The Netherlands as a Science Nation

Current Status

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Contents

The Netherlands as a Science Nation – Current Status

Summary

- **How well is Dutch science performing?**
  Dutch science excels exceptionally well in terms of its impact on global science: Dutch research is frequently cited by scientists from all over the world. When we look at the 20 most research-intensive countries, the Netherlands, along with Switzerland, leads in scientific impact.

- **What are the success factors?**
  Dutch science particularly excels in engaging in international collaborations with both universities and businesses. The Netherlands is exceptionally internationally oriented, and these cross-border collaborations yield significantly more scientific impact than national collaborations. Moreover, research resulting from academic-corporate collaborations has even more impact on science.

- **What is the impact on innovation and policy?**
  Dutch science not only impacts research globally but also innovation and policy. We observe that Dutch research is frequently cited in international patents. Especially in the realm of government policy, Dutch science ranks at the top with the highest impact on policy documents worldwide.

- **What is the impact on sustainability?**
  Dutch science also contributes to the UN's sustainability goals (the 'SDGs'): for instance, the Netherlands is very active in the areas of peace & security and climate. Dutch research has high scientific impact across all SDGs, but particularly health and climate stand out. Research in sustainable energy, AI, and key technologies constitutes a modest contribution from the Netherlands in terms of scale but with high scientific impact.

- **Which disciplines contribute the most to research impact?**
  Medical science is by far the largest contributor, followed by natural sciences. Medical science, along with humanities & social sciences, has the greatest impact on science.

- **Which Dutch universities perform the best?**
  All Dutch universities perform much better than the world average on scientific impact. The University of Amsterdam and Utrecht are the most productive, while Erasmus University in Rotterdam and the University of Amsterdam lead in scientific impact.

Key Data

- The Netherlands scores **72%** above the world average in scientific impact.
- **63%** of all Dutch articles involve international collaborations.
  - This is much higher than the world average (20%) or the EU27 (43%).
  - These international articles have more than **twice the world average** impact, while national articles from the Netherlands are only 20% above the world average.
- Dutch collaborations between companies and academic institutions have even higher impact: **3 times the world average.**
- In terms of impact on government policy: 9% of all Dutch articles are cited in policy documents.
  - Netherlands leads in this aspect: double the EU27 average and **3 times the world average.**

Introduction

How well is the Netherlands performing in the realm of science? It's a simple question that isn't always easy to answer. However, when we examine Dutch publications and their impact on global science, innovation, policy, and sustainability, we gain a fairly comprehensive understanding of the state of Dutch science. We will discover that the Netherlands is outstanding in the field of science. Furthermore, we will delve deeper into the key success factors.

Chapter 1 covers the position of the Netherlands in the global scientific landscape. In Chapter 2, we explore the success factors of Dutch science. Chapter 3 describes the impact of Dutch research beyond science: on innovation, policy, and sustainability. Chapter 4 examines the scientific disciplines and universities that contribute the most to the success of Dutch science. We conclude with summaries (Chapter 5) and definitions (Chapter 6).

This report is part of a series of reports that Elsevier has released over the years, including the international report on Net Zero, and more Netherlands-focused reports on biodiversity and Amsterdam as a knowledge city.

While Elsevier is a leading international corporation and the world's largest scientific publisher, our roots are firmly planted in the Netherlands, with our headquarters in Amsterdam, employing 1000 workers, and strong historical ties to the seventeenth-century Elzevier publishing house in Leiden. Therefore, it is fitting that Elsevier can contribute to Dutch science, not only through our publications but also through reports like this one, based on Elsevier data and data analyses.

1 How Well Does the Netherlands Perform Compared to Other Countries?

To answer the question of how the Netherlands is performing in the field of science, we examine publications.

The number of publications serves as a good measure of productivity (or output). These publications are cited by other scientists, which is a good indication of scientific impact. For this purpose, we use the Field Weighted Citation Index (FWCI), which is normalized to 1.0 for the world average. An FWCI of 1.2 is 20% better than the world average, while an FWCI of 3.0 is three times better, and so forth.

In terms of productivity, we can examine the share of all publications worldwide. Larger countries such as China and the US contribute around 20%. Refer to the Definitions section (Chapter 6) for more information on publications, citations, FWCI, productivity, etc.

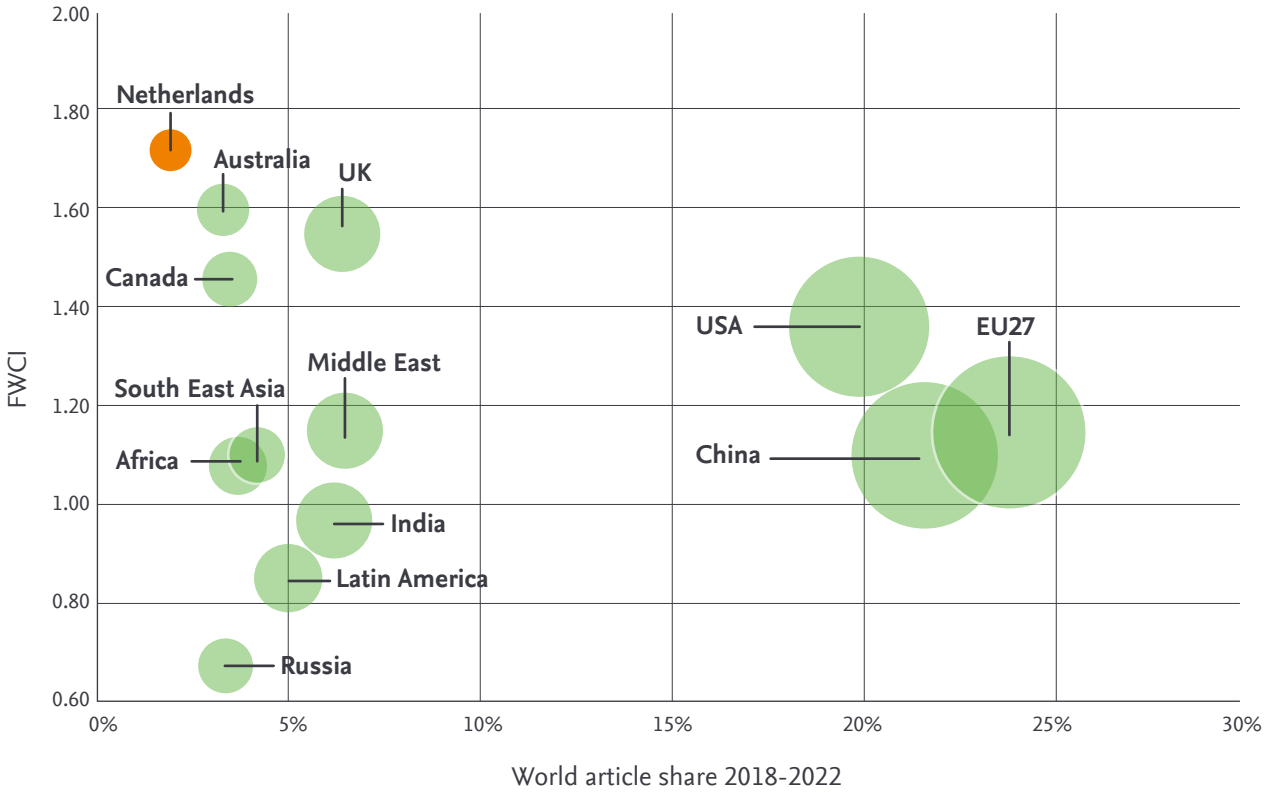


Figure 1: FWCI vs. Relative Share of Different Countries and Regions

As depicted in Figure 1, the Netherlands ranks at the top in terms of citation impact, measured by the FWCI, surpassing countries such as the US and UK.

However, in terms of the number of publications relative to the global total, the contribution of the Netherlands is modest, as one would expect from a relatively small country.

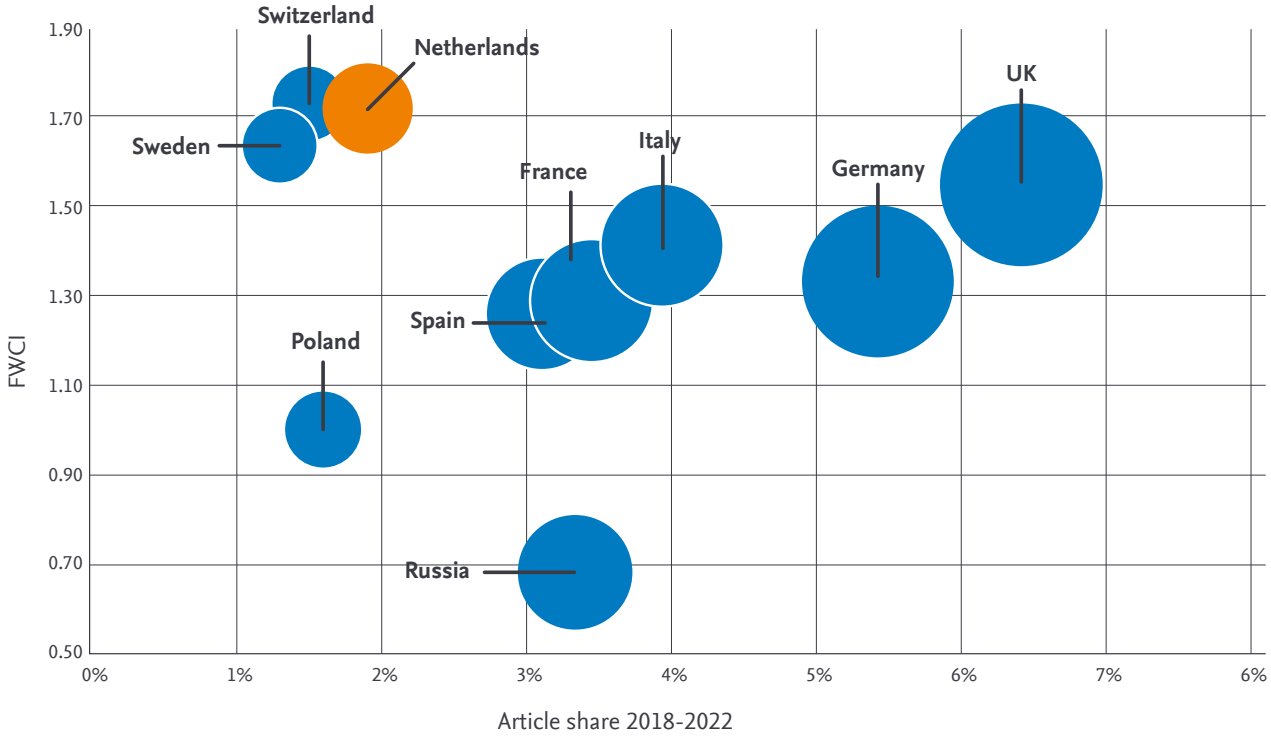


Figure 2: Scientific Impact Measured in FWCI vs. Relative Contribution of Selected European Countries

As observed in Figure 2, the Netherlands excels remarkably well in terms of scientific impact, tied for the lead with Switzerland (FWCI is 1.72), and clearly outperforming larger European countries such as the UK, Germany, Italy, Spain, and France. Russia ranks lowest here, with an impact well below the world average.

The Netherlands ranks 16th in the Top 20 of most productive research nations worldwide (and 7th in Europe). In this Top 20, the Netherlands and Switzerland lead in scientific impact, 72% above the world average.

2 What are the Success Factors of Dutch Science?

Two factors stand out immediately for Dutch science: the amount of research conducted in collaboration with scientists abroad and the close ties between industry and science.

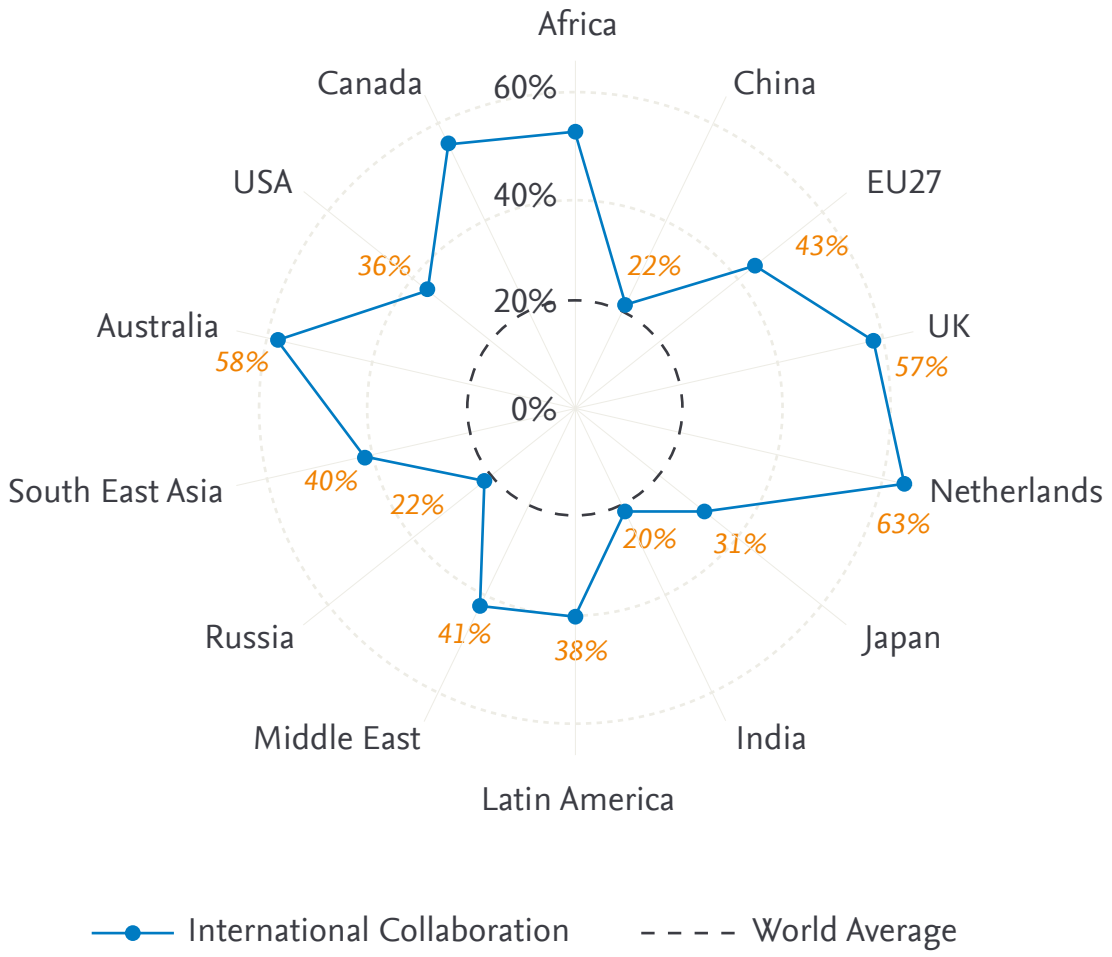


Figure 3: Internationalization of Scientific Research in Different Countries and Regions. The world average is 20%.

In Figure 3, we observe the degree of internationalization in research. For instance, when research is conducted by a Dutch researcher in collaboration with one (or more) scientists from abroad, it is considered international scientific collaboration.

The world average is at 20%, the EU27 average at 43%, and the Netherlands leads with 63%. The UK and Australia come close but remain below 60%.

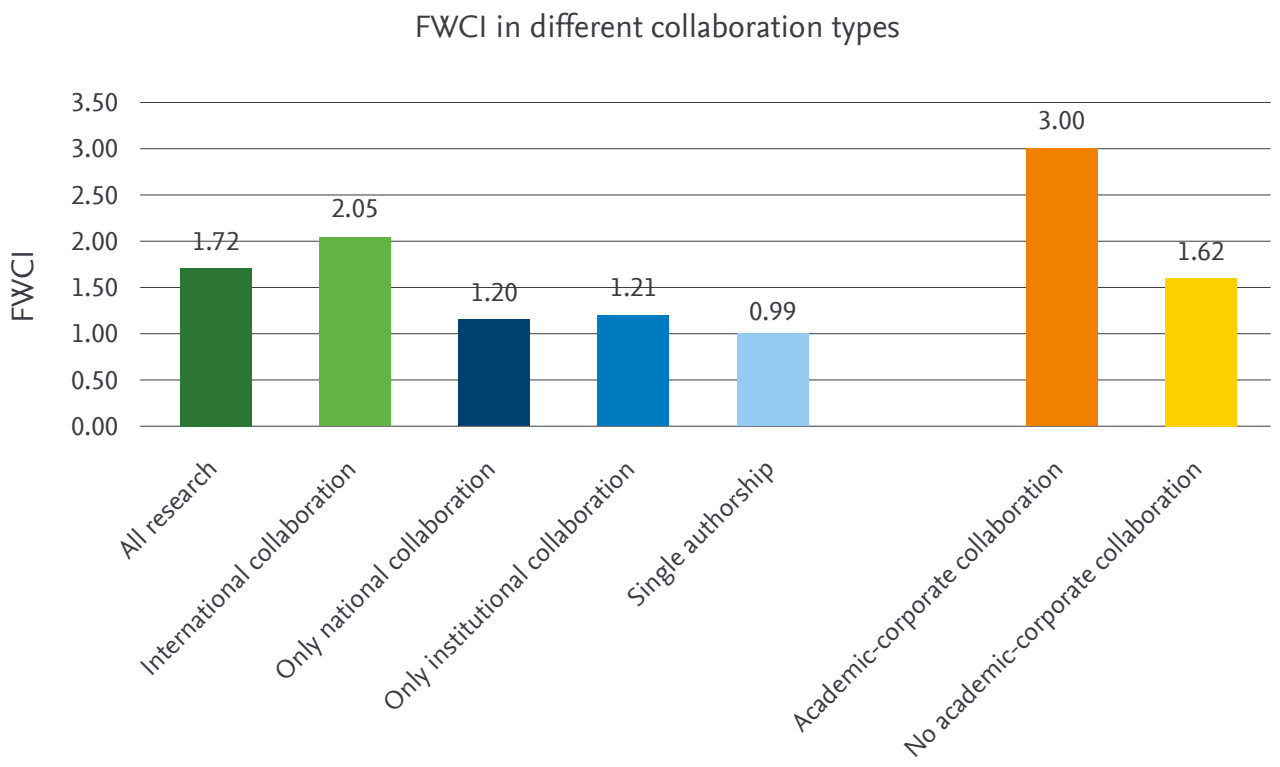


Figure 4: The Research Impact Measured as FWCI for All Dutch Research (1.72), for International Research (2.05) Compared to National Research (1.20).

As shown in Figure 4, international research has significantly more impact than national research: 2.05 vs. 1.20; international articles have more than twice the world average impact while Dutch national articles are only 20% above the world average.

The most important success factor of Dutch science is the combination of exceptionally high levels of international research from the Netherlands that has a significantly higher research impact.

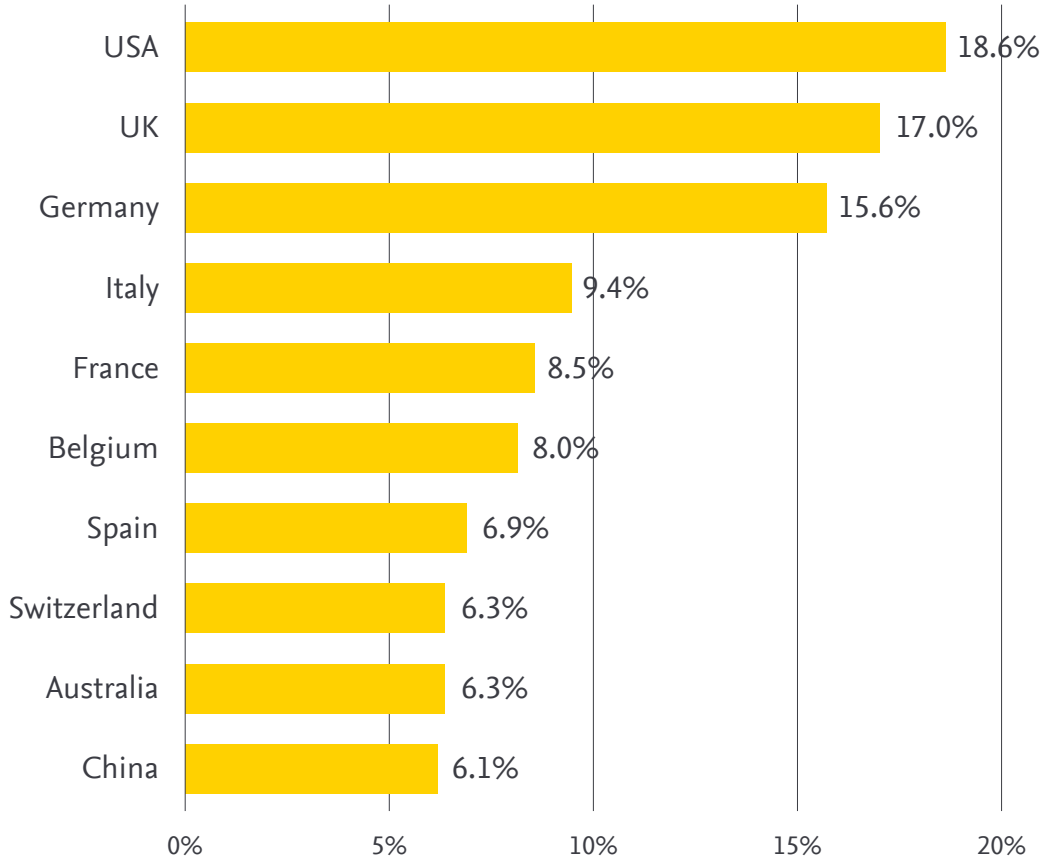


Figure 5: Countries Collaborating with the Netherlands (as a Percentage of Total Dutch Output)

Given the extensive international scientific collaboration involving the Netherlands, the question arises: with which countries? Figure 5 illustrates that half of the international collaborations involve the US, the UK, and Germany, while only 6% of collaborations involve China. Later, we will see that Dutch universities typically collaborate with academic leaders such as Harvard and Oxford.

Figure 4 also demonstrates the impact of research conducted in collaborations between universities and the business sector: three times the world average. 7.4% of all Dutch articles stem from such collaborations, significantly higher than the EU27 average of 4.1% or the world average of 2.7%. Among Dutch universities, Delft and Wageningen perform remarkably well. The vast majority of these collaborations are with the pharmaceutical industry, as we will see later. Refer to the Definitions section for more information on university-business collaborations.

In conclusion, we identify two crucial success factors for the high scientific impact of the Netherlands: firstly, international collaboration (with an impact more than two times higher than the world average) and secondly, academic-corporate collaboration (with an impact three times higher than the world average).

3 Impact of Science on Innovation, Policy and Sustainability

Dutch research demonstrates not only scientific impact but also shows impact on innovation, and especially on policy and sustainability.

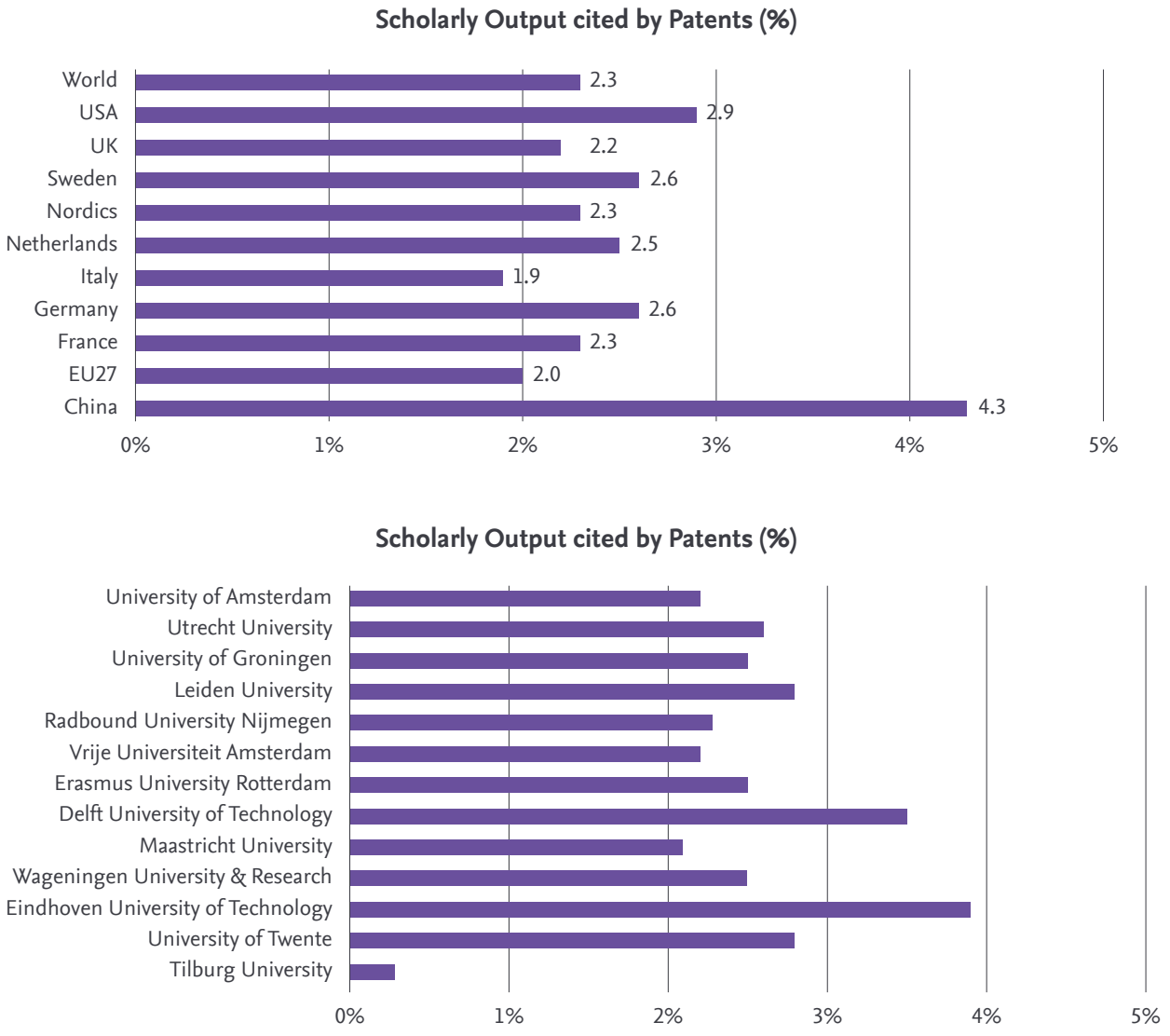
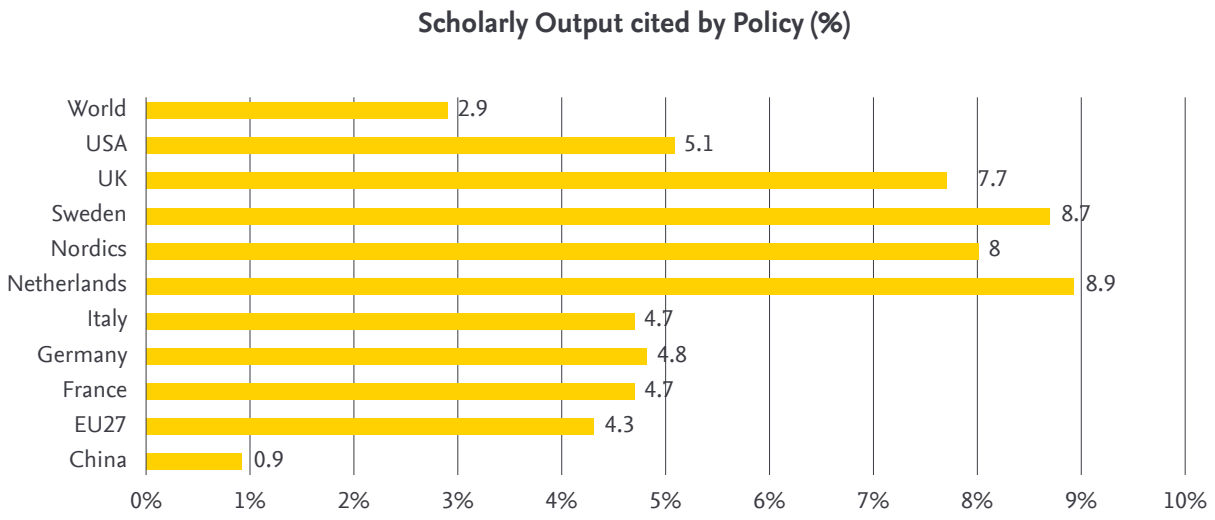


Figure 6: Scientific Articles Cited in Patents (as a Percentage of All Articles from the Country, Region, or Institution).

A good indication of innovation is patents, which typically cite scientific articles, allowing us to measure the extent to which science leads to innovation. Therefore, we examine the percentage of scientific articles cited in patents worldwide. In Figure 6, we observe that 2.5% of all Dutch articles are cited in patents – slightly above the EU27 average. In Europe, the Netherlands ranks third, after Germany and Sweden, and significantly above the United Kingdom, France, and Italy. TU Delft and especially TU Eindhoven score substantially higher (more than 3.5%) than the national average.



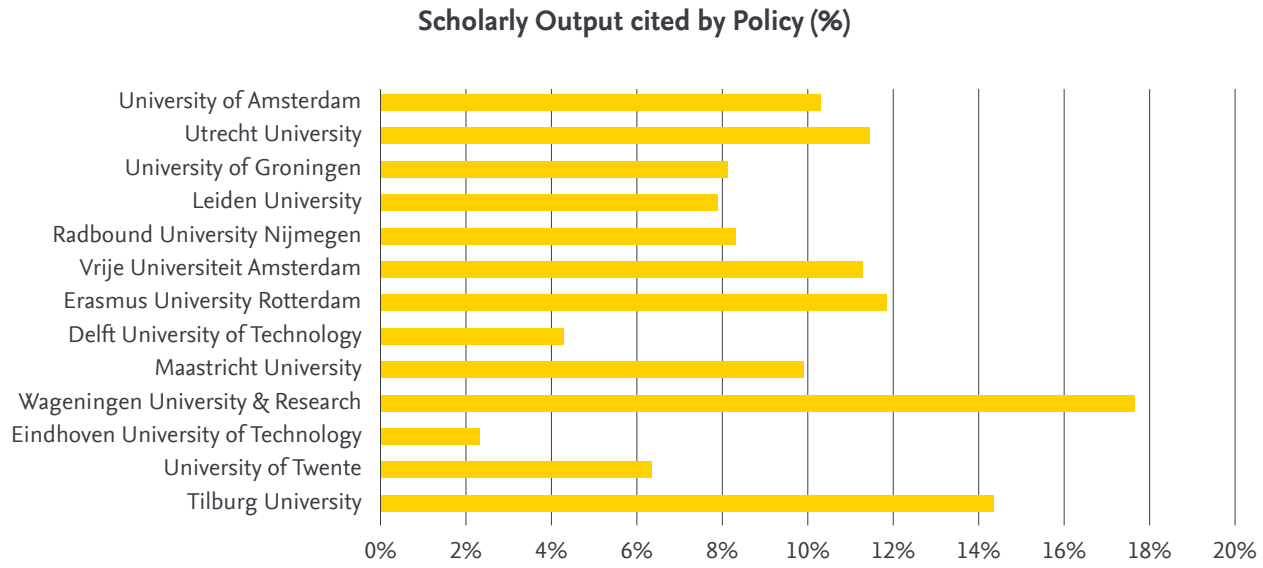


Figure 7: Scientific Articles Cited in Policy Documents (as a Percentage of All Articles from the Country, Region, or Institution).

We can also examine the impact of Dutch research on government policy worldwide. This is done by looking at how many scientific articles are cited in policy documents worldwide. We observe interesting results: 9% of all Dutch articles are cited in policy documents.

Netherlands leads in this aspect: double the EU27 average and three times the world average. Wageningen stands out positively with 18% of its articles cited in policy documents (twice the national average).

RAI (Relative Activity Index)

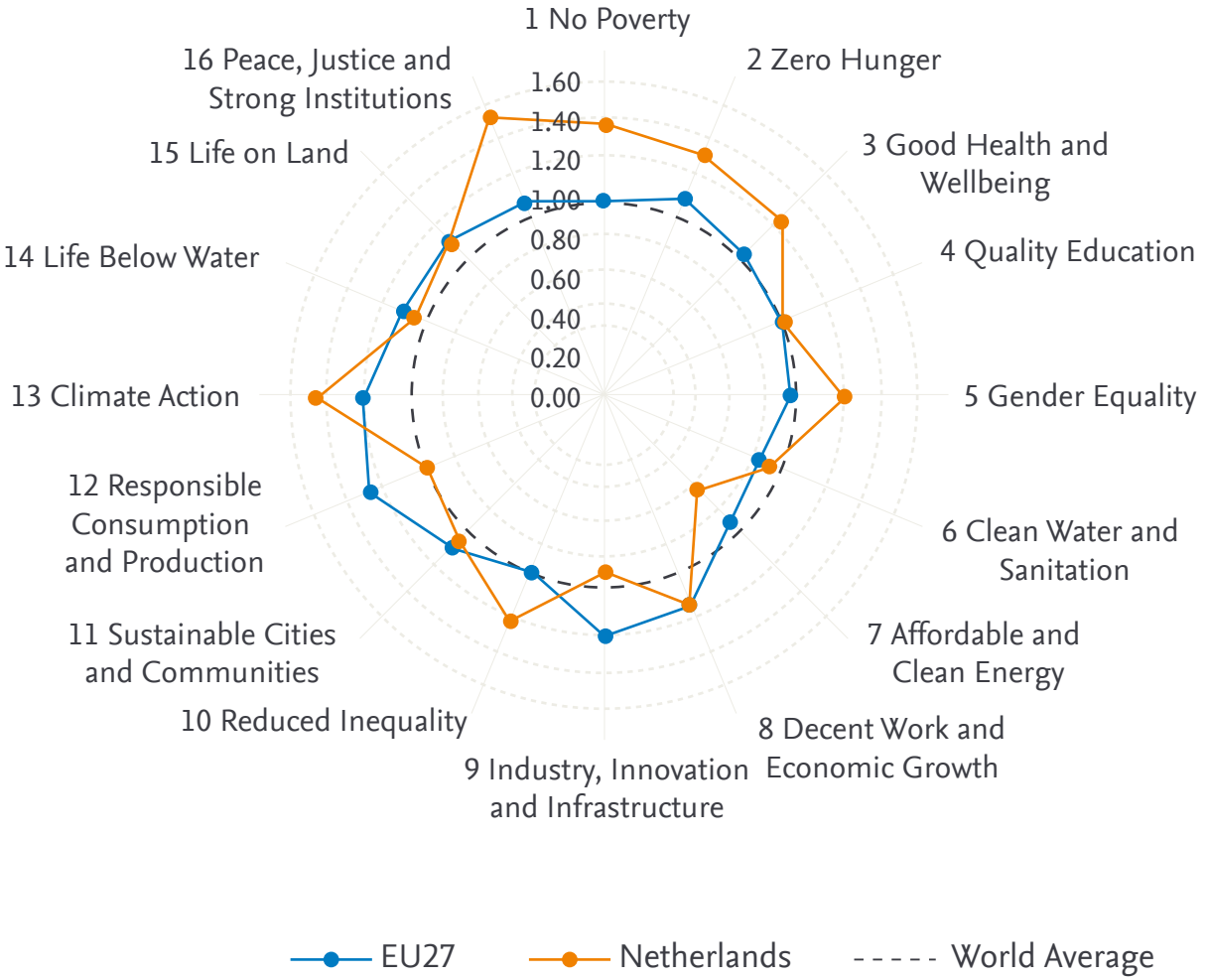


Figure 8: How Active is the Netherlands in Research Related to the 16 SDGs, Compared to the World (Normalized to 1.0) and the EU27.
The Netherlands is exceptionally active in the areas of SDG 13 and 16.

FWCI

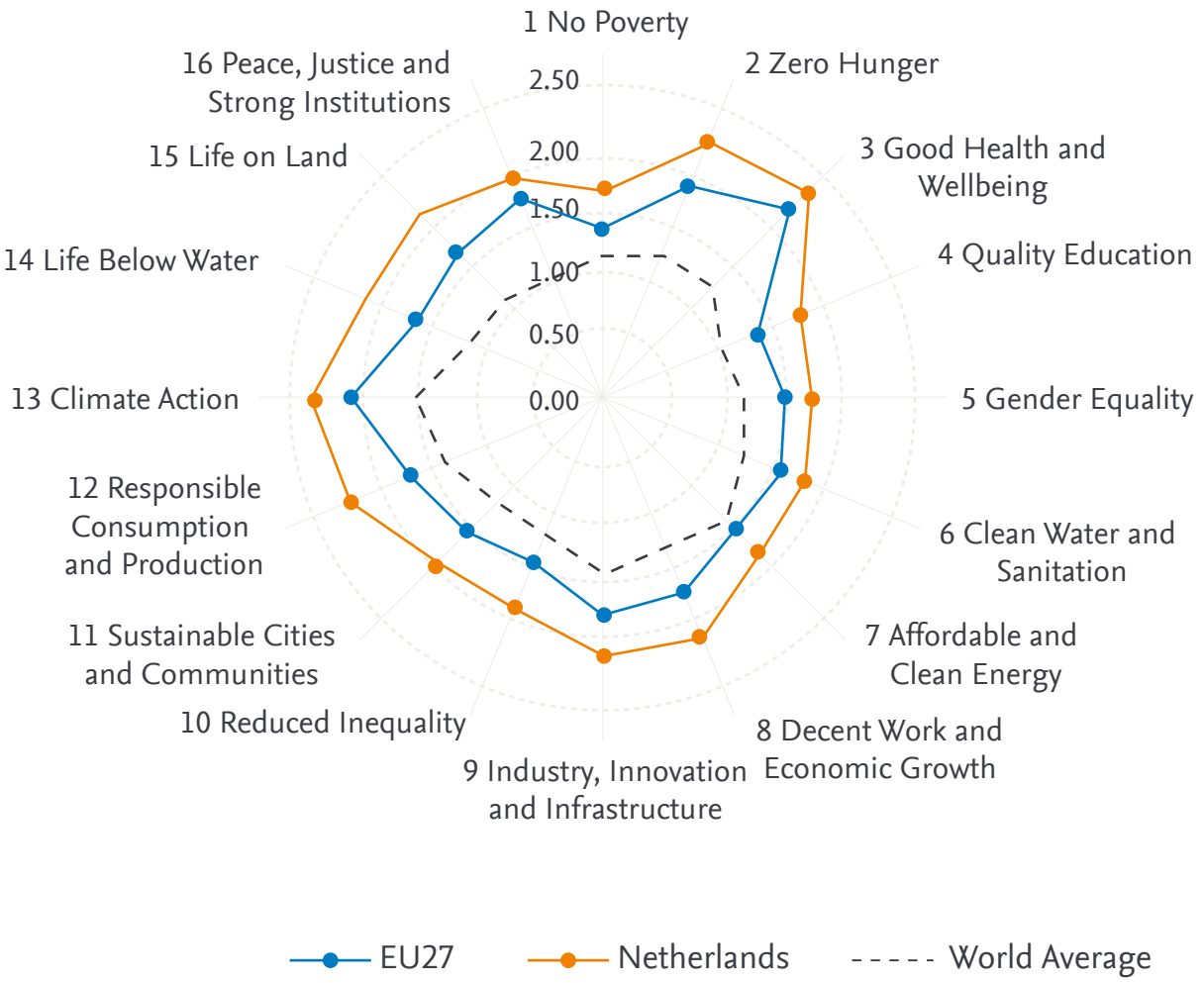


Figure 9: What is the Scientific Impact of the Netherlands' Research Related to the 16 SDGs, Compared to the World and EU27?

Dutch research also has an impact on the United Nations' Sustainable Development Goals (SDGs). We particularly focus on research related to specific SDGs. In Figure 8, we observe that the Netherlands is more active (higher productivity of articles) than the rest of the world in 8 of the 16 SDGs and notably active in SDG 16 (peace & justice) and SDG 13 (climate).

For all 16 SDGs, the Netherlands has more scientific impact than the world or the EU27, but particularly in the areas of health (SDG 3) and climate (SDG 13), with more than twice the world average, as shown in Figure 9.

Biodiversity:

As part of SDG 15, life on land, biodiversity is crucial. The recent report from 2023 demonstrates that Dutch biodiversity research has exceptionally high impact (over 2 times the world average) and is highly international (83% of all research is conducted in collaboration with foreign institutions).

Sustainable Energy – Net Zero:

When we examine SDG 7 (energy) and SDG 13 (climate) and focus on sustainable energy, as per the Net Zero report, an interesting picture emerges for the Netherlands in the realm of sustainable energy towards a Net Zero world. Relative to other countries, the Netherlands conducts relatively little research in this area, with an activity score of 70% of the world average, even below the EU27 average of 90%. In the Top 25 of most active countries in Net Zero research, the Netherlands ranks a modest 21st. However, in this Top 25, the Netherlands performs well in terms of impact on science: the FWCI is 1.73, comparable to Canada, the US, and the UK, but behind countries like Australia. Again, we see that the Netherlands is highly international (with 68% in the top 3) and engages in relatively high academic-corporate collaboration (with 11% ranking first in this Top 25).

Artificial Intelligence (AI):

Examining the Dutch contribution to AI research, we see a similar pattern as for Net Zero research: modest but with high scientific impact. In the Top 20 of AI research, the Netherlands ranks 20th. The activity level is 68% of the world average, below the EU27 percentage of 75%. However, the impact on science is again high: with an FWCI of 2.28, the Netherlands ranks 6th, alongside Canada, but behind the US, the UK, and Australia. And once again, international collaboration and collaboration with the business sector are high: both rank fourth in the Top 20.

Key Technologies:

A 2024 report mapping out key technologies in the Netherlands, "*Quantitative Analysis of Dutch Research and Innovation on Key Technologies*" shows that compared to other countries, the Netherlands is less active in research related to key technologies except in the fields of biotechnology and life sciences; however, this research does have high scientific impact.

In conclusion:

- We observe that Dutch science not only has an impact on research worldwide but also on innovation and particularly on international policy.
- Additionally, Dutch research contributes significantly to the SDGs with high scientific impact for all 16 SDGs.
- We also see this high impact in the fields of AI and Net Zero research, but the scale of Dutch research in these areas is modest and lags behind the EU and the world. The same trend is observed in key technologies: certainly of high scientific quality but relatively modest in scale compared to other countries.

4 Which disciplines and universities contribute the most to Dutch success?

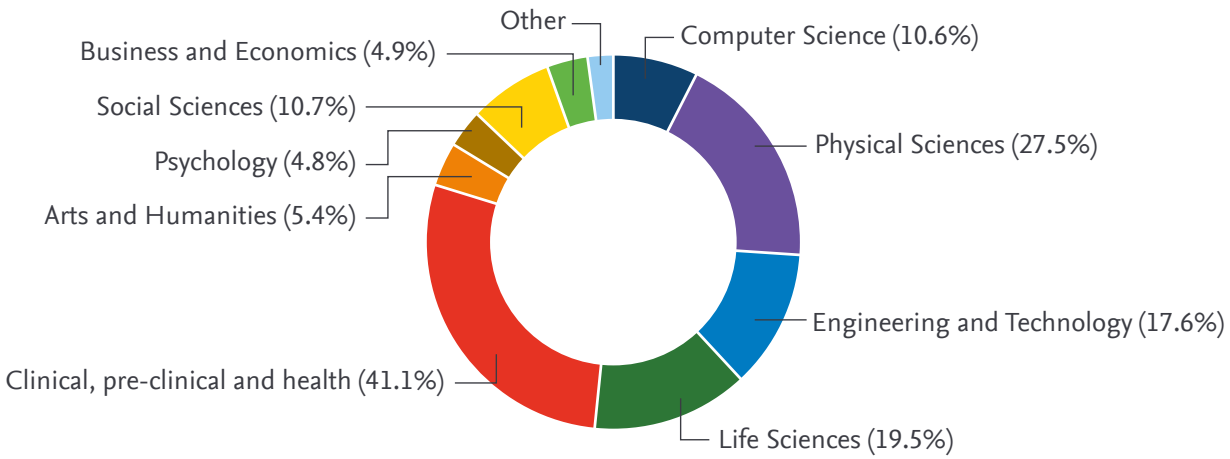


Figure 10: Relative Contribution per Discipline to Dutch Science. The FWCI of the disciplines is: Medicine (Clinical, pre-clinical, and health): 1.89; Natural Sciences (Physical Sciences): 1.56; Life Sciences: 1.69; Humanities and Social Sciences: 1.81.

When we examine fields of study (Figure 10), we observe that Dutch research related to:

- Medicine (red; 41% of all articles) has a scientific impact of 89% above the world average.
- Natural Sciences (purple; 28%): impact +56%.
- Life Sciences (green; 20%): impact +69%.
- Humanities and Social Sciences (orange and yellow; 16%; HSS): impact +81%.

Thus, Medicine and HSS contribute more to scientific impact than the national average (of 72%).

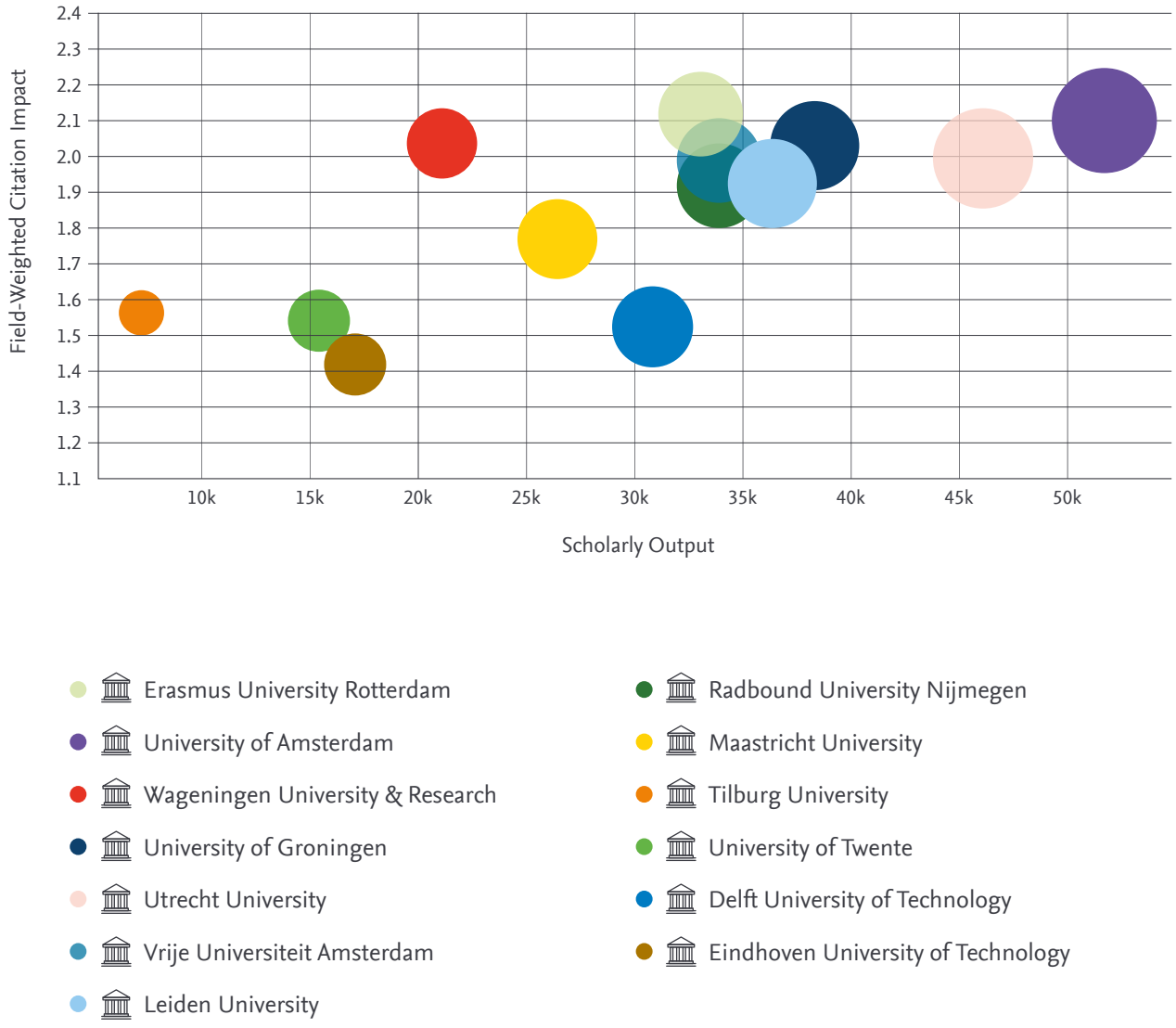


Figure 11: For Dutch universities, the output (in thousand articles) and the scientific impact (in FWCI).

In the Netherlands, the University of Amsterdam, Utrecht University, and the University of Groningen lead in terms of productivity (see Figure 11).

The University of Amsterdam and Erasmus University Rotterdam lead in scientific impact, followed by Groningen and Wageningen. All Dutch universities perform well above the world average (of 1.0).

Top Academic International Collaborators of the three most research intensive universities in Netherlands (papers with less than 100 authors)

With Univ. of Amsterdam		Co-authored publications	FWCI
BEL	KU Leuven	1,623	3.89
GBR	UCL	1,420	5.99
GBR	Oxford	1,392	3.02
USA	Harvard	1,305	5.51
DNK	Copenhagen	1,102	4.37
GBR	Imperial	1,068	4.25
FRA	Paris Cité	1,008	7.42
CAN	Toronto	959	7.62
BEL	Ghent	930	3.77
SWE	Karolinska	922	4.30

With Utrecht		Co-authored publications	FWCI
GBR	UCL	1,243	3.47
GBR	Oxford	1,203	3.98
BEL	KU Leuven	1,126	3.95
USA	Harvard	1,086	3.70
GBR	Imperial	1,042	4.43
BEL	Ghent	913	3.05
FRA	Paris Cité	892	4.45
DNK	Copenhagen	891	3.61
GBR	King's College	855	3.90
SWE	Karolinska	819	4.03

With Groningen		Co-authored publications	FWCI
USA	Harvard	911	5.68
BEL	KU Leuven	896	3.86
FRA	Paris Cité	772	4.91
GBR	UCL	764	4.53
DNK	Copenhagen	728	4.63
GBR	Oxford	697	4.43
GBR	Imperial	683	5.02
SWE	Karolinska	619	4.07
GBR	King's College	582	4.37
DEU	Heidelberg	550	4.10

Top Corporate Collaborators with the three most research intensive universities in Netherlands (2018-2022)

With Univ. of Amsterdam	Co-authored publications	FWCI
GlaxoSmithKline	128	2.69
Novo Nordisk	100	7.10
Fresenius AG	99	4.20
Johnson & Johnson	95	7.57
Danone S.A.	84	2.02
AstraZeneca	73	9.72
Cardialysis B.V.	72	2.75
Novartis	72	5.76
Alphabet Inc.	70	23.47
Pfizer	69	8.60

With Utrecht	Co-authored publications	FWCI
Danone	256	1.39
China National Nuclear Corp.	190	2.27
GlaxoSmithKline	114	9.17
AstraZeneca	89	6.91
Johnson & Johnson	83	6.01
Genetech Incorporates	71	9.77
Pfizer	70	8.52
MOH Holdings Pte	66	4.87
F. Hoffman-La-Roche	65	4.05
GD Animal Health	64	2.58

With Groningen	Co-authored publications	FWCI
AstraZeneca	176	8.68
Johnson & Johnson	118	9.82
MOH Holdings Pte	113	8.64
Novo Nordisk	93	8.02
Novartis	89	6.30
Filmlab Laboratories	85	8.66
GlaxoSmithKline	81	14.90
Fresenius AG	80	10.96
Pfizer	77	8.66
Danone	76	1.06

Figure 12: Here we examine international collaboration (top) and collaboration between universities and industry (bottom) for the University of Amsterdam, Utrecht University, and the University of Groningen. We look at the Top 10 based on the number of articles and also display the scientific impact of these collaborations, measured by the FWCI.

When we then look at the 10 most productive collaborations of the top three universities in the Netherlands (Figure 12), several important points immediately stand out:

- All foreign institutions are in Western Europe or North America.
- The world's best institutions are on the list, such as Oxford and Harvard. Dutch universities collaborate most with academic powerhouses from the US, the UK, Scandinavia, France, Belgium, and Germany.
- The scientific impact is enormous: at least 3 times and in some cases up to 7 times the world average.
- The list of collaborations between universities and industry is dominated by the pharmaceutical industry.

5 Conclusions

The Netherlands excels in scientific endeavors, leading in the Top 20 of the most productive countries on impact. The primary success factor is international collaboration: a remarkably high percentage of all publications stem from international cooperation, and this collaboration yields significantly higher scientific impact. Dutch universities successfully collaborate with the absolute academic elite from Europe and North America.

The collaboration between universities and industry in research exhibits an enormous scientific impact, even surpassing that of international collaboration. Dutch universities primarily collaborate with the pharmaceutical industry.

Dutch researchers not only impact global science but also influence innovation and international policy. The Netherlands demonstrates exceptional impact on policy documents worldwide.

Dutch research related to the Sustainable Development Goals (SDGs) performs remarkably well. The Netherlands is highly active in half of the SDGs, and for all 16 SDGs, Dutch research has more scientific impact than the world or EU27 average. We observe this high research impact in the fields of AI, Net Zero, and key technologies, although the scale of Dutch research in these areas is modest and lags behind the EU and the rest of the world.

When examining fields of study within Dutch research, medicine stands out: it contributes the most in terms of output and also exhibits high scientific impact – certainly higher than the national average.

In conclusion, we can confidently assert that Dutch research ranks among the best worldwide and makes an exceptional contribution to science, innovation, and policy.

6 Definitions

This report is based on Scopus data covering the years 2018-2022.

International collaboration

International collaboration in this report is indicated by papers with at least two different countries listed in the authorship byline.

Academic-corporate collaboration

In Scopus, institutions are classified into one of four main sectors (Corporate, Academic, Government, and Medical sectors). In this report, academic–corporate collaboration is analysed via the proxy of papers whose authors' affiliations belong to both the academic and corporate sectors.

Citation

A citation is a formal reference to earlier work made in a paper or patent, frequently to other papers. A citation is used to credit the originator of an idea or finding and is typically used to indicate that the earlier work supports the claims of the work citing it. The number of citations received by a paper from subsequently published papers can be used as a proxy of the quality or importance of the reported research.

FWCI (Field-weighted citation impact)

Field-weighted citation impact (FWCI) is an indicator of mean citation impact and compares the actual number of citations received by a paper with the expected number of citations for papers of the same document type (article, review, or conference proceeding), publication year, and subject area. When the paper is classified in two or more subject areas, the harmonic mean of the actual and expected citation rates is used. The indicator is therefore always defined with reference to a global baseline of 1.0 and intrinsically accounts for differences in citation accrual over time, differences in citation rates for different document types (e.g., reviews typically attract more citations than research articles), as well as subject specific differences in citation frequencies overall and over time and document types. It is one of the most sophisticated indicators in the modern bibliometric toolkit.

RAI (Relative Activity Index)

Relative Activity Index is defined as the share of an entity's publications in a subject relative to the global share of publications in the same subject. A value of 1.0 indicates that an entity's research activity in a field corresponds exactly with the global activity in that field; higher than 1.0 implies a greater emphasis while lower than 1.0 suggests a lesser focus.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