupta and David, 1994, p. 490).

Innovative and routine research

Research is enamoured with innovation. The 'first' discovery of a particle, effect, or other breakthrough is rewarded with Nobel Prizes, Field Medals, and similar distinctions. Much research policy is likewise obsessed with the prizes that seem to signal success as a precursor of future breakthrough discoveries. One often-heard criticism of such policies is that 'it would not have made a difference for Einstein'. There are two reasons why this is not a very strong argument. The first is that it seems really difficult to predict the emergence of Einsteins. So far, a strong correlation has been established between excellence and funding levels. The lavishly endowed Oxbridge colleges in the UK, and Ivy League universities in the US, seem to do really well in terms of Nobel Prizes, because they have the facilities to attract the very best scholars. This simultaneously improves those top-level institutions and impoverishes the rest. It is, in other words, a typical example of 'beggar thy neighbour' and not a policy that could be repeated by many other countries. This implies that countries where such world-class research facilities are not widely available (basically everybody else) have to design different research policies, adequate to their own specific research environments.

The truth of the matter is – the second problem with the Einstein argument – that most researchers are not Einsteins, and that most research is not ground-breaking. And this is just as well, because next to novel ideas we also need more precise knowledge about how things really work. In fact, we need solid testing and replication of research findings, most certainly if the research is to have 'impact'. Routine research, or basic research, in other words, is as necessary as ground-breaking research, especially if it is taking local circumstances into account. University rankings identify world-class institutions, but not necessarily world-class systems. Currently (2015), the Times Higher Education world university ranking classifies 17 US universities in the top 25. The United States, in other words, completely dominates. Classifications that rank countries according to the number of universities in the world's top 200, and take the size of their economies (GDP) into account, give us a very different picture. In 2012, when these figures were compiled, among the ten highest ranked countries, six were located in Europe (Times Higher Education World University Rankings, 2011-12, p. 17). The Netherlands was classified second, after Hong Kong, while the UK, Switzerland, Sweden, Ireland, and Denmark also made the grade, in that order. This ranking seems to suggest that the current policy mix in the Netherlands works rather well, and that perhaps it would be easier to spoil the 'magic potion' than to improve it.

The literature about the organisational and institutional preconditions for creativity suggests factors that stimulate creative research. These include opportunities for multiple interactions with colleagues, staff mobility, communication across disciplinary boundaries, and leadership by scholars who are themselves still active in research. As far as organisational aspects are concerned, a survey among 185 American and European experts in human genetics and nanoscience and nanotechnology also underlines several points that are important for research policy (Heinze et al., 2009, pp. 616-19).

a Agenda-setting: broadly defined problems and long-term targets allow focus and freedom at the same time.
b 'Complementary variety': research units will become more creative when they are regularly exposed to ideas from groups working in adjacent fields, with different skills and methodologies.
c Flexible funds: creative groups indicate that they benefit from funding that allows them to follow their ideas, instead of being constrained by very specific budgets. Block grants, rather than project grants, help to create this sort of flexibility.
d Job mobility: grant schemes could encourage this by creating the right conditions.
e Funding supportive of risks: moving from one field to another takes a lot of time. The best part of five years may be required to build up a credible publication portfolio in that new field to help attract new funding. Funding agencies do not usually support this type of move. Moreover, they require well-defined targets, at the expense of exploratory, open-ended projects.

These observations suggest that a mixture of funding tools will best support a healthy research biotope (Laudel, 2006, p. 384). That mixture should include targeted and open-ended funding, allow spending flexibility, and stimulate cross-disciplinary interactions and researcher mobility.

'Blue skies' and 'brown earth' research

What drives scientific and scholarly research? Or rather, what inspires scientists and scholars to employ their talents and creativity to advance our understanding and search for solutions? In policy circles a distinction is often made between the various purposes of scientific research in an attempt to influence and steer the course of scientific progress. Various classifications and concepts circulate, such as 'fundamental', or 'blue skies', research that is supposed to be driven by scientific excellence, contrasted with 'use-inspired', 'applied' or what we might call 'brown-earth' research, which is supposed to be more focused on 'useful' results for the real world. Often these types of scientific research are depicted in contrast to one another, competing for funds and attention.

The current European science policy employs a threefold classification: Science for Science, Science for Society, and Science for Competitiveness. 'Science for Science' refers to fundamental research, emerging from the scientific community, with 'curiosity' as the presumed driving force. 'Science for Society' implies research that is directed towards solving societal problems, where research questions are defined by societal stakeholders. 'Science for Competitiveness' refers to research originating from industrial agendas to develop new business opportunities, often performed in public-private partnerships. Here too, the stakeholders, together with the researchers, determine the agenda.

However useful such classifications may be to clarify positions, they are in practice a gross simplification of the way scientific research actually works, and therefore not a very useful tool for guiding scientific advancement or indeed promoting useful outcomes. In actual fact, most scientific research is nurtured by multiple sources of inspiration, including curiosity, a longing to understand and explain, as well as the sense of responsibility to address societal challenges. Furthermore, in the Netherlands scientific research is closely linked to (higher) education, adding another source of inspiration.[5]

In the real world of scientific research, these distinctions are, thus, very difficult to make. Take the four winners of the 2015 NWO Spinoza Prizes. These winners were honoured for the excellence of their academic work, because 'according to international standards [they] belong to the absolute top of science. The Spinoza Laureates perform outstanding and ground-breaking research', and 'inspire young researchers'.[6] They are, in other words, first and foremost excellent scholars who, following their curiosity, have managed to produce outstanding work. At the same time, these people do work that is, directly or indirectly, relevant to society. René Janssen's group at Eindhoven Technical University combines physics and chemistry to develop plastic solar cells, which look likely to be produced commercially in the future. Anthropologist Birgit Meyer works in Utrecht on African religions and how they transfer to European contexts in migrant communities. At the University of Amsterdam, mathematician Aad van der Vaart develops statistical models that can help understand the outbreak of epidemics. Cisca Wijmenga, professor of Genetics in Groningen, has

5 This has prompted some to propose a fourth category 'Science for Education', referring to the fact that scientific research plays an important role in our education systems.

6 www.nwo.nl/en/research-and-results/programmes/spinoza+prize, consulted on February 21, 2016.

worked on the causes of diabetes, leukaemia, and gluten intolerance. In all four cases, the distinction between fundamental and applied research simply fails to make sense. Paradoxically, this may be especially true at the pinnacle of the research system.

Modern scientific research is predominantly performed in groups and networks, uniting the creativity and inspiration of multiple individuals at different stages in life and from different backgrounds. People interact, discuss options and challenges, leading to mutual inspiration and a stimulating environment which attracts others. Increasingly, these others also include external stakeholders and professionals who may be interested in the research or benefit from it in their own professional environments. In the same way, researchers trained in different scientific disciplines connect and cooperate to combine expertise, for example to address complex scientific and societal challenges.

Such a diverse and dynamic environment responds to a variety of signals, but is always focused on finding opportunities to continue a promising line of investigation. 'Promising' is often defined by a combination of fundamental challenges and opportunities for application, as in the examples of the 2015 Spinoza Prize winners, and the people driving the research combine opportunities to secure the necessary means, making use of various sources of funding. Policy organisations, including funding agencies, often focus exclusively on their direct, individual contribution to the research endeavour, assuming that targeted funding and criteria guide choices by the scientist applying for it. However opportunistic scientists may appear (as any other entrepreneurial individuals), we argue that, in reality, directed funding does not in fact steer much at all. Nor should it. Put in an ecological perspective, it is the seeds growing on the plants themselves that germinate when ready, and grow into diverse blossoms, with nutrition coming from fertile lands. Here, funding is merely a source of water determining its growth rate, but not its cause.

The ecological metaphor implies an important dimension of modern science: interdisciplinary work and, more in general, a denser set of connections between scientific disciplines. For much of the twentieth century, science and scholarship benefited from increased specialization within the clearly defined boundaries of the 'disciplines'. These had common agendas, methodologies, and professional standards, as well as communities of practitioners who were referring to a shared literature. In recent decades, the life sciences in particular have led the way in a process of breaking down barriers and establishing new, interdisciplinary connections and even completely new fields of research – with spectacular successes like the unravelling of the human genome. A similar success story is the emergence of brain and cognitive sciences, where natural and life sciences team up with behavioural sciences. Technological developments are breaking down the barriers between other fields as well. Think of 'big data' with its novel approaches creating new fields that connect but also complement existing disciplines.[7]

The Dutch National Research Agenda: policy or not?

Like science itself, science policy is not static. The NWA is a new string to the bow of research policies. As explained in the introduction of this volume, the Dutch NWA has adopted an unusual approach, and produced an unusual result. It is therefore, in more than one way, an experiment. This has proven confusing for scientists as well as policymakers, perhaps also because of its interactive and uncontrolled process. The NWA was invented and produced on the hoof. Still, we would argue, this experiment blends in very positively with what we consider a healthy research environment.

First and foremost, because its experimental nature reflects in a fundamental way the process of research itself: it has direction, but no premeditated outcome. Its shape as a result defies the type of simplistic classifications often underpinning science policies. Instead of a reductionist approach, the NWA has embraced the diversity of science, the heterogeneity of the Dutch research landscape, and the complexity of the societal challenges the Agenda seeks to address. Its very form, 140 questions, underlines that there are no straightforward solutions to complex problems. This, of course, is also its weakness; the NWA has not produced a list of 'greatest hits' that politicians might embrace. The identification of a limited number of 'routes' has provided such a shortlist, but it would be a pity if the 140 questions that form the body of NWA would be lost from sight as policymakers concentrate on the skeleton of the selected routes.

This brings us to a second asset of the NWA: it is, unlike many science policy measures, inclusive in nature rather than exclusive. It is not primarily about competition, selection, or choices, but instead highlights linkages, synergies, and added value. It aims to connect scientific, societal and economic challenges and brings together scientific disciplines. In doing so, it also straddles the divide between fundamental and applied research.

7 European Commission. Validation of the results of the public consultation on Science 2.0: Science in Transition. 2015. Available through https://ec.europa.eu/research/openscience/index.cfm.

In other words, this Agenda harnesses the intrinsic processes in science, rather than forcing it to change course and direction against the grain of scientific practices. We expect that it will therefore be easier to embed in current policies, reducing the transaction costs that are inevitable with any policy reform. It is precisely for this reason, we would like to argue, that the – at first sight unwieldy – list of 140 questions and 27 routes may well prove to be effective. Of course we have to await formal evaluations and can, at this point, not even properly assess its potential. There are, however, promising signs.

This has much to do with what we see as a third strength of the NWA: its potential to connect. In one sense, the NWA has been constructed as a critique of the previous round of major science policies in the Netherlands, the so-called top sectors. This was a top-down initiative that has had mixed reviews, precisely because of commitment problems. Scientists were reluctant to participate in what felt like a coercive collaboration, and for many societal stakeholders it was unclear how they might find partners in the academic community. Especially small and medium-sized businesses, without their own R&D units and science managers, found it difficult to engage. The NWA process has already created inspiring encounters between scientists, policymakers, and professional experts from society and the business community. From these dialogues joint ideas and shared visions emerge on how to move forward. Building on this enthusiasm, we expect new collaborations to emerge that were less likely in the previous, top-down approaches, or indeed in a completely unstructured bottom-up dynamic.

In general, the NWA still falls within the principle outlined in the 1918 Haldane Report in the UK, which argued that the development of science policy, due to its innate complexity, was best left to the experts themselves. This principle has been the foundation of the very successful development of research during the last century.

Conclusion

We have considered some features of the Dutch science system and the merits of sensible science policies. In both, 'diversity' is prominent. The Dutch academic system is strong in many disciplines, and is located in more than a dozen universities, plus another two dozen prominent research institutes. Although some programmes are truly outstanding, there is no evident cluster that can be the foundation for a single-centred policy, in terms of subject or location. A reorientation of policy in that direction seriously risks damaging the whole system, and nipping promising new developments in the bud. The science system can probably improve its societal impact, but not by privileging applied over fundamental research, for the simple reason that cutting-edge research more often than not combines the two. The NWA reflects these features of the Dutch science system and tries to build on them in ways that try to produce new synergies.

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