International Comparative Benchmark of Dutch Research Performance in TKI Themes: Food and Health

A report prepared by Elsevier for the Netherlands Enterprise Agency, December 2014
Executive Summary
Food and Health

The Netherlands’ publications in Food and Health are impactful, measured by citations. The average field-weighted citation impact (FWCI) of the Netherlands’ publications in this subject area in 2005-2011 was 1.90 (90% higher than the world average) and 7th highest among the world’s top 20 most prolific countries in this subject area. The FWCI of the Netherlands’ publications grew steadily, from 1.83 in 2005-2007 to 1.99 in 2009-2011.

In the period 2005-2011, the Netherlands produced 415 publications in Food and Health, which contributed to 4.1% of world publications, ranking 6th in the world. Globally, the research output in Food and Health decreased at a compound annual growth rate (CAGR) of -0.8% in 2005-2011. The Netherlands showed a growth rate of -4.0%, the 2nd lowest among comparators. For many comparator countries, including the US and the UK, the research output decreased from 2005 to 2011. A few countries still had high CAGR, e.g., China’s 19.0% and South Korea’s 24.6%.

The Netherlands’ research in Food and Health was collaborative. Around 48.4% of the Netherlands’ publications in this subject area in 2005-2011 involved international collaboration, 7th highest among comparators. These internationally collaborated publications are highly impactful. With a FWCI of 2.48, it is well above that of the Netherlands’ total publications in Food and Health in the same period.

There is also strong linkage between the Netherlands’ research in Food and Health and the industry. Around 6.3% of the publications were produced in collaboration with the industry. The Netherlands ranked the 5th in this percentage among the comparators. These publications collaborated with the corporate sector are highly impactful with an FWCI of 3.64.

The Netherlands’ research in Food and Health was more frequently cited in patent citations than the world average in 2005-2011. In this period, the Netherlands’ publications in Food and Health were cited 1.5 times in patent applications, contributing to 10.1% of world patent citations in Food and Health research.
Key Findings

RESEARCH OUTPUT

415 documents
4.1% world output share

FIELD-WEIGHTED CITATION IMPACT

1.90
90% higher than the world average

HIGH INTERNATIONAL COLLABORATION PERCENTAGE

48.4%

HIGH CROSS-SECTOR COLLABORATION PERCENTAGE

6.3%
Preface

This report is one in a series of benchmarks for (research) themes within the Top consortia for Knowledge and Innovation (TKI). It focuses on measurement of publication output, growth, citation impact and collaboration between academia and industry. It provides TKIs and other stakeholders with a tool to benchmark their research themes internationally, aiding them to build and maintain a smart portfolio of research programs and projects.

This benchmark of scientific research is part of a larger monitoring system of the TKIs and the Netherlands’ government Enterprise policy and Top Sector approach. (For more information, please refer to www.top-sectoren.nl). The results of this benchmark may be included in the annual progress report of the Enterprise policy, which is sent to parliament in autumn.

This benchmark was commissioned by the Netherlands Enterprise Agency, part of the Ministry of Economic Affairs and performed by Elsevier. Of course, this benchmark could not have been created without the help of the experts at the TKIs. We thank them for their response and comments. We also thank the steering committee that commented on the first draft of the first benchmarks.

The TKI’s main task is to implement the research roadmaps that resulted from the innovation contracts drawn up by each of the nine Top sectors in 2011. In these contracts companies, researchers and the government have made agreements on how the resources earmarked for knowledge and innovation will be used in each top sector to build on existing scientific excellence and to meet the need for innovative solutions to societal problems. In doing so, the TKI’s foster collaborative ties between industry and academia. To aid this effort, the Dutch Government introduced a TKI allowance stimulating private contributions to TKI-projects as well as an instrument (MKB Innovatiesimulator Topsectoren: MIT) to provide financial support to projects that enhance active participation of SME’s.

Research in a TKI can be purely scientific, in a laboratory setting, or it can be very practical, for instance in building a prototype for a new innovation. Each TKI has defined one or more themes to focus its research.
# Contents

**Executive Summary & Key Findings** 1

**Preface** 4

**Contents** 5

**Introduction** 6

1 **Publication Output** 7
   1.1 Key Findings 8
   1.2 Defining the Field 9
   1.3 Publication Volume 10
   1.4 Citation Impact 12
   1.5 Patent Citations 15
   1.6 Hot Topics in Adjacent Research Areas 17

2 **Collaboration** 20
   2.1 Key Findings 21
   2.2 Background 22
   2.3 International Collaboration 23
   2.4 Academic-corporate Collaboration 25

APPENDIX A: **Methodology** 27

**References** 30

**About** 31

**Authors** 31

**Notes** 32
Introduction

Using advanced agricultural technology to produce sustainable and healthy food and other agricultural products is essential to addressing the challenge of meeting higher demand for food whilst reducing energy consumption in the production process. As the world second largest exporter in agri-food products, the Netherlands plays an essential role in the world agri-food market.

The Dutch Top Sector Agri&Food is a close collaboration between academia and industry that addresses questions such as

- How can we feed a fast-growing world population with rising consumption levels linked to increasing prosperity?
- How can we prevent the depletion of raw materials?
- How can we develop healthier and more sustainable food products?

This report on Food and Health research is one of the series of reports that Elsevier will produce to cover various TKIs in the Top Sector Agri&Food.

In this report we will firstly investigate the research output and citation impact of the Netherlands’ publications in Food and Health, compared to the world top 20 most prolific countries in the research in this subject area. We will then focus on the collaboration in Food and Health research. This includes two aspect of collaboration: international collaboration and academic-corporate collaboration. The details of the methodology are presented in Appendix A.

In the coming 40 years, global food demand will rise by approximately 65%. At the same time, fossil fuels will become increasingly scarce, so the sector is facing the challenge of producing more with fewer raw materials. A healthy food pattern increases the quality of life and reduces overweight, obesity and cardiovascular diseases. The Agri&Food Top Sector wants to focus even more on both sustainability and health in the coming years.

Chapter 1
Publication Output

Firstly, this chapter describes how the field of Food and Health has been defined in the setting of this study. Subsequently, this chapter focuses on two aspects of publication output of Food and Health research: its volume and its citation impact. In addition, a third aspect of output is analysed: how often are research articles cited in patents? Finally, the chapter lists ‘hot topics’ in adjacent research fields.
1.1 Key Findings

“Scholarly communication is key to academic endeavour and research outputs are a traditional indicator of research intensity. [...] Taken over time, bibliometrics based on journal articles and citations offer a rich indicator of changes in research intensity and behaviour.”


<table>
<thead>
<tr>
<th>RESEARCH OUTPUT</th>
<th>FIELD-WEIGHTED CITATION IMPACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>415</td>
<td>1.90</td>
</tr>
</tbody>
</table>

The Netherlands produced 415 publications in Food and Health in 2005-2011, ranking 6th in the world.

The FWCI of the Netherlands’ publications in Food and Health in 2005-2011 was 1.90, ranking the 7th amongst the comparators.

<table>
<thead>
<tr>
<th>RESEARCH PRODUCTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.36</td>
</tr>
</tbody>
</table>

The productivity index of the Netherlands’ publications in Food and Health was 0.36 in 2005-2011.
1.2 Defining the Field

Defining the field of Food and Health research is a crucial step in this study, so this first section sets out to explain the methodology used. In order to define the field of Food and Health research, an Elsevier subject matter expert has constructed a set of 100 articles that are relevant to the field. This set was presented for validation to the relevant TKI expert. This list of 100 articles, also known as a golden training set, was then used to Fingerprint with the Elsevier Fingerprint Engine. The Elsevier Fingerprint Engine scans abstracts from Scopus and extracts meaningful concepts (Fingerprints). A variety of thesauri spanning all major subject areas, along with Natural Language Processing (NLP) techniques, can be used to scan and analyse the information, and to identify and weigh the key concepts in the text. Each document is assigned a collection of key concepts which represent that document. The advantage of using key concepts based on Fingerprint technology is that they are of higher quality and more representative than standard sets of keywords, which often suffer from problems such as duplicates, synonyms, and inclusion of irrelevant terms. The concepts that together form the Fingerprint used for this study are reproduced in Appendix B.

These Fingerprinted keywords were in turn used to construct a top-down set of documents. Which documents - other than the ones on the golden training set - should also be included in the set that defines Food and Health research?

Figure 1 shows the world output for the field of Food and Health research. The compound annual growth rate (CAGR) for the field was -0.8% whereas the average growth in the whole Scopus database was 4.3% per annum. Research output in Food and Health research therefore grew much slower than the world average in the same period. In absolute terms, the research output in this subject area dropped from 1,624 in 2005 to 1,295 in 2009. Then it increased again to 1,543 in 2011. This trend is almost opposite to many of the subject areas related to agriculture and food in this series of report. For many other subject areas, research output increased most rapidly from 2005-2009 and then slowed down slightly.

![Figure 1 - World output in Food and Health, 2005-2011.](image)
1.3 Publication Volume

We now take a closer look at each country’s publication volume in Food and Health research. Publications have been attributed to a country by using the following definition: all publications published with an affiliation based in the Netherlands will be assigned to the Netherlands’ output in this field. A publication that is co-authored among different countries will therefore be double-counted. For example, if a Dutch researcher publishes an article together with a Swedish colleague, this article will count towards the Dutch output as well as the Swedish output.

*Figure 2 - Output in Food and Health research per country, 2005-2011. The US and the UK are excluded for the ease of view.*

As can be seen in Figure 2 and Table 1, the Netherlands ranked 6th in terms of total output volume in 2005-2011, producing 415 publications in total. The US and the UK are not plotted in the figure, but they are by far the most productive countries in
this field. The US produced in total 3,134 publications and the UK produced 1,262 in the period 2005-2011.

The CAGR of the research output of the top 20 countries shows very different patterns. Most of the more mature research countries had a negative CAGR. For example, the US and the UK’s research output in this subject area dropped at an annual rate of 2.8% and 0.8%, respectively. The Netherlands showed a CAGR of -4.0%, 2nd lowest among comparators. Italy had the lowest growth rate amongst the comparator countries (-4.2%). A few countries in particular the emerging countries show high speed of growth even when world output dropped. For example, South Korea’s output increased at an annual rate at 24.6% and that of China at 19.0%. More details can be found in Table 1.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USA</td>
<td>3134</td>
<td>-2.8%</td>
</tr>
<tr>
<td>2</td>
<td>GBR</td>
<td>1262</td>
<td>-0.8%</td>
</tr>
<tr>
<td>3</td>
<td>CAN</td>
<td>515</td>
<td>-0.2%</td>
</tr>
<tr>
<td>4</td>
<td>AUS</td>
<td>461</td>
<td>4.0%</td>
</tr>
<tr>
<td>5</td>
<td>DEU</td>
<td>460</td>
<td>-2.8%</td>
</tr>
<tr>
<td>6</td>
<td>NLD</td>
<td>415</td>
<td>-4.0%</td>
</tr>
<tr>
<td>7</td>
<td>FRA</td>
<td>407</td>
<td>-2.6%</td>
</tr>
<tr>
<td>8</td>
<td>ITA</td>
<td>384</td>
<td>-4.2%</td>
</tr>
<tr>
<td>9</td>
<td>ESP</td>
<td>347</td>
<td>9.4%</td>
</tr>
<tr>
<td>10</td>
<td>CHN</td>
<td>323</td>
<td>19.0%</td>
</tr>
<tr>
<td>11</td>
<td>BRA</td>
<td>306</td>
<td>3.8%</td>
</tr>
<tr>
<td>12</td>
<td>JPN</td>
<td>306</td>
<td>-1.8%</td>
</tr>
<tr>
<td>13</td>
<td>IND</td>
<td>282</td>
<td>4.4%</td>
</tr>
<tr>
<td>14</td>
<td>CHE</td>
<td>213</td>
<td>-3.2%</td>
</tr>
<tr>
<td>15</td>
<td>SWE</td>
<td>187</td>
<td>-4.0%</td>
</tr>
<tr>
<td>16</td>
<td>NZL</td>
<td>172</td>
<td>0.7%</td>
</tr>
<tr>
<td>17</td>
<td>DNK</td>
<td>165</td>
<td>0.5%</td>
</tr>
<tr>
<td>18</td>
<td>BEL</td>
<td>158</td>
<td>-1.7%</td>
</tr>
<tr>
<td>19</td>
<td>KOR</td>
<td>152</td>
<td>24.6%</td>
</tr>
<tr>
<td>20</td>
<td>FIN</td>
<td>145</td>
<td>5.2%</td>
</tr>
</tbody>
</table>
1.4 Citation Impact

In addition to publication volume, it is important to include a measure of the quality of the publications. Citations are widely recognised as a possible proxy for quality\(^1\). For this study, we used Field-weighted Citation Impact (FWCI) as the measure of citation impact. This is a measure of citation impact that normalises for differences in citation activity by subject field, article type, and publication year. The world is indexed to a value of 1.00, meaning that values above 1.00 indicate above average citation impact. For example, a citation impact of 1.80 indicates a citation impact which is 1.8 times the average, or 80% above the average.

Figure 3 – Field-Weighted Citation Impact for 3-year periods with a moving window, 2005-2007 to 2009-2011.

\(^1\) Davis, P. (2009) Reward or persuasion? The battle to define the meaning of a citation. Learned Publishing 22(1) pp. 5-11.
Figure 3 shows that in the last 3-year window 2009-2011, the Netherlands had the 5th highest FWCI (1.99), after Switzerland (2.39), Sweden (2.20), Belgium (2.19) and Denmark (2.07). The Netherlands’ FWCI increased slightly in the period 2005-2011: it was 1.83 in 2005 and 1.99 in 2011. Japan had the lowest FWCI among comparators in all years in 2005-2011 and it also decreased rapidly in the period 2005-2011.

Figure 4 - Publication and citation share 2005-2011

Figure 4 shows that in the period 2005-2011, the Netherlands occupies the 6th position with a world publication share of 4.1% and a world citation share of 6.4%. This means that whilst the Netherlands authored 4.1% of all publications in that period, they received 6.4% of all citations, indicating that the Dutch research output in this field is of relatively high quality. Among comparator countries, the Netherlands had the 6th highest ratio between publication share and citation share (1.51), after Finland (1.75), Belgium (1.62), New Zealand (1.59), Denmark (1.58), and Switzerland (1.57).

We see that among others the US, the UK and Germany also had a higher citation share than publication share, indicating relatively high quality of research, while countries with fast growing research outputs such as China and Brazil exhibited the opposite trend. Clearly, the US remains a leader in the field of Food and Health research with a publication share of 31.0% and a citation share of 41.6%.

An important aspect of a country’s scientific performance is the productivity of its human capital, or, in other words, how efficient is a country when output is corrected for the number of authors. Figure 5 depicts the relation between productivity (output per author) and FWCI.
Except South Korea and Japan, all comparator countries in Figure 5 had a FWCI higher than the world average of 1. The Netherlands had the 7th highest FWCI amongst all comparator countries. For the period 2005-2011, the average FWCI for the Netherlands was 1.90, 90% higher than the world average. In terms of productivity, the Netherlands ranked in the middle of comparators. On average, each Dutch author produced 0.36 articles per year, close to the productivity of the American authors (0.35). Switzerland stood out with the highest productivity index (0.47) and the 3rd highest FWCI (2.20). Countries such as Japan, South Korea, China and Brazil had relatively low productivity.
1.5 Patent Citations

In early citation studies, technological progress was viewed as more or less a direct result of scientific progress. To paraphrase Bassecoulard & Zitt, it had been assumed that there is a diachronic relationship, in which the science of today is the technology of tomorrow. However, as many authors have since made clear, there are several issues related to using a linear model. Over the last decades ‘science’ (being more theoretical) and ‘technology’ (more practical) have become closely intertwined. It is even becoming increasingly common for a researcher to be active in both worlds; i.e. one may work at a corporate R&D lab, but also hold an academic position (adjunct professorship) or vice versa.

In this section, we analyse the number of patent citations per country. The fairest comparison between countries can be made by taking patent data from WIPO, the international patent office. Selecting the US Patent and Trademark Office may show a bias towards the US, and the same applies for the other national patent offices. Still, the results for the US may be disadvantaged because we are not looking at the US patent office data, and this office would contain most of the US patent citations.

---

Figure 6- Number of patent citations per country.

---


2 See www.researchtrends.com, issue 33 for more details on this subject.
In 2005-2011, the Netherlands' publications in Food and Health received 15 citations in patent applications. This number was 149 for the world overall. This means that the Netherlands received 10.1% of the world citations in patent applications in 2005-2011. Since the Netherlands produced around 4.1% of the publications in Food and Health, relative to its world publication share the Netherlands' publications in Food and Health were cited two and half times more often than the world average in patent applications. The US led the comparators in patent citations, receiving in total 31 patent citations in the period 2005-2011 or 20.8% of all patent citations in the world.
1.6 Hot Topics in Adjacent Research Areas

In section 1.1, we described how the field of Food and Health studies has been defined in the context of this study, with expert input and the use of sophisticated concepts and fingerprinting. However, it is plausible that research fields that are in close proximity may also be interesting to monitor. A particularly interesting question is which topics in these adjacent fields are ‘hot’, meaning that they receive more attention than others. In this section, we identify a list of ‘hot topics’ that are adjacent to, but not unique to Food and Health studies. This provides additional information on which interesting topics that in first instance might be overlooked are currently being investigated.

By following the approach described in section 1.1 to define the field of Food and Health studies, essential concepts have been identified and used to create a full set of documents. In this set of documents, many other concepts are present (so-called adjacent concepts), even though they have not actively been included: they just co-occur often with the concepts that were defined as essential to this research area.

In order to be able to define adjacent research areas, we have taken these related concepts and broadened the set by actively including them. Articles that include a concept that is essential, but also a concept that is adjacent, were already included in the original set. Articles that only include an adjacent concept but no essential concepts are captured in the second set, used to investigate ‘hot topics’.

This second set of articles, adjacent but not essential for Food and Health studies, has been analysed by looking at the most frequently downloaded concepts within this set. As a benchmark, the average downloads per article were 1,618 downloads per article.

All concepts listed below in Table 2 are downloaded well above average and could therefore be of interest as adjacent hot topics for Food and Health research. The table shows the concept names, number of articles within the concepts that can be found in ScienceDirect and two example articles from each concept.
<table>
<thead>
<tr>
<th>Concept</th>
<th>Articles</th>
<th>Downloads per paper</th>
<th>Article publication year</th>
<th>Journal</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biodiesel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>31632</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>Bioresource Technology</td>
<td>Cyanobacteria and microalgae: A positive prospect for biofuels</td>
<td>Parmar A.; Singh N.; Pandey A.; Gnansounou E.; Madamwar D.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Renewable and Sustainable Energy Reviews</td>
<td>Integrated CO2 capture, wastewater treatment and biofuel production by microalgae culturing - A review</td>
<td>Razzak S.; Hassain M.; Lucky R.; Bassi A.; De Lasa H.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biofuels</td>
<td>17</td>
<td>18678</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Renewable and Sustainable Energy Reviews</td>
<td>Carbon sequestration and the role of biological carbon mitigation: A review</td>
<td>Farrelly D.; Everard C.; Fagan C.; McDonnell K.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Biotechnology Advances</td>
<td>Microalgae for high-value compounds and biofuels production: A review with focus on cultivation under stress conditions</td>
<td>Markou G.; Nerantzis E.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuels</td>
<td>8</td>
<td>18369</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>Journal of Exposure Science and Environmental Epidemiology</td>
<td>Perchlorate exposure from food crops produced in the lower Colorado River region</td>
<td>Sanchez C.; Barraj L.; Blount B.; Scrafford C.; Valentin-Blasini L.; Smith K.; Krieger R.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Science of the Total Environment</td>
<td>Studying the effects of polycyclic aromatic hydrocarbons on peripheral arterial disease in the United States</td>
<td>Xu X.; Hu H.; Kearney G.; Kan H.; Sheps D.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sustainable development</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>New Biotechnology</td>
<td>Why farming with high tech methods should integrate elements of organic agriculture</td>
<td>Ammann K.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Meat Science</td>
<td>Sustainable sheep production and consumer preference trends: Comparabilities, contradictions, and unresolved dilemmas</td>
<td>Montossi F.; Font i Furnols M.; Del Campo M.; San Julián R.; Brito G.; Saluido C.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity</td>
<td>8</td>
<td>16661</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Bioresource Technology</td>
<td>Photobioreactor strategies for improving the CO2 fixation efficiency of indigenous Scenedesmus obliquus CNW-N: Statistical optimization of CO2 feeding, illumination, and operation mode</td>
<td>Ho S.; Lu W.; Chang J.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Atmospheric Environment</td>
<td>An assessment of GHG emissions from small ruminants in comparison with GHG emissions from large ruminants and monogastric livestock</td>
<td>Zervas G.; Tsipakou E.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>9</td>
<td>15760</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Environmental and Experimental Botany</td>
<td>Grain quality characteristics of spring wheat as affected by free-air CO2 enrichment</td>
<td>Högy P.; Brunnbauer M.; Koehler P.; Schwadorf K.; Breuer J.; Franzing J.; Zhunusbayeva D.; Fangmeier A.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Global Environmental Change</td>
<td>The impact of biofuel-induced food-price inflation on dietary energy demand and dietary greenhouse gas</td>
<td>Scovronick N.; Wilkinson P.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Issue</td>
<td>Page</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-------</td>
<td>------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wastewater treatment</td>
<td>6</td>
<td>14471</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Current Opinion in Biotechnology</td>
<td>Plant based phosphorus recovery from wastewater via algae and macrophytes</td>
<td>Shilton A.; Powell N.; Guieysse B.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedstocks</td>
<td>9</td>
<td>13699</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Industrial Crops and Products</td>
<td>Purification of ferulic acid solubilized from agroindustrial wastes and further conversion into 4-vinyl guaiacol by Streptomyces setonii using solid state fermentation</td>
<td>Salgado J.; Max B.; Rodriguez-Solana R.; Domínguez J.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>Renewable and Sustainable Energy Reviews</td>
<td>Morphology, composition, production, processing and applications of Chlorella vulgaris: A review</td>
<td>Safi C.; Zebib B.; Merah O.; Pontalier P.; Vaca-García C.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microalgae</td>
<td>16</td>
<td>12669</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>Aquatic Botany</td>
<td>Understorey benthic microalgae and their consumers depend on habitat complexity and light in a microtidal coastal ecosystem</td>
<td>Rubach A.; Hillebrand H.; Eriksson B.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Aquaculture</td>
<td>Comparison of non-volatile compounds and sensory characteristics of Chinese mitten crabs reared in lakes and ponds: Potential environmental factors</td>
<td>Kong L.; Cai C.; Ye Y.; Chen D.; Wu P.; Li E.; Chen L.; Song L.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wastes</td>
<td>13</td>
<td>12324</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>Waste Management</td>
<td>Determination of plate waste in primary school lunches by weighing and visual estimation methods: A validation study</td>
<td>Liz Martins M.; Cunha L.; Rodrigues S.; Rocha A.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In this chapter, we investigate two aspects of research collaboration for Food and Health: international collaboration and academic-corporate collaboration. We focus on the absolute number of the collaborated publications, the share of the collaborated publications out of the total output and the FWCI of the collaborated publications.
2.1 Key Findings

"[...] the increase of citation impact by international collaboration became almost a commonplace notion. Indeed, publications with one or more co-authors from institutions in different countries seem to be the results of greater efforts than those by authors from one and the same country or institute. However, the reasons for international collaboration are manifold. Some of the factors influencing co-publications are intra-scientific, economic and (geo-)political."


<table>
<thead>
<tr>
<th>INTERNATIONAL COLLABORATION</th>
<th>CROSS-SECTOR COLLABORATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>48.4%</td>
<td>6.3%</td>
</tr>
</tbody>
</table>

Around 48.4% of The Netherlands’ publications in Food and Health in 2005-2011 involve international collaboration, the 7th highest amongst the comparators.

Dutch Food and Health research has a moderate linkage with the industry, producing 6.3% of its publications with the industry. The Netherlands ranked the 5th among comparator countries in this percentage in 2005-2011.

FWCI OF INTERNATIONALLY COLLABORATED PUBLICATIONS

2.48

The FWCI of the Netherlands’ internationally collaborated publications was 2.48 in 2005-2011, higher than its total publications in Food and Health (1.90).
2.2 Background

International collaboration is generally acknowledged as a positive force, driving research impact and prestige. Previous studies have shown how articles with only one affiliation listed on the article have lower FWCI than articles with more than one affiliation listed. The same holds true for countries: the more countries collaborating on an article, the higher its impact.

Figure 7 – Effect of number of collaborating affiliations on FWCI

Figure 8 – Effect of collaboration type on FWCI
2.3 International Collaboration

This section of the report focuses on collaboration across country, most commonly referred to as international collaboration. International collaboration rates are consistently rising. In Nature, Thijsen et al. looked at international collaborations for different countries. Overall, the average collaboration distance increased more or less linearly from 334 kilometres in 1980 to 1,553 km in 2009 implying the irrelevance of international physical borders as a result of the Internet boom.

The Netherlands’ output in Food and Health research was internationally collaborative, as is shown in Figure 9. Around 48.4% of all publications from The Netherlands were co-authored with at least one international colleague. Switzerland had the highest percentage (66.2%) followed by Denmark (64.8%). Japan, China, South Korea and the US had the lowest percentage of internationally collaborated articles. In general among the top 20 most prolific countries, the countries with relatively smaller number of publications (except South Korea) had the highest percentage of internationally collaborated publications.

*Figure 9 – Proportion of articles resulting from international collaboration, 2005-2011.*

---

Internationally co-authored papers have been shown to have a positive effect on citations\(^9\). In Figure 10, the proportion of articles that are internationally co-authored is plotted against the FWCI of these internationally co-authored articles in the same period, 2005-2011.

The FWCI of the Netherlands’ internationally collaborated publications was 2.48, higher than that of the total publications of the Netherlands in Food and Health in the same period (1.90). New Zealand’s internationally collaborated publications had the highest FWCI among the comparators (2.90).

All 20 countries except Japan had FWCs well above the world average of 1 and the world average in Food and Health (1.40), reflecting high quality of internationally collaborated publications.

2.4 Academic-corporate Collaboration

This section of the report focuses on a special type of collaboration that between an academic institution and a corporate organization.

*Figure 11-Academic-corporate collaboration per country, 2005-2011.*

The absolute number of academic-corporate collaborated publications is correlated with the volume of research output. To make this indicator more comparable for the comparator countries, we normalize the number of collaborated publications by the number of total publications for each country. The Netherlands is amongst the leading countries measured by this indicator (Figure 11), ranking the 5th amongst the comparator countries. Around 6.3% of the Netherlands’ publications in Food and Health in 2005-2011 were co-authored with the industry. Switzerland and Finland led comparators in this indicator: 17.8% and 12.4% of their publications in 2005-2011 resulted from collaboration with the industry, respectively.
Figure 12 plots the percentage of cross-sector collaborated publications against FWCI. For all comparators, the FWCI of academic-corporate collaborated publications was above the world average of 1. Brazil had a high FWCI but the number is based on a small number of publications (3) and is likely to be driven by a few highly cited publications. The FWCI of the Netherlands’ publications collaborated with the corporate sector was 3.64 in 2005-2011, well above that of the Netherlands’ total publications in this subject area (1.90).
Appendix A
Methodology

Methodology and rationale
Our methodology is based on the theoretical principles and best practices developed in the field of quantitative science and technology studies, particularly in science and technology indicators research. The Handbook of Quantitative Science and Technology Research: The Use of Publication and Patent Statistics in Studies of S&T Systems (Moed, Glänzel and Schmoch, 2004) gives a good overview of this field and is based on the pioneering work of Derek de Solla Price (1978), Eugene Garfield (1979) and Francis Narin (1976) in the USA, and Christopher Freeman, Ben Martin and John Irvine in the UK (1981, 1987), and in several European institutions including the Centre for Science and Technology Studies at Leiden University, The Netherlands, and the Library of the Academy of Sciences in Budapest, Hungary.

The analyses of bibliometric data in this report are based upon recognised advanced indicators (e.g., the concept of relative citation impact rates). Our base assumption is that such indicators are useful and valid, though imperfect and partial measures, in the sense that their numerical values are determined by research performance and related concepts, but also by other, influencing factors that may cause systematic biases. In the past decade, the field of indicators research has developed a best practices which state how indicator results should be interpreted and which influencing factors should be taken into account. Our methodology builds on these practices.

Article types
For all bibliometric analysis, only the following document types are considered:
- Article (ar)
- Review (re)
- Conference Proceeding (cp)

Counting
All analyses make use of whole counting rather than fractional counting. For example, if a paper has been co-authored by one author from the UK and one author from the Netherlands, then that paper counts towards both the publication count of the UK, as well as the publication count of the Netherlands. Total counts for each country are the unique count of publications.

Data Sources
Scopus was developed by and is owned by Elsevier. It is the largest abstract and citation database of peer reviewed research literature in the world, with abstracts and citation information from more than 50 million scientific research articles in 20,000 peer-reviewed journals published by over 5,000 publishers spanning all science sectors, including the Arts & Humanities. Scopus covers approximately 5900 titles from North-America, 8400 from Europe, 2800 from Asia-Pacific and 800 from Latin-America and Africa. Scopus.com is used by 1,900 customers, with more than 3 million users in 2010. The average click through to full-text rate is 2.1M per month, with over 25.5M in 2010. Scopus currently includes over 50M publications from more than 4000 global publishers. See http://info.scopus.com for more information.

Patent citation data is obtained from LexisNexis which is a member of Reed Elsevier Group plc. LexisNexis Patents include patent data from the United States Patent and Trademark Office (USPTO), the European Patent Office (EPO), the Japanese Patent Office (JPO), the Patent...
Cooperation Treaty (PCT) of the World Intellectual Property Organization (WIPO) and the UK Intellectual Property Office (UKIPO). For this study, data from WIPO has been used.

The full-text article download metrics used in this study are calculated based on the large number of users in ScienceDirect.com downloading daily millions of full-text articles. ScienceDirect is a leading full-text articles and books scientific platform. With an invaluable and incomparable customer base, the use of scientific research on ScienceDirect.com will provide a different look a performance measurement. ScienceDirect is used by more than 12,000 institutions worldwide, with more than 11 million active users and over 700 million full text article downloads in 2012. The average click through to full-text per month is 50 million. ScienceDirect covers over 10,500 books going back as far as 1993.

**Publication output**

The number of publications per country, which have at least one author affiliated to an institution in that country. A publication which is co-authored by authors from different countries, thus counts towards the publication output of each country.

**CAGR: Compound Annual Growth Rate**

The Compound Annual Growth Rate is defined as the year-over-year constant growth rate over a specified period of time. Starting with the first value in any series and applying this rate for each of the time intervals yields the amount in the final value of the series:

\[
CAGR(t_0, t_n) = \left( \frac{V(t_n)}{V(t_0)} \right)^{\frac{1}{t_n - t_0}} - 1
\]

Where \( V(t_0) \) is the starting value, \( V(t_n) \) is the finishing value, and \( t_n - t_0 \) is the number of the years.

**Publication share**

The global share of publications for a specific country expressed as a percentage of the total output within the field of Food and Health. Using a global share in addition to absolute numbers of publications provides insight by normalizing for increases in world publication growth and expansion of the field in question or the whole Scopus database.

**Field-weighted Citation Impact**

Citations accrue to published articles over time, as articles are first read and subsequently cited by other authors in their own published articles. Citation practices, such as the number, type and age of articles cited in the reference list, may also differ by research field. As such, in comparative assessments of research outputs citations must be counted over consistent time windows, and publication and field-specific differences in citation frequencies must be accounted for.

Field-weighted citation impact is an indicator of mean citation impact, and compares the actual number of citations received by an article with the expected number of citations for articles of the same document type (article, review or conference proceeding paper), publication year and subject field. Where the article is classified in two or more subject fields, 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 (reviews typically attract more citations than research articles, for example) 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.

When field-weighted citation impact is used as a snapshot, an unweighted variable window is applied. The field-weighted citation impact value for ‘2008’, for example, is comprised of articles published in 2008 and their field-weighted citation impact in the period 2008-12, while for ‘2012’ it is comprised of articles published in 2012 and their field-weighted citation impact in 2012 alone.
Appendix B
Fingerprints

The following concepts are used to select publications in Food and Health. Publications that contain at least one of the concepts were selected and used to generate the indicators for the analysis.

<table>
<thead>
<tr>
<th>Thesaurus</th>
<th>Concept Id</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>nal</td>
<td>199265</td>
<td>healthy diet</td>
</tr>
<tr>
<td>msh</td>
<td>28531</td>
<td>Health Food</td>
</tr>
<tr>
<td>nal</td>
<td>41763</td>
<td>health foods</td>
</tr>
<tr>
<td>geo</td>
<td>4308</td>
<td>health and nutrition</td>
</tr>
<tr>
<td>msh</td>
<td>4069</td>
<td>Child Nutritional Physiological Phenomena</td>
</tr>
<tr>
<td>msh</td>
<td>11278</td>
<td>Infant Nutritional Physiological Phenomena</td>
</tr>
<tr>
<td>msh</td>
<td>15117</td>
<td>Maternal Nutritional Physiological Phenomena</td>
</tr>
<tr>
<td>msh</td>
<td>15118</td>
<td>Nutritional Physiological Phenomena</td>
</tr>
<tr>
<td>nal</td>
<td>28863</td>
<td>food preparation</td>
</tr>
</tbody>
</table>
References


Authors

This study was commissioned and funded by the Netherlands Enterprise Agency. It was conducted and written by Lei Pan.

DR. LEI PAN

Lei Pan is part of the Analytical Service team at Elsevier, focusing on analysing the research performance and trends for public agencies and academic institutes. She concentrates on the European region for her analytical work at Elsevier and is enthusiastic in serving the needs of clients in general and particularly in Europe. She specializes in combing publication and citation data with macroeconomic data to link research performance to policy and economic development. Most recently she has worked for Ecorys, a European research and consultancy firm. Before that, she was an assistant professor at Wageningen University. Lei holds a PhD in Economics from VU Amsterdam and a Master in Economics from Erasmus University in Rotterdam and Tinbergen Institute.

About

This report has been prepared and published by Elsevier’s Analytical Services, part of the Elsevier Research Intelligence portfolio of products and services which serve research institutions, government agencies, and funders. Whether your institution is conducting research or funding it, Elsevier Research Intelligence provides the objective and analytical insight needed to improve your ability to establish, execute, and evaluate national and institutional research strategy.

For more information about Elsevier Research Intelligence, please visit: elsevier.com/research-intelligence