

IMPACT OF THE NOVO NORDISK FOUNDATION ON PUBLIC RESEARCH

2015





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ABOUT THE IMPACT OF THE NOVO NORDISK FOUNDATION ON PUBLIC RESEARCH

This report measures the Foundation's input of resources to the research community and the subsequent research activities in 2006–2015 and includes bibliometric analyses of how the Foundation affected public research in 2006–2013. Whenever possible, the report compares the performance of the grant recipients with the performance in Denmark and elsewhere.

The report uses such indicators as research funding, the number of doctorate degrees per 1000 population, the proportion of doctorate students from outside the European Union, public–private partnerships and international scientific collaboration and patent applications from the Innovation Union Scoreboard 2015¹ to assess the Foundation's contribution to Denmark's overall research and innovation performance. The Innovation Union Scoreboard 2015 ranks Denmark number 3 in the European Union. The publication uses the Leiden Ranking for assessing scientific impact, such as citation scores. This enables comparison by scientific fields, years and countries.

¹ The Innovation Union Scoreboard is a comparative measuring system of the European Commission assessing innovation performance based on 25 indicators, including human resources (labour force), the research system, funding, investment in research, intellectual assets, innovators and economic effects.

Key Messages

FUNDING AND GRANTS

In 2015, the Foundation allocated 52% of the nearly DKK 1 billion paid out to health science research, 18% to education and dissemination, 14% to biotechnology research and 11% to social and humanitarian causes.

The Foundation paid for 3% of Denmark's public research expenditure in 2014. The amount the Foundation paid out for public research in 2006–2014 increased 11 times more than the increase in total research expenditure in Denmark during the same period (both as proportions of gross domestic product).

Three years after being awarded a grant, half the grant recipients state that they have obtained additional external funding for their project. The grant recipients obtain 0.5–2 times more external funding than the original grant from the Foundation.

GRANT RECIPIENTS

For open-competition grants, 19% of the applicants for funding instruments targeting Denmark's research community receive a grant. For instruments targeting the research community in the Nordic countries as a whole, the Foundation awards grants to 22–26% of the applicants, lowest for applicants from Denmark and highest for applicants from Norway. For all applicants, 20% of men applying receive a grant versus 17% for women. The Foundation awards every third grant to a woman.

The number of PhD programmes in progress wholly or partly supported by the Foundation rose from 51 in 2006 to 400 in 2015. The number of postdoctoral programmes in progress sponsored by the Foundation grew from 53 in 2006 to 440 in 2015.

The total number of established and new research leaders supported by the Foundation has been stable at about 400 during the past 10 years, and the number of new research leaders supported by the Foundation's programmes or research centres increased from 5 in 2006 to 74 in 2015. Further, the average grant for research projects awarded to established research leaders quadrupled from 2009 to 2015.

SCIENTIFIC OUTPUT

In 2015, grant recipients with projects in progress produced 1914 research publications, with 92% being articles in international scientific journals. The number of articles grant

recipients report has grown 8-fold since 2006. The Foundation's grant recipients account for 18% of the scientific articles produced in the health sciences in Denmark in 2012–2014.

RESEARCH COLLABORATION

Six of 10 scientific articles by recipients of grants from the Foundation are co-published with researchers from institutions outside Denmark, and 12% of the scientific articles by recipients of grants from the Foundation are co-published with researchers from industry. Both figures are high in an international context.

SCIENTIFIC IMPACT

In 2006-2013:

- ▶ 4–8% of the scientific articles published by recipients of grants from the Foundation in international journals within microbiology, cell biology, molecular biology, genetics and internal medicine were among the 1% most frequently cited articles globally.
- ▶ 25–35% of the scientific articles published by recipients of grants from the Foundation within molecular biology, genetics and heredity, cell biology, microbiology and multidisciplinary sciences were among the 10% most frequently cited articles globally.

The average impact (mean normalized citation score (MNCS)) of all articles published by recipients of grants from the Foundation in 2013 was more than twice the world average.

The scientific impact of the research centres supported by the Novo Nordisk Foundation is 3.3 times the world average in 2013.

The MNCS for articles published by recipients of grants from the Foundation and prepared in public-private partnerships was almost 4 times the world average in 2013.

KNOWLEDGE SHARING AND INFLUENCE ON POLICY

Of the grant recipients from 2013, 31% reported three years later that the research activity supported by the Foundation has paved the way for at least one knowledge dissemination activity.

APPLICATION OF RESEARCH

Of the grant recipients from 2013, 16% reported three years later that they have applied the knowledge obtained to products, treatments, intellectual property, spin-outs etc.

1.0

INTRODUCTION

Since 1927², the Novo Nordisk Foundation has awarded grants to researchers at universities and hospitals in Denmark and the other Nordic countries to support research in biomedicine, biotechnology, general practice, nursing and art history at public knowledge institutions. The Foundation also supports scientific objectives within innovation, education, dissemination and humanitarian and social purposes. To monitor whether the Foundation continues to award grants for high-quality research and to monitor the impact of the Foundation's grants on research and innovation developments during the past decade, the Foundation measures the impact of and monitors the research activities supported by grants from the Foundation.

The purpose of this report is to provide an overview of how the Foundation's grants contribute to the scientific community and an overview of their impact on developments in research, postgraduate researcher education and innovation. As Foundation awards more grants, the need for this insight increases. It is important to ensure that grants are used for objectives that can strengthen the knowledge society of tomorrow and improve welfare in society optimally.

The Foundation's grant recipients systematically report on activities and findings generated based on their grants. Since 2015, the Foundation has used an online system, researchfish®, which is used by more than 80 foundations funding research based in the United Kingdom and other countries. The data in this report are based on the data registered by the Foundation and the grant recipients combined with international databases and statistics, such as the *Web of Science*.

Grant recipients have publishing freedom and may decide their priorities for their research and how to publish. Researchers and the public knowledge institutions that receive and administer Foundation grants own the results. Since other sources also fund these researchers and knowledge institutions, not all the results included in the report should be ascribed to the Foundation's contribution alone.

The report describes the activities and impact of the Foundation's grants for scientific purposes for 2006–2015. The report distinguishes between input, output and outcome.

1. INPUT: Covers such aspects as money the Foundation pays out for free and independent research, especially at universities and hospitals. The report includes the number of grants and their distribution and the size of the grants. Finally, under input, we report on the effects of the number of postgraduate researchers in education programmes and research leader programmes.

2. OUTPUT: Covers such aspects as published scientific works authored by recipients of grants from the Foundation, dissemination activities and the researchers' patterns of collaboration³ with other organizations and researchers.

3. OUTCOME: Covers such aspects as the scientific citation activity (scientific impact⁴) of grant recipients' publications and commercialization activities: products, inventions, patents and patent applications and spin-outs.

² From 1927 to 1990 as the Nordisk Insulin Foundation, Nordisk Insulinlaboratorium and Novo Foundation. The Novo Nordisk Foundation was created in connection with the merger of Novo Industri A/S and Nordisk Gentofte A/S in 1990.

³ This report defines collaboration as collaboration at the publication level via the affiliations of the authors.

⁴ The scientific impact is measured as the number of citations of research publications in the Web of Science database.

NOVO NORDISK FOUNDATION IN BRIEF

The Novo Nordisk Foundation is an independent Danish foundation with corporate interests whose history dates back to 1922, when Nobel Prize Laureate August Krogh obtained a licence from the Insulin Committee of Toronto to manufacture insulin in Scandinavia. The Foundation's vision is to contribute significantly to research and development that improves the health and welfare of people. The Foundation has the following main objectives as set out in the Articles of Association:

1. to provide a stable basis for the commercial and research activities:
 - > of Novo Nordisk A/S, which is engaged in research in, development, production and sale of pharmaceuticals and related products and services;
 - > of Novozymes A/S, which is engaged in carrying out research in, development of, production of and trade in biological solutions;
 - > of any future public or private limited companies in which the Foundation's subsidiary, Novo A/S, may hold a material equity interest or over which Novo A/S may have material influence, whether through proxy or otherwise;
2. to support physiological, endocrinological, metabolic and other medical research;
3. to contribute to the preservation and operation of Novo Nordisk A/S' research hospital activities; and furthermore
4. to support other scientific as well as humanitarian and social purposes.

In the commercial arena, the Foundation's ambition is that the companies in the Novo Group position themselves as internationally recognized and significant actors and create innovation and world-class business results. This is done through research-based products and services that improve the combating of disease and support the sustainable use of natural resources.

For grants, the Foundation strives to use its independence and flexibility to promote world-class public research at universities and hospitals etc. in Denmark and the other Nordic countries. The Foundation wants to contribute to developing the Nordic region so that it is recognized as an international health science and biotechnology powerhouse. The Foundation believes that world-class research is best carried out through long-term support for the development of knowledge environments.

STRATEGIC OBJECTIVES FOR THE NOVO NORDISK FOUNDATION'S ACTIVITIES

In 2013, the Foundation's Board of Directors adopted a strategy for the amount paid out for grants for 2014–2018 and, in 2015, a financial strategy for the Foundation. The Foundation's strategic objectives for its activities were implemented in 2014. There are two societal goals, three strategic goals for the Foundation's commercial activities and six strategic goals for grant activities.

SOCIETAL GOALS:

With Denmark as the Novo Nordisk Foundation's centre of gravity, the prime focus is:

- ▶ to promote world-class research and innovation in the medical, biotechnological and natural sciences and help to foster a world-class education system
- ▶ to help to develop a knowledge-based society that contributes to long-term economic activity and job creation for improving general health and welfare.

COMMERCIAL GOALS:

- ▶ Be a strong owner of the companies in the Novo Group
- ▶ Generate attractive investment returns for the Foundation on its financial investment portfolio
- ▶ Make investments with the main goal of promoting knowledge and world-class research

GOALS FOR GRANT ACTIVITIES:

- ▶ Strengthen biomedical and biotechnology research in selected fields
- ▶ Fuel cross-disciplinarity
- ▶ Advance individual scientific excellence
- ▶ Spur imagination, inspiration and knowledge about science and technology
- ▶ Build bridges between scientific discoveries and their commercial applications
- ▶ Achieve social and humanitarian impact

2.0

DENMARK'S INTERNATIONAL POSITION IN RESEARCH

Research performance is continually measured internationally. The indicators used in this report adhere to the international standard for reporting investment in public research, the impact of this investment and the performance of researchers and research environments. This enables the Foundation's grants for public research and grant recipients' research results to be compared with other types of investment in public research in Denmark and with the impact of research in Denmark and internationally.

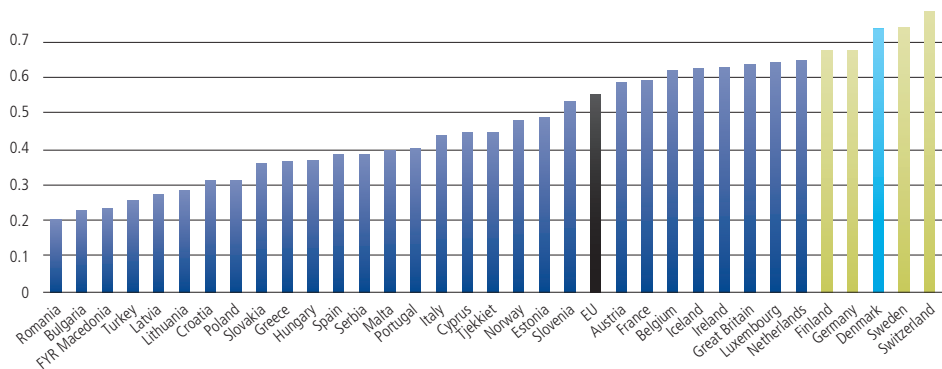
This report uses the Leiden Ranking to assess how the Foundation contributes to scientific impact (such as citation scores). This enables scientific fields, years and countries to be compared. This report uses the Innovation Union Scoreboard 2015⁵, the European Commission's comparative measuring system, for assessing how the Foundation contributes to Denmark's overall research and innovation performance. The indicators used to look at the Foundation's contribution in other areas than the scientific impact include research funding, the number of doctorate degrees per 1000 population, the proportion of doctorate students from outside the European Union, public-private partnerships, international scientific collaboration, patent applications etc. The Innovation Union Scoreboard has been developed to compare European countries' performance in research and innovation based on 25 indicators for input, output and outcome or impact. Half the indicators focus on research and the other half on education and innovation. Overall, Denmark is number 3 in the Innovation Union Scoreboard in 2015 after Switzerland and Sweden but before Finland and Germany. All five countries are classified as innovation leaders (Figure 1, green). Denmark scores especially high on the research and education indicators.

Every year since 2007, except in 2010, Denmark has improved its overall research, education and innovation performance (Figure 2a and 2b), including in relation to the best performers in the EU and the EU average. The EU and the Organisation for Economic Co-operation and Development (OECD) use supplementary indicators to better capture the microeconomic and macroeconomic impact of research and innovation. These are not included here.

⁵Note: The Innovation Union Scoreboard is a method of assessing a country's research and innovation performance by means of 25 indicators, all of which are weighted equally. An indicator varies between 0 and 1: 1 indicates a country's highest score on the indicator and 0 a country's lowest score on the indicator compared with all countries in the Innovation Union Scoreboard. Indicators include human resources (labour force), the research system, funding, investment in research, intellectual assets, innovators and economic effects. The data are based on figures published by Eurostat. There may be minor deviations in relation to the national publication of data, since the data delivered to Eurostat comprise fewer lines than the national publication.

Note: The average score of the 25 indicators determines the overall score. Denmark's performance score for research and innovation is more than 20% higher than the average performance score for the 28 EU countries. In all dimensions, Denmark scores higher than the EU average. Denmark performs especially well in entrepreneurship, research systems, including citations of articles and public-private and industrial research partnerships, education, research funding and venture capital and intellectual assets. To improve comparison between countries, the statistics are compiled as a percentage of gross domestic product (GDP) or per capita.

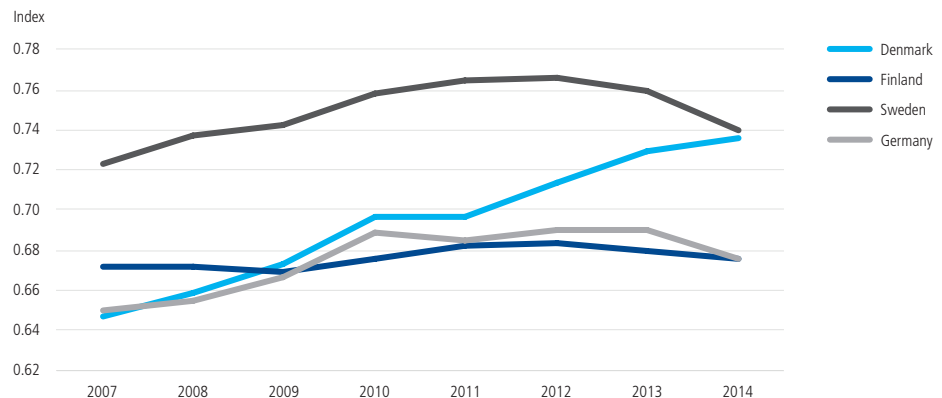
FIGURE 1: INNOVATION UNION SCOREBOARD FOR EUROPE



⁶⁾ The Foundation's grants affect especially the following nine Innovation Union Scoreboard indicators: (1) the number of doctorate degrees per 1000 population, (2) the proportion of doctorate students from countries outside the European Union (EU), (3) the proportion of scientific publications among the top 10% most cited publications worldwide, (4) international scientific co-publications per million population, (5) public-private co-publications per million population and (6) research and development expenditure in the public sector as a percentage of GDP. In addition, the Foundation's grants indirectly affect: (7) patent applications, (8) patent applications in societal challenges and (9) venture capital investment as a percentage of GDP.

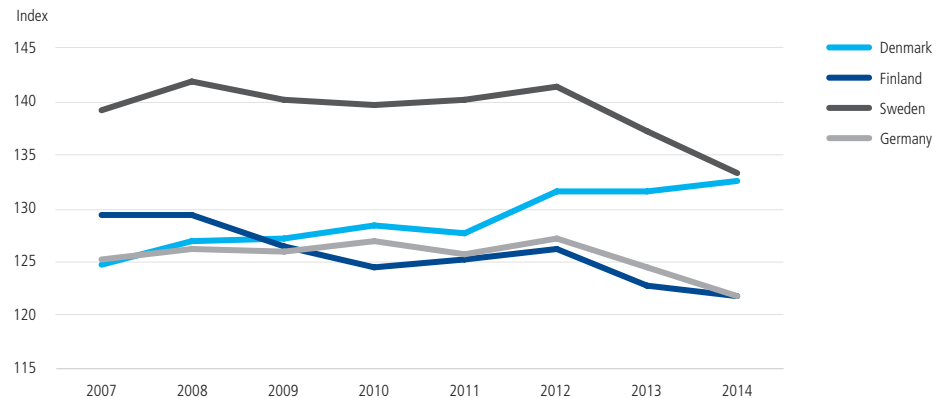
The Foundation's grants are expected to affect the Innovation Union Scoreboard indicators under input (funding and human resources), output (publications and scientific collaboration) and outcome (citation scores, patents etc.)⁶. The following sections demonstrate that the effect the Foundation's grant recipients have on public research through the Foundation's grant policy positively contributes to improving Denmark's research performance in the Innovation Union Scoreboard. Among the innovation leaders in the Innovation Union Scoreboard 2015, only Denmark has maintained improvement in performance. In the EU, Sweden has the highest score for the entire period 2007–2014, but Denmark has managed to catch up with Sweden.

FIGURE 2a: INNOVATION SCORE FOR DENMARK, FINLAND, GERMANY AND SWEDEN, 2007–2014



Note: Source: Innovation Union Scoreboard 2015.

FIGURE 2b: INNOVATION SCORE FOR DENMARK, FINLAND, GERMANY AND SWEDEN RELATIVE TO THE AVERAGE EU SCORE, 2007–2014 (EU=100)



3.0

TRENDS IN PUBLIC INVESTMENT IN RESEARCH IN DENMARK

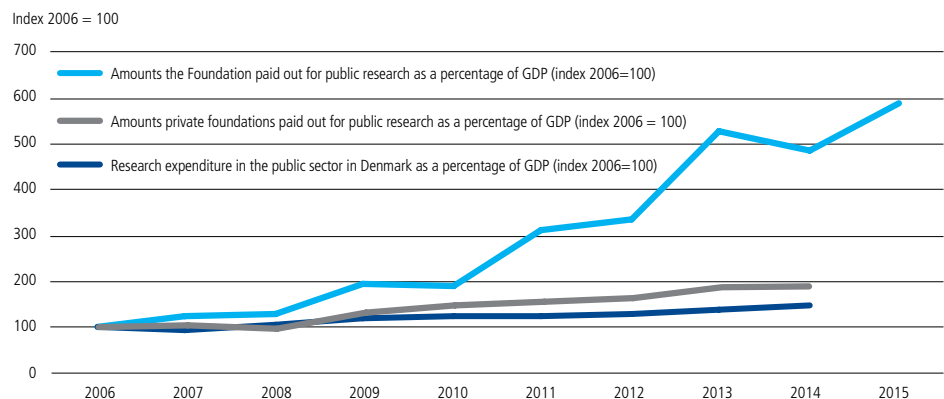
The total investment in public research as a proportion of GDP in Denmark was stable in 1998–2007 at about 0.74% of GDP. Since 2008, the share has grown significantly and reached 1.15% of GDP in 2014 (Table 1). In 1998–2006, the Foundation’s grants rose from 0.001% to 0.008% of GDP. In 2015, the amount the Foundation paid out for public research reached 0.046% of GDP, which contributes to lifting Denmark in the Innovation Union Scoreboard 2015, since research and development expenditure in the public sector as a percentage of GDP is a key Innovation Union Scoreboard indicator.

TABLE 1. RESEARCH EXPENDITURE IN THE PUBLIC SECTOR IN DENMARK AND THE AMOUNTS THE FOUNDATION PAID OUT AS A PERCENTAGE OF GDP, 2006–2015

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Research expenditure in the public sector in Denmark as a percentage of GDP	0.79	0.74	0.82	0.93	0.97	0.99	1.03	1.10	1.15	not yet known
Amounts the Foundation paid out for public research as a percentage of GDP	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.04	0.04	0.05
Amounts private foundations paid out for public research as a percentage of GDP	0.06	0.07	0.06	0.08	0.09	0.10	0.10	0.12	0.12	not yet known

Figure 3 shows that the amounts the Foundation paid out for public research as a percentage of GDP increased by 491% from 2006 to 2015, nearly six times higher. During the same period, total research expenditure in the public sector as a percentage of GDP rose by just under half (46%).

FIGURE 3: RESEARCH EXPENDITURE IN THE PUBLIC SECTOR IN DENMARK AS A PERCENTAGE OF GDP, 2006–2015



The annual amount the Foundation paid out for public research rose from about DKK 30 million in the early 1990s to nearly DKK 1 billion in 2015. In 2016, the Foundation's ambition is to pay out DKK 2 billion, most of which is expected to be allocated to research.

In 2014, the private foundations in Denmark paid out DKK 2.4 billion for research in the public sector, corresponding to nearly 10% of the total research expenditure in the public sector, which was DKK 22.4 billion in 2014 (Figure 5). The amounts the Foundation paid out accounted for about 30% of the DKK 2.4 billion. The continued growth in the amounts paid out by all private foundations means that the foundations are increasingly contributing to funding research in the public sector in Denmark both in nominal terms and as a percentage of GDP (Figure 3).

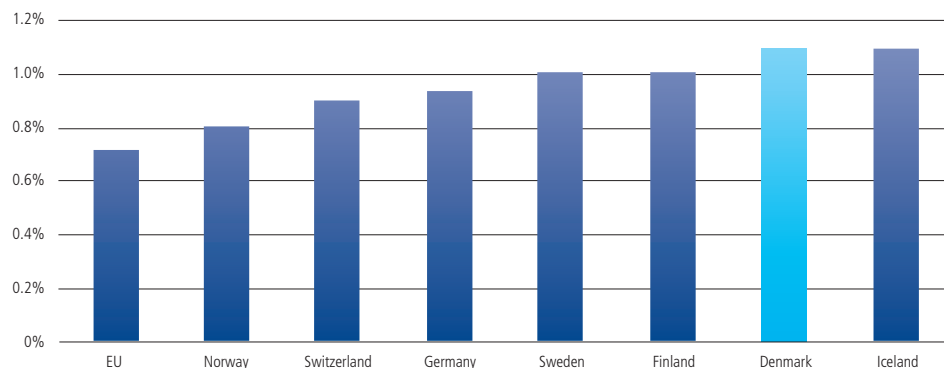
Denmark and Iceland lead in research expenditure in the public sector as a percentage of GDP. In the latest comparable data from 2013, Denmark and Iceland invested 1.1% of GDP in research in the public sector. In Denmark, private foundations paid 0.12 percentage points, and without this, Denmark would have ended up investing less than 1% of GDP in research in the public sector (Table 1).

Denmark's funding of research in the public sector differs from that of other European countries. Private foundations contribute nearly one tenth of the total investments in research in the public sector, whereas the percentage in other countries is less than 2%. However, private companies in Denmark contribute least to funding research in public-sector research institutions (Figure 5).

The European Commission has compared European countries in the total funding from private foundations for research in both the public sector and private organizations. The calculation is based on figures for 2012; more recent figures are not available. Private foundations in the United Kingdom fund the most research in nominal terms. Germany follows in second place and Denmark in third place (Table 2). In the amounts paid out per capita for research, Denmark's private foundations are number 1 in Europe in 2012, funding €79 of research per capita. By comparison, the Foundation funded €12 of research per capita in 2012, which was almost twice the overall amount paid out per capita by Germany's private foundations in 2012.

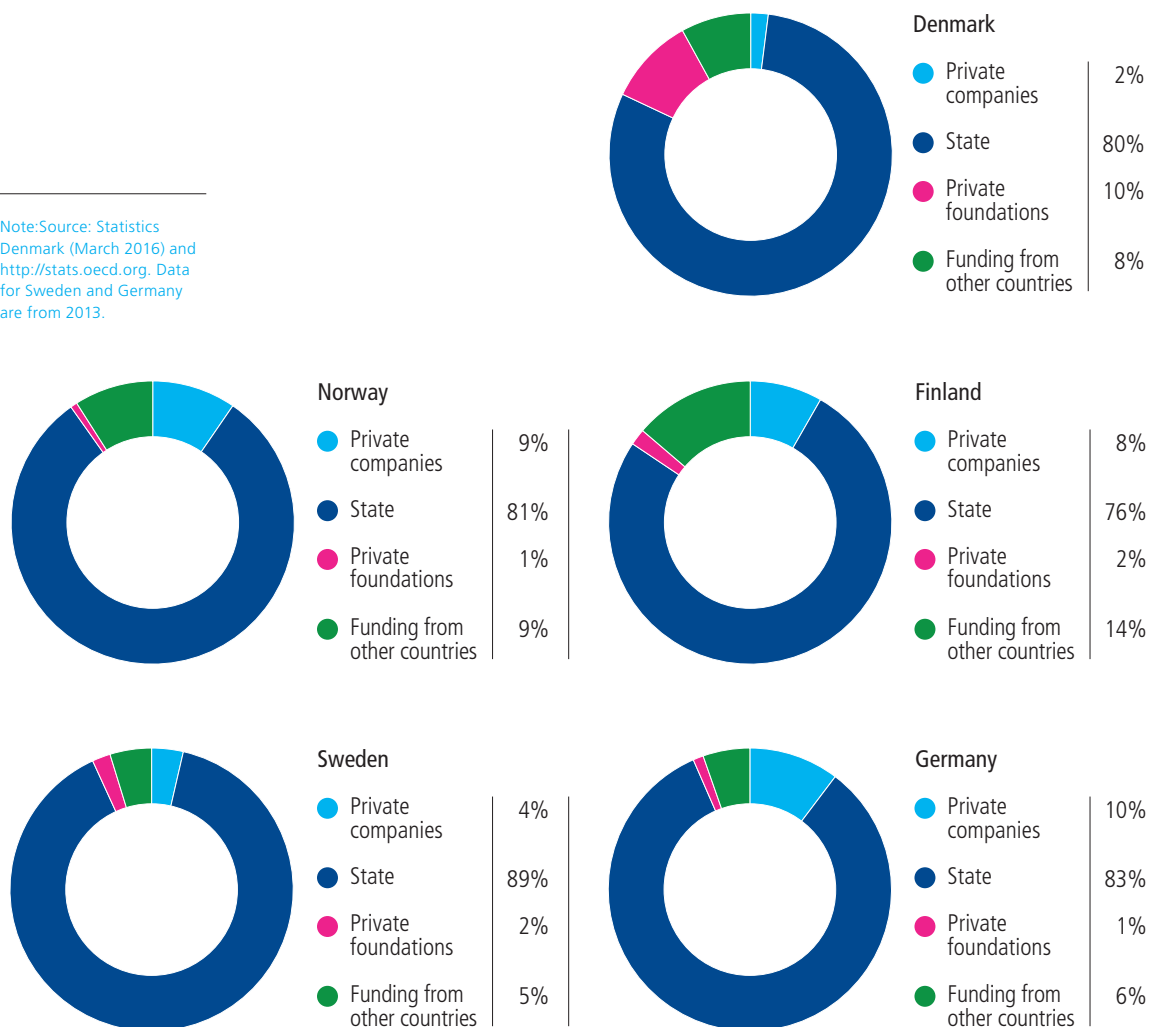
Note: Source: Innovation and research 2016, Statistics Denmark. Comparable data for 2014 are not yet available. The figure shows the seven countries in Europe with the highest research expenditure in the public sector as a percentage of GDP.

FIGURE 4: RESEARCH EXPENDITURE IN THE PUBLIC SECTOR AS A PERCENTAGE OF GDP IN 2013, SELECTED EUROPEAN COUNTRIES AND THE EU AVERAGE



FIGUR 5: EXPENDITURE FOR RESEARCH IN THE PUBLIC SECTOR BY FUNDING SOURCE IN FIVE EUROPEAN COUNTRIES

Note: Source: Statistics Denmark (March 2016) and <http://stats.oecd.org>. Data for Sweden and Germany are from 2013.



Note: Source: EUFORI Study 2014, European Commission (2014). More recent data than for 2012 are not available. 7 out of 66 MEUR were awarded to other Nordic countries than Denmark.

TABLE 2: FUNDING OF PUBLIC AND PRIVATE RESEARCH EXPENDITURE BY PRIVATE FOUNDATIONS IN 2012 IN THE FOUR EUROPEAN COUNTRIES IN WHICH PRIVATE FOUNDATIONS FUND THE MOST RESEARCH

Countries	Research Awards (MEUR)	Research awards per capita (EUR)
Great Britain	1662.5	26
Germany	581.1	7
Denmark (Novo Nordisk Foundation)	441.8 (66)	79 (12)
Sweden	436.7	46

4.0

THE NOVO NORDISK FOUNDATION'S POLICY ON GRANTS

Since 1927, when the Novo Nordisk Foundation began to award grants for research, the Foundation has supported research at public institutions in Denmark and the other Nordic countries. Grants have especially been awarded within physiology, endocrinology, metabolism, general practice, nursing and other scientific fields (biotechnology, interdisciplinary research, education and art history). In addition, the Foundation has supported innovation and humanitarian and social causes. The size of the Foundation's grants, the numbers of grants and the policy on awarding grants have developed markedly since the Foundation started.

The Board of Directors of the Foundation provides grants in two ways. One way is to award grants in open competition based on the Board's decisions on the selection of instruments and on budgets and based on the applications submitted after calls for applications within thematic fields. The other way is that the Board chooses to initiate or support one-off initiatives without calls for applications in accordance with the Foundation's purposes.

Both types of grants are typically assessed by peers in the committees established by the Board and/or by a panel of international experts in the scientific field. Members of the Foundation's committees are internationally recognized scientific experts with strong qualifications for assessing the quality, feasibility, novelty and potential of the proposed projects and the applicants' qualifications.

For administrative purposes, the Foundation divides applications and grants into four categories:

- ▶ Research and innovation grants awarded based on open competition within medical research and other scientific fields such as biotechnology, innovation, nursing research and art history.
- ▶ Strategic grants: research centres and stand-alone grants for research, education, dissemination, innovation, social objectives, etc.
- ▶ Steno grants: the Foundation supports the research hospital Steno Diabetes Center
- ▶ Humanitarian and social purposes: in particular, the Foundation has supported humanitarian and social aid organizations.

THE NOVO NORDISK FOUNDATION'S GRANT AREAS

RESEARCH AND INNOVATION GRANTS

Innovation
Investigator grants
Postdoctoral fellowships
Prizes and symposia
Programmes
Projects
Scholar and PhD scholarships

STRATEGIC AWARDS

Research centres
Stand-alone grants
Education and outreach
One-off grants

HUMANITARIAN AND SOCIAL GRANTS

Stand-alone grants
Research and education projects
Assistance projects

STENO GRANTS

Steno Diabetes Center
Projects

5.0

THE NOVO NORDISK FOUNDATION'S GRANT AREAS

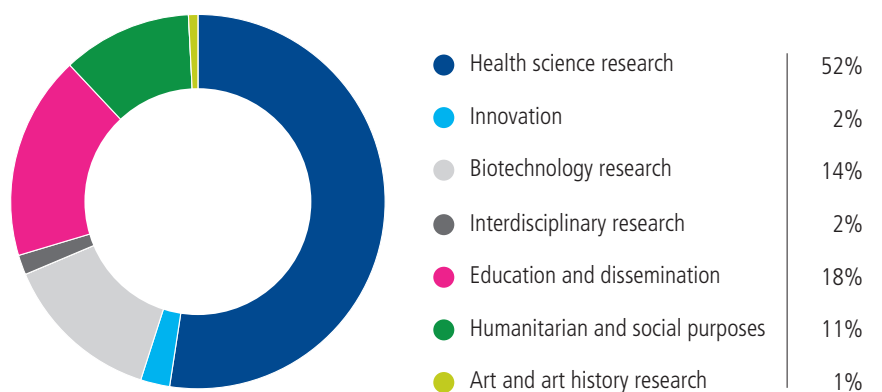
The Foundation strives to contribute to creating, maintaining and developing strong research and education environments at universities and hospitals in Denmark and the rest of the Nordic countries. Talented researchers and graduates from Denmark and other countries are the employees of the future in the private sector and the public sector. The Foundation therefore supports initiatives that can strengthen research-based education, bolster the supply of talented university graduates and researchers and attract talented researchers and graduates from outside Denmark. Finally, the Foundation wants to use the grants to contribute to improving health, preventing disease, diagnosis and treatment.

More than half the Foundation's grants are allocated to health science research in the public sector (Figure 6), 18% funds education and dissemination initiatives, 14% biotechnology research and 11% humanitarian and social purposes (including the Steno Diabetes Center). The Foundation provides broad support in the health sciences, with special focus on endocrinology, metabolism, molecular biology and cell biology.

The Foundation's grants are especially awarded to public sector institutions such as universities and hospitals. The Foundation's share of the budgets of the recipient institutions varies, in some cases accounting for more than 10% of their budgets.

Note: The distribution by award area for 2015 has been calculated by adding up the amounts the Foundation paid out. In 2015, these totalled DKK 914 million.

FIGURE 6:
FOUNDATION PAYOUTS (%) BY MAIN CATEGORIES OF OBJECTIVES, 2015



6.0

TOTAL AMOUNTS PAID OUT AND AWARDED FOR SCIENCE

Since the Foundation began, it has funded more than 11,000 small and large research projects. Researchers and their knowledge institutions have received about DKK 10 billion. During the past 10 years alone, the Foundation has awarded grants totalling DKK 8 billion to research in the public sector and the Foundation's other purposes.

6.1

TRENDS IN THE TOTAL ANNUAL AMOUNT PAID OUT

In 2015, the Foundation paid out DKK 914 million, the highest in the Foundation's history. This was an increase from DKK 733 million paid out in 2014. Both total annual grants and the amounts paid out have risen gradually year by year (Figures 7 and 8).

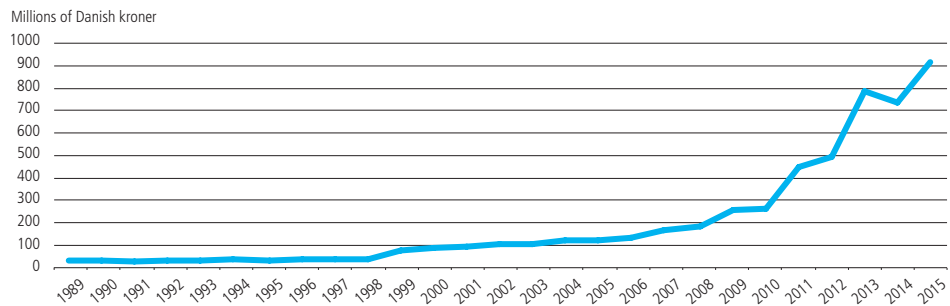
6.2

TRENDS IN THE TOTAL ANNUAL VALUE OF GRANTS

Figure 8 shows large annual fluctuation in the total annual value of the grants awarded, since large strategic awards, including establishing the research centres supported by the Novo Nordisk Foundation in 2007 and 2010, meant a large total value of grants awarded in these years. Since grants for the research centres last 10 years, the amounts paid out by the Foundation are more evenly distributed and therefore staggered in relation to the time the grants were awarded. The total value of the grants awarded in 2015 was DKK 1.158 billion.

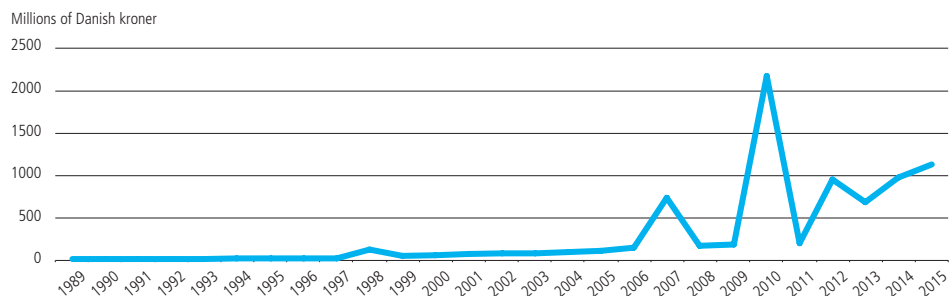
Note: The figure shows the gross payments.

FIGURE 7: ANNUAL AMOUNTS PAID OUT BY THE FOUNDATION, 1989–2015



Note: The figure shows the gross payments.

FIGURE 8: TOTAL ANNUAL VALUE OF THE GRANTS AWARDED BY THE FOUNDATION, 1989–2015



7.0

TRENDS IN THE NUMBER OF GRANTS AND GRANT SIZE AWARDED IN OPEN COMPETITION

7.1

SCIENTIFIC GRANTS AND AVERAGE GRANT SIZE

Until the turn of the millennium, the Foundation awarded many small, short-term grants. Since 1998, the number of grants has been reduced. Conversely, the average grant size and the grant period of the individual research grant have increased (Figures 9–11).

The background for this trend is the strategic decision of the Board of Directors to initiate large, long-term and more targeted projects in selected scientific fields, such as metabolism, stem cells and bio-based technologies. In recent years, several major research programmes have been created in addition to the research centre cluster. In 2012, the Foundation established the Laureate Research Grant (7-year grants), in 2014, the Challenge Programme (6-year grants) and the Interdisciplinary Synergy Programme (4-year grants) and, in 2015, the Young Investigator Award (6-year grants).

The Foundation's awarded the first major strategic stand-alone grant in 1998 of DKK 100 million, to a Nordic research consortium that operated in 1998–2009. Since 2007, the Foundation has awarded grants totalling DKK 3.7 billion for establishing a cluster of four research centres at universities in Denmark and a Danish national biobank. The Foundation plans to award further large strategic grants in the coming years and to strengthen collaboration between the research centres and between the centres and the rest of the world.

The average grant size for research projects that have received grants in open competition⁷ has increased from about DKK 40,000 in 1991 to DKK 1.2 million in 2015 (Figure 10): increasing by a factor of 30 in 25 years. The main reason for the increase in grant size is the Foundation awarding grants for longer-term projects and scholarships (Figure 10). In addition, the Foundation has increased the number of major research programmes with longer duration and larger volume⁸.

⁷ The following Foundation committees award grants for research projects: the Nordic Research Committee, the Committee on Medical and Natural Sciences Research, the Committee on Nursing Research, Committee on Art History Research and the Committee on Biotechnology-based Synthesis and Production Research.

⁸ The following programmes are included in the data: advanced grants, Excellence Project, Hallas-Møller Scholarship, Clinical Research Fellowship, Laureate Research Grant, Challenge Programme, Interdisciplinary Synergy Programme and Tandem Programme.

FIGURE 9: NUMBER OF FOUNDATION GRANTS AWARDED IN OPEN COMPETITION, 1960–2015

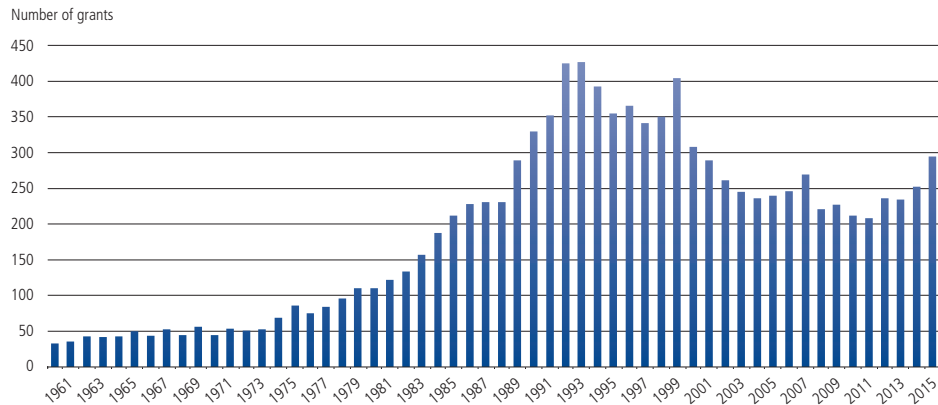


FIGURE 10: AVERAGE SIZE OF FOUNDATION GRANTS FOR RESEARCH PROGRAMMES (LEFT VERTICAL AXIS) AND RESEARCH PROJECTS (RIGHT VERTICAL AXIS), 1989–2015

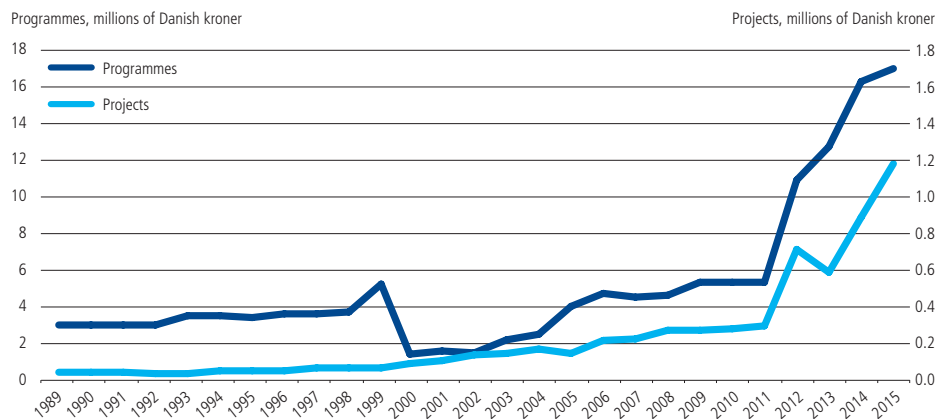
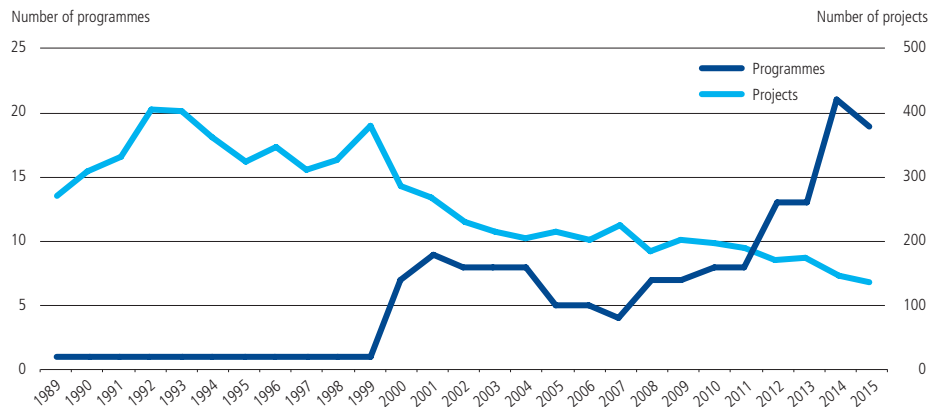


FIGURE 11: NUMBER OF FOUNDATION GRANTS FOR RESEARCH PROGRAMMES (LEFT VERTICAL AXIS) AND RESEARCH PROJECTS (RIGHT VERTICAL AXIS), 1989–2015



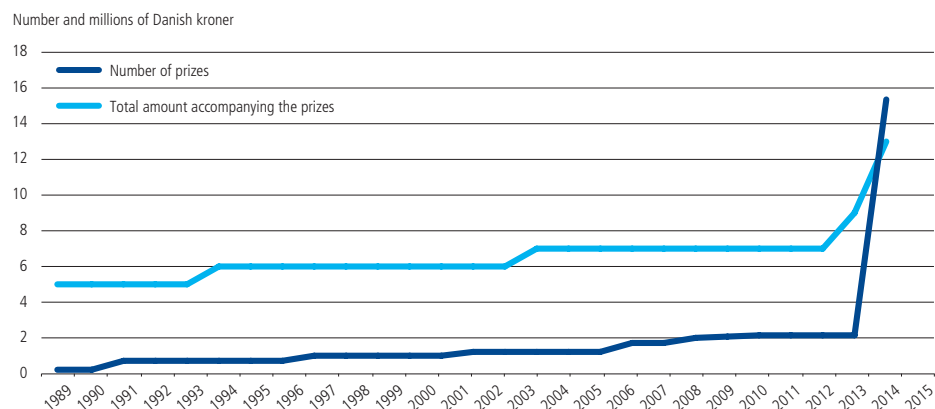
7.2

SCIENTIFIC PRIZES

Figure 12 shows the number of honorary prizes awarded by the Foundation. The Foundation awarded six prizes in the early 1990s accompanied by about DKK 200,000⁹ per year, today, 13 prizes are awarded annually, accompanied by nearly DKK 16 million per year. The Novo Nordisk Prize (DKK 3 million), the Novozymes Prize (DKK 3 million) and the EASD–Novo Nordisk Foundation Diabetes Prize for Excellence (DKK 7 million) account for most of the total money accompanying the prizes.

Note: Figure 12 includes the following prizes: Novo Nordisk Prize, Jacobæus Prize, Marie and August Krogh Prize, Novo Nordisk Foundation Lecture, Hagedorn Prize, August Krogh Distinguished Lectureship (from 1994), Bodil M. Schmidt-Nielsen Distinguished Mentor and Scientist Award (from 2004), two Novo Nordisk Foundation Prizes for Upper-Secondary School-teachers (from 2014), EASD–Novo Nordisk Foundation Diabetes Prize for Excellence (from 2015), two Novo Nordisk Foundation Science Teacher Prizes (from 2015) and the Novozymes Prize (from 2015).

FIGURE 12: NUMBER OF PRIZES AND TOTAL ACCOMPANYING MONEY AWARDED BY THE FOUNDATION, 1989–2015



⁹ Only the Novo Nordisk Prize was associated with an accompanying payment. The other five were exclusively honorary awards in the early 1990s.

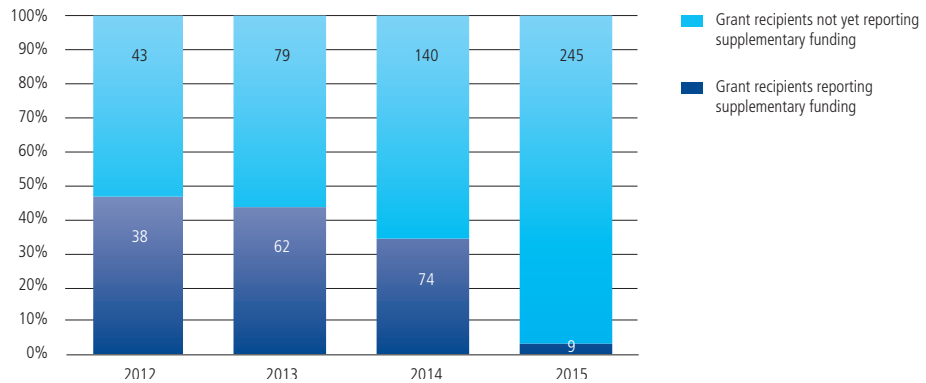
8.0

SUPPLEMENTARY FUNDING OBTAINED BY RECIPIENTS OF GRANTS

When a foundation awards a grant to researchers, the researchers often obtain supplementary funding from other public sources or private foundations. For recipients of Foundation grants awarded in open competition, 35–47% reported subsequently receiving supplementary funding from other sources for their project (Figure 13). Three years after the grant was awarded, almost half the grant recipients state that they have obtained supplementary funding for the project.

Note: Recipients of grants from the Foundation reporting supplementary funding reported an average of 2.2 sources of supplementary funding.

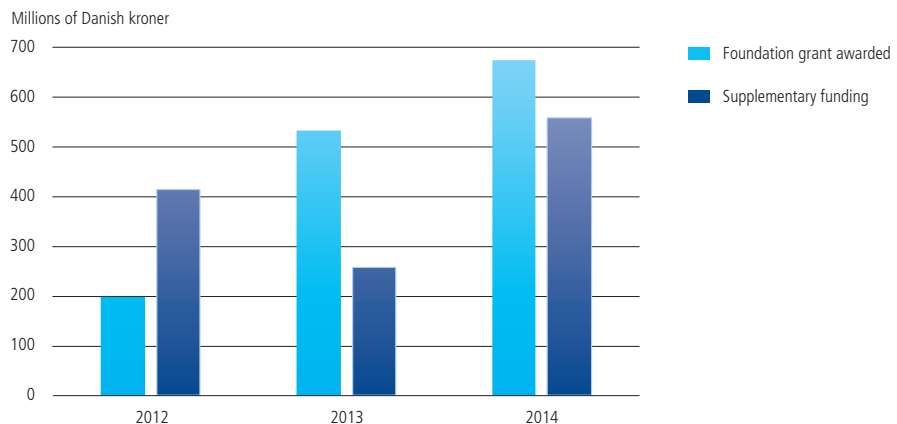
FIGURE 13: PERCENTAGE OF RECIPIENTS OF GRANTS FROM THE FOUNDATION REPORTING SUPPLEMENTARY FUNDING FOR THE PROJECT



In the first 2–4 years after the Foundation awards a grant, grant recipients report receiving supplementary funding estimated to be 0.5–2.0 more than the original Foundation grant (Figure 14).

Note: The data set covers recipients of grants from the Foundation in open competition who have reported further grants from other funding sources. Supplementary financing is indicated as single lump sum in the year of the original grant from the Novo Nordisk Foundation. There is no requirement for external funding.

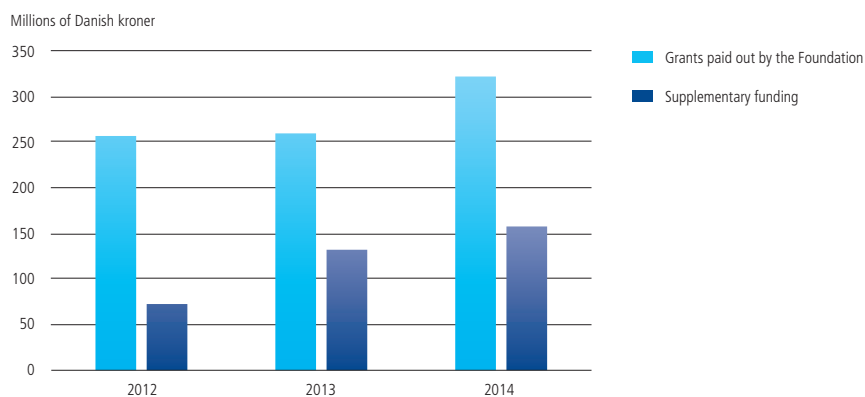
FIGURE 14: SUPPLEMENTARY FUNDING FOR RECIPIENTS OF FOUNDATION GRANTS IN OPEN COMPETITION, 2012–2014



The four research centres also obtain supplementary funding – although to a lesser extent than the recipients of grants in open competition (Figure 15). The research centres obtain supplementary funding equivalent to 25–50% of the annual amount paid out by the Foundation.

Note: Since 2007, the Foundation has awarded DKK 3.7 billion for establishing four large research centres and the Danish National Biobank in Greater Copenhagen. The grants extend over at least 10 years. External financing is indicated as single lump sum in the year of the supplementary grant was awarded. There is no requirement for external funding.

FIGURE 15: SUPPLEMENTARY FUNDING OBTAINED BY THE RESEARCH CENTRES SUPPORTED BY THE NOVO NORDISK FOUNDATION, 2012–2014



9.0

OPEN-COMPETITION SCIENTIFIC GRANTS

The number of grant recipients has grown as the Foundation has increased the total value of its grants. This chapter shows selected characteristics of the grant recipients, including sex, geography, training of researchers, etc. The Foundation receives about 2000 applications annually for scientific purposes in research, innovation and education and for humanitarian and social purposes. A large majority of applications are submitted based on calls for applications in open competition.

9.1

GEOGRAPHICAL DISTRIBUTION OF GRANT RECIPIENTS FOR INSTRUMENTS

For grants awarded in open competition based on instruments solely targeting Denmark's research community, the Foundation awarded grants to 19% of the applicants in 2013–2015 (Figure 16). Nevertheless, this varies geographically. The percentages of applicants awarded grants in Denmark's five administrative regions ranged from 9.1% to 20.0% for 2013–2015. The North Denmark Region received the fewest grants, substantially below the national average. The percentage for Central Denmark Region was slightly above the average and the combined Region Zealand and Capital Region of Denmark marginally above the national average.

For instruments aimed at the research community in the Nordic countries as a whole, the Foundation awarded grants to 22–26% of the applicants in 2013–2015. The percentages were lowest for applicants from Denmark and highest for applicants from Norway (Figure 17). Iceland is not shown as only one application has been received. Grants for the research community in the Nordic countries are awarded primarily through the Nordic Research Committee, the Committee on Exploratory Pre-seed Grants and the Committee on Biotechnology-based Synthesis and Production Research.

FIGURE 16: PERCENTAGE OF APPLICANTS AWARDED OPEN-COMPETITION GRANTS BY THE FOUNDATION BASED ON DENMARK-ORIENTED INSTRUMENTS ACCORDING TO THE ADMINISTRATIVE REGION OF THEIR HOST INSTITUTION, 2013–2015

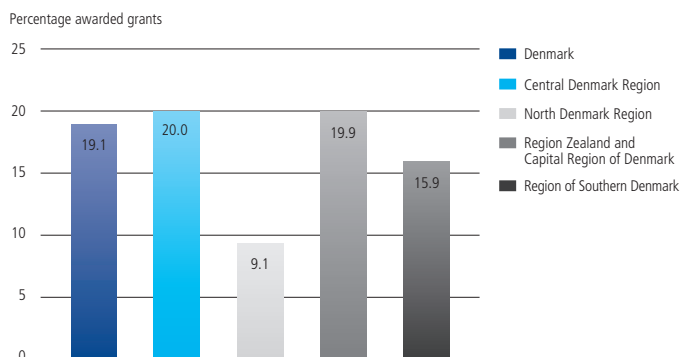
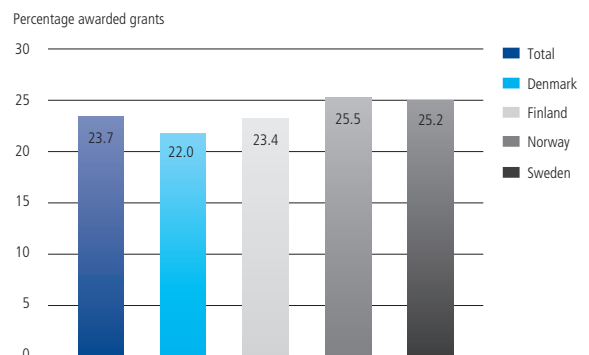


FIGURE 17: PERCENTAGE OF APPLICANTS AWARDED OPEN-COMPETITION GRANTS BY THE FOUNDATION BASED ON INSTRUMENTS AIMED AT THE RESEARCH COMMUNITY IN THE NORDIC COUNTRIES AS A WHOLE ACCORDING TO THE COUNTRY OF THEIR HOST INSTITUTION, 2013–2015



9.2

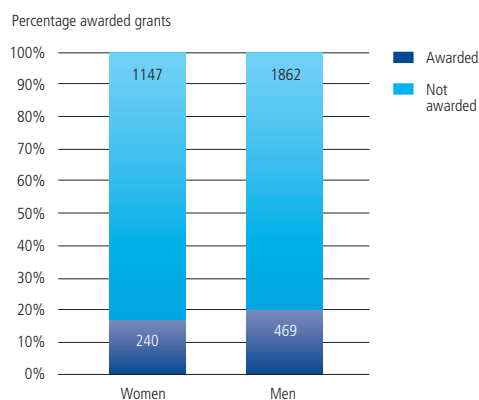
SEX AND AGE DISTRIBUTION OF GRANT RECIPIENTS

The percentages of men and women applicants awarded Foundation grants in 2013–2015 were close to identical (20% for men and 17% for women). Since fewer women than men applied for grants, this means that about one third of the grant recipients are women (Figure 18).

The percentage of applicants awarded grants in 2013–2015 increases with age for applicants aged between 20 (9%) and 69 years (24%) (Figure 19) but falls sharply for applicants older than 70 years. The Foundation awards 88% of the grants to applicants 30–59 years old.

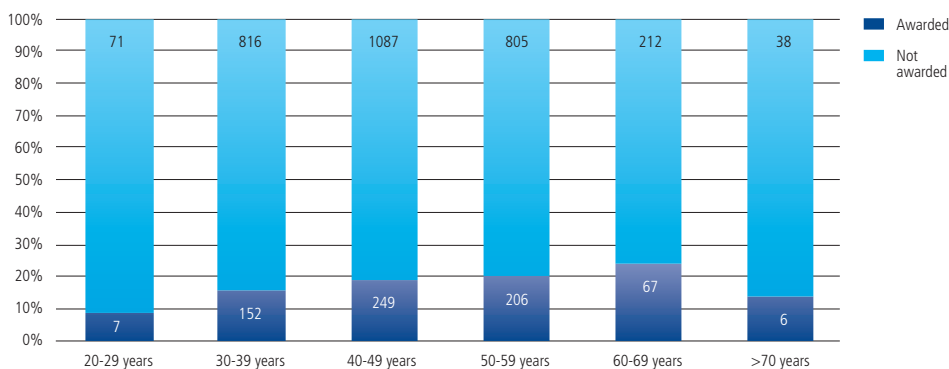
Note: Based on the 3718 applications from 2013–2015 stating the sex of the applicant. 1387 women and 2331 men had applied.

FIGURE 18. PERCENTAGE OF APPLICANTS AWARDED OPEN-COMPETITION GRANTS BY THE FOUNDATION ACCORDING TO SEX, 2013–2015



Note: Based on the 3716 applications for grants in 2013–2015 stating the applicant's age.

FIGURE 19. PERCENTAGE OF APPLICANTS AWARDED OPEN-COMPETITION GRANTS BY THE FOUNDATION ACCORDING TO AGE GROUP, 2013–2015



10.0

SCIENTIFIC PERSONNEL FUNDED BY THE NOVO NORDISK FOUNDATION

The Foundation strives to promote the development of talented researchers, strengthen the opportunities for research careers and recruit new research leaders. The Foundation achieves this by supporting researcher education, researcher training and research leadership.

To promote researcher education and training, the Foundation awards PhD scholarships and postdoctoral fellowships and awards grants for PhD programmes and postdoctoral projects through grants for research programmes, research projects, research centres and stand-alone grants. To recruit new research leaders and support existing research leaders, the Foundation awards grants for research projects, research programmes and research centres.

This chapter explores the trends in the number of scientific personnel at public research institutions employed based on Foundation grants. The statistics are based on the data reported to the Foundation. Personnel at the research centres supported by the Novo Nordisk Foundation may also be employed based on supplementary funding from other sources than the Foundation.

10.1

PHD PROGRAMMES

Figure 20 shows the trends in the number of PhD programmes in progress for 2006–2015 funded by Foundation grants. The number increased from 51 in 2006 to 400 in 2015. PhD programmes in progress may be wholly or partly funded by Foundation grants.

Note: The data include PhD programmes wholly or partly funded by the Foundation.

FIGURE 20: NUMBER OF PHD PROGRAMMES FUNDED BY FOUNDATION GRANTS, 2006–2015

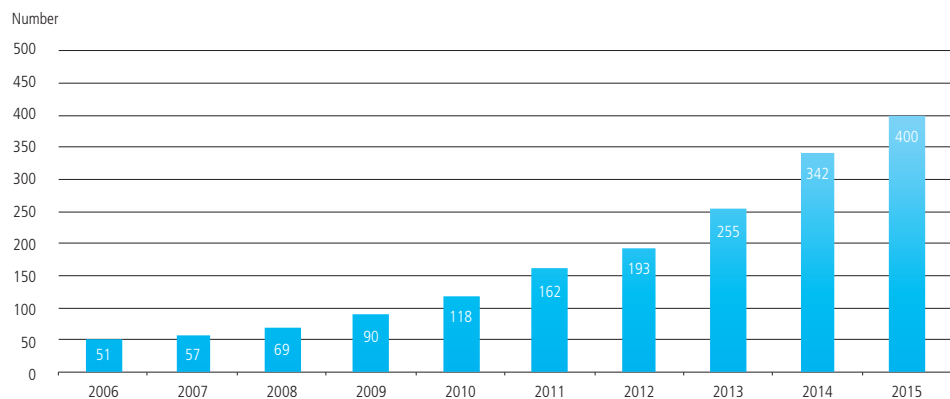
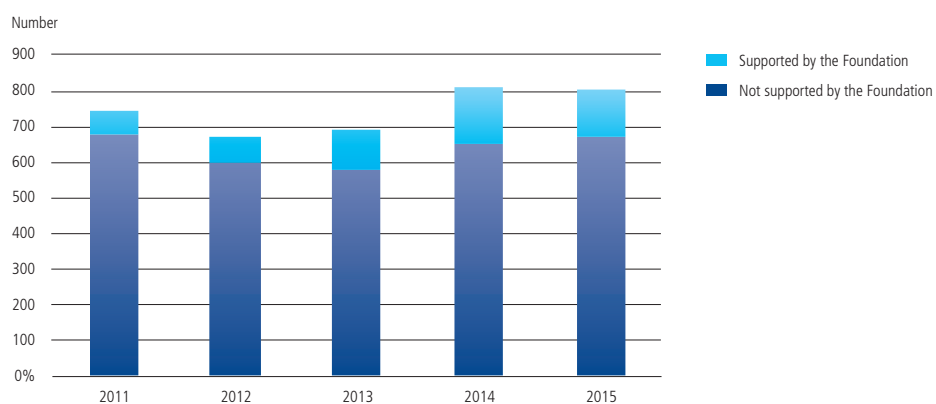


Figure 21 shows that the number of new PhD programmes in the health sciences in Denmark was 800 in 2015, of which 133 are supported by the Foundation.

Note: Source: Statistics Denmark, and own data

FIGURE 21: NUMBER OF NEW PHD PROGRAMMES IN THE HEALTH SCIENCES IN DENMARK, 2011–2015



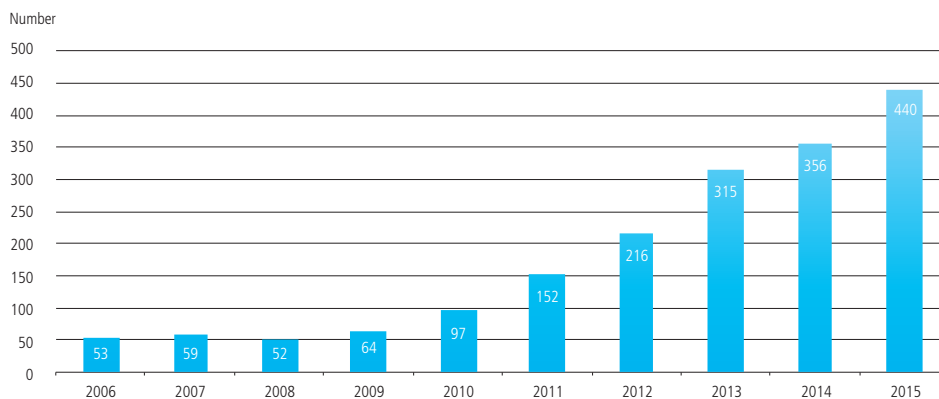
10.2

POSTDOCTORAL FELLOWSHIPS

Figure 22 shows the trend in the number of postdoctoral programmes in progress (lasting 1–4 years) wholly or partly funded by the Foundation for 2006–2015. The number has increased over 10 years, from 53 in 2006 to 440 in 2015.

Note: The data include postdoctoral projects wholly or partly funded by the Foundation

FIGURE 22: NUMBER OF POSTDOCTORAL PROGRAMMES IN PROGRESS WHOLLY OR PARTLY FUNDED BY THE FOUNDATION, 2006–2015



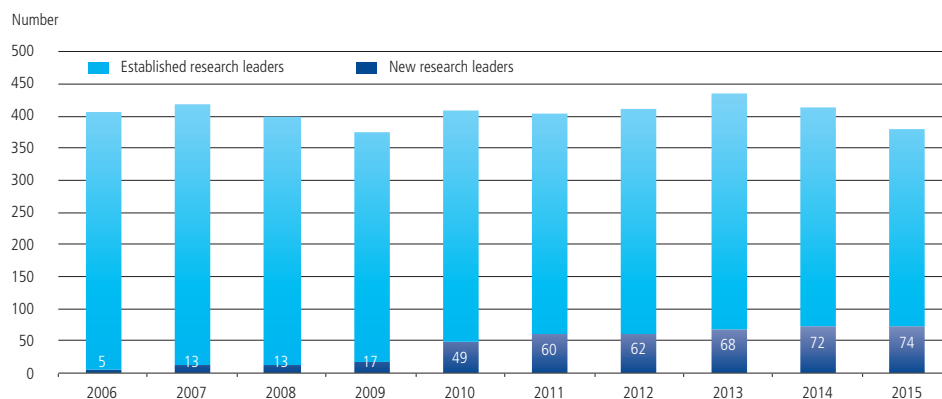
10.3

RESEARCH LEADERS

Figure 23 shows the trend in the number of research leaders supported by the Foundation. Although the total number of research leaders receiving Foundation grants (including established principal investigators who receive project funding) has been relatively stable, the number of new research leaders (young principal investigators and newly recruited principal investigators) supported by the Foundation's major research programmes and research centres has increased in recent years. The increase from 2009 to 2011 especially resulted from the establishment of the Foundation's four research centres.

Note: The category of new research leaders includes those supported by the Foundation through research programmes and centres. Research programmes include Laureate Grants, the Challenge Programme, Hallas-Møller Scholarships and the Interdisciplinary Synergy Programme. The category of established research leaders supported by the Foundation includes project funding from the Committee on Medical and Natural Sciences Research, Nordic Research Committee, Committee on Biotechnology-based Synthesis and Production Research, Committee on Exploratory Pre-seed Grants, Committee on Art History Research and Committee on Nursing Research.

FIGURE 23: NUMBER OF RESEARCH LEADERS RECEIVING FOUNDATION GRANTS, 2006–2015



10.4

PERSONNEL IN THE RESEARCH CENTRES SUPPORTED

As Figure 23 showed, much of the increase in PhD programmes, postdoctoral programmes and research leader programmes supported by the Foundation resulted from the Foundation establishing four research centres in 2007–2010. Figure 24 shows the increase in personnel in the four research centres supported by the Foundation since 2007.

Note: Data includes postdoctoral projects that are either fully or partially funded by Novo Nordisk Foundation.

FIGURE 24. NUMBER OF SCIENTIFIC PERSONNEL IN THE FOUR FOUNDATION RESEARCH CENTRES, 2007–2015

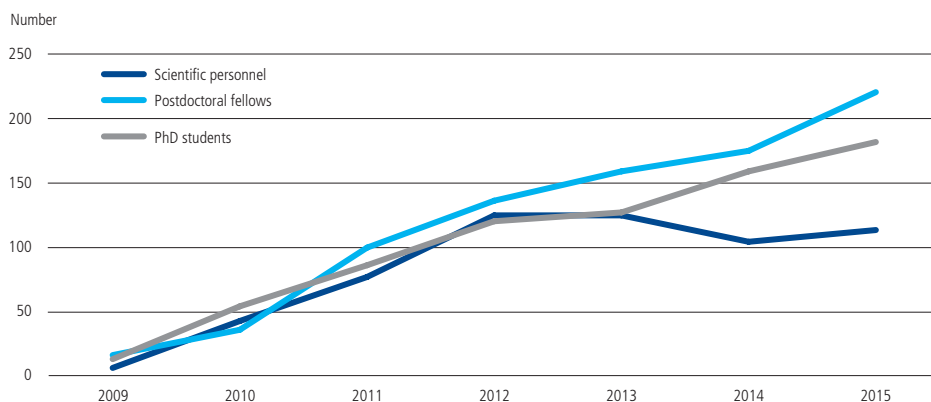
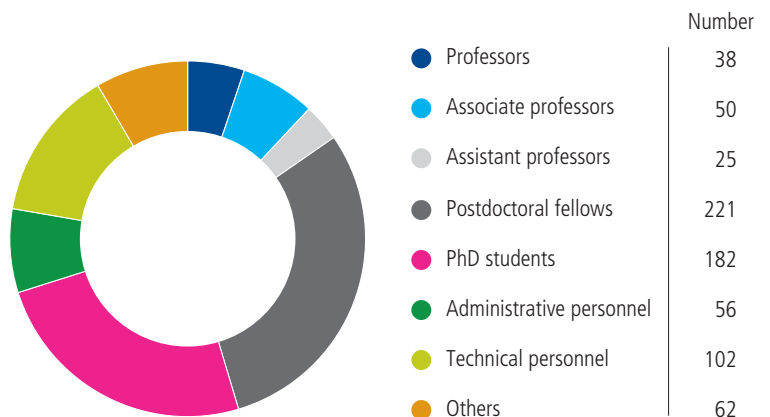


Figure 25 shows the personnel in the Foundation research centres in 2015 distributed by type of personnel. The largest group is postdoctoral fellows (221), followed by PhD students (182) and technical personnel (102). The research centres have 113 professors (professors, associate professors and assistant professors).

About 45% of the employees at the Foundation research centres in 2015 were recruited from outside Denmark. The Foundation has launched several initiatives to attract PhD students from outside Denmark and increase the percentage of these PhD students. The proportion of doctorate (mostly PhD) students from outside the EU is an indicator in the Innovation Union Scoreboard, and Denmark is 42% below the EU average for this indicator. The research centres supported by the Novo Nordisk Foundation help to ensure that Denmark does not rank even lower.

FIGURE 25: PERSONNEL IN THE FOUNDATION RESEARCH CENTRES DISTRIBUTED BY TYPE, 2015



11.0

PRODUCTION OF SCIENTIFIC PUBLICATIONS

Research in the public sector creates knowledge, education and inventions that benefit society. Scientific results benefit society when they are shared and disseminated so that they can form a basis for developing such things as new technology and new forms of disease prevention and treatment. This can be achieved through lectures, collaboration and dialogue between researchers and especially by publishing scientific articles and books. One way of quantitatively assessing the new knowledge produced through grants from the Foundation is to calculate the number of articles published in scientific journals and other types of publications reported by recipients of grants from the Foundation.

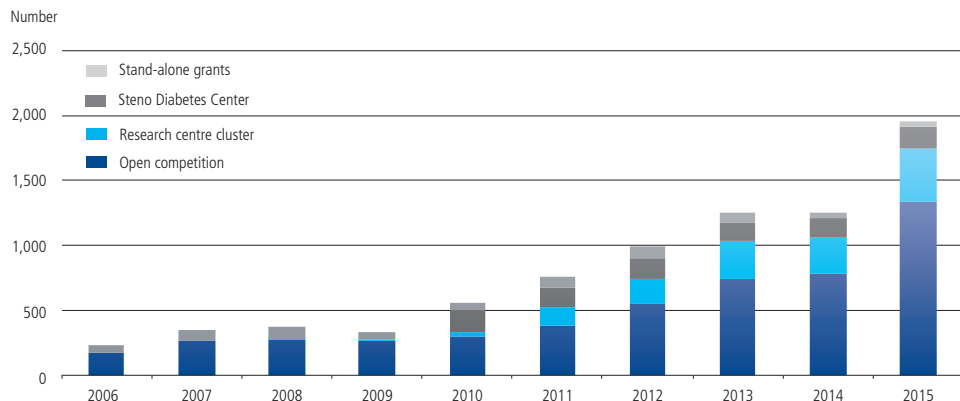
11.1

PRODUCTION OF PUBLICATIONS AND TYPES OF PUBLICATIONS

The Foundation has registered more than 10,000 scientific publications prepared based on grants from the Foundation. In 2013 and in 2014, the grant recipients published between 1200 and 1300 scientific publications. This number increased in 2015 to 1956 research publications (Figure 26). The recipients of grants in open competition have the largest numbers of registered articles. The Research centres supported by the Novo Nordisk Foundation registered 404 publications in 2015.

Note: In recent years, the Foundation has required all grant recipients to report their production of research publications. The numbers of publications for the years before 2012 are based on an estimated 70–90% of the grants. Starting in 2013, 100% of the grants are covered by reporting. In 2015, the data include conference articles, journal articles, theses, etc. The number of publications for stand-alone grants in 2015 is estimated as being close to the figure for 2014, since the data are not yet available from the reporting.

FIGURE 26: PUBLICATIONS REGISTERED BY RECIPIENTS OF GRANTS FROM THE FOUNDATION AS BEING PRODUCED BASED ON THE FOUNDATION GRANT, 2006–2015

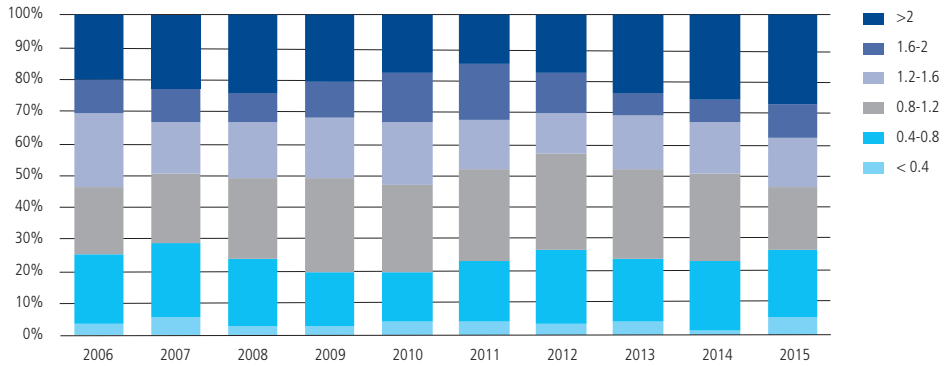


The impact of journal articles in scientific environments varies substantially. Some journals are very infrequently cited, whereas others have a high impact. Figure 27 shows the scientific impact of the journals in which the Foundation's grant recipients have published. The share of publications by grant recipients in journals with very high impact has increased from 20% in 2006 to 28% in 2016. Further, more than 50% of all publications are published in journals that are cited more frequently than the global average. Only about 25% are published in journals cited less frequently than the global average.

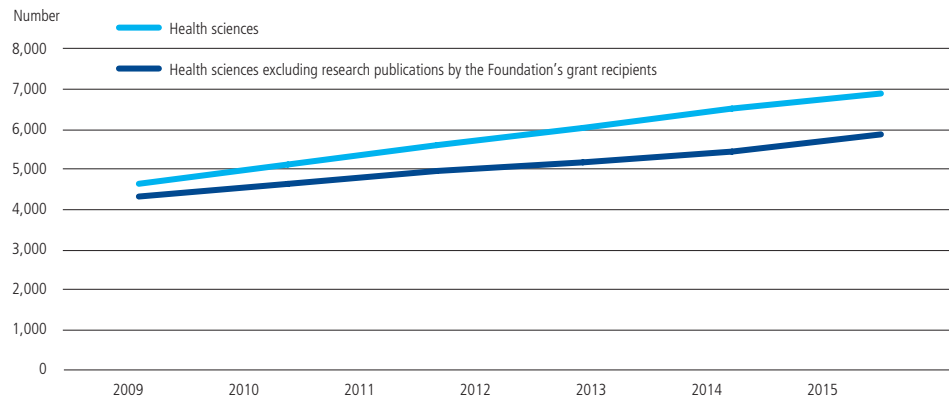
Figure 28 shows the total scientific production in the health sciences compared with that produced by the Foundation's grant recipients. The scientific production of the Foundation's grant recipients is increasing steadily. In 2014, the foundation's grant recipients increased the total production of articles by 18%.

Note: The scientific impact of journals is measured by the average number of citations for their articles. The average is normalized relative to other journals within the journal's scientific field. Thus, the value 1 is the average at any time within each scientific field, and a value of 2 shows that, on average, the journal is cited twice as often as the global average.

FIGUR 27: THE DISTRIBUTION OF PUBLICATIONS WITH RESPECT TO THE IMPACT FACTOR FOR THE JOURNALS IN WHICH THEY WERE PUBLISHED



FIGUR 28: NUMBER OF RESEARCH PUBLICATIONS IN THE HEALTH SCIENCES INCLUDING AND EXCLUDING THOSE PUBLISHED BY THE FOUNDATION'S GRANT RECIPIENTS, 2009-2014



Of the publications reported in 2013–2015, 92% were published in scientific journals, and 8% are other types, such as theses and presentations at scientific conferences (Figure 29). As described previously, since the grant recipients typically obtain funding from other sources, their production of publications should not solely be ascribed to Foundation grants.

Note: The figure is based on 4018 research publications reported by the Foundation's grant recipients in 2013–2015.

FIGURE 29: RESEARCH PUBLICATIONS BY THE FOUNDATION'S GRANT RECIPIENTS BY TYPE OF PUBLICATION, 2013–2015



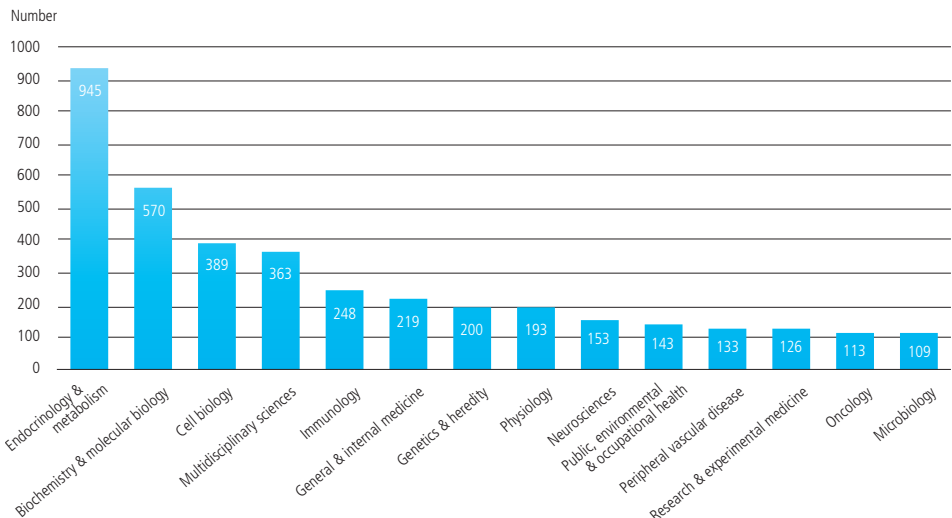
11.2

RESEARCH FIELDS FOR ARTICLES IN SCIENTIFIC JOURNALS

The Foundation's grant recipients publish within a wide range of health science fields (Figure 30). They publish most often within endocrinology, metabolism, molecular biology and cell biology. The main reason for the volume of publications categorized as multidisciplinary science is that Science and Nature publications are classified in this category. The scientific field are defined according to the definition made by the journals that the publications are published in and not according to researchers' own academic field or the contents of the article.

Note: The Web of Science categorizes about 60 journals, including Science, Nature and Proceedings of the National Academy of Sciences of the United States of America as multidisciplinary sciences.

FIGURE 30: NUMBER OF RESEARCH PUBLICATIONS BY THE FOUNDATION'S GRANT RECIPIENTS IN THE 14 MOST FREQUENT WEB OF SCIENCE CATEGORIES, 2006–2015



11.3

SCIENTIFIC JOURNALS IN WHICH GRANT RECIPIENTS PUBLISH

The Foundation's grant recipients publish most frequently in PLoS ONE, Diabetologia, Diabetes, Journal of Clinical Endocrinology & Metabolism and Journal of Biological Chemistry (Table 4).

Note: The articles in the 10 journals comprise 20% of all research articles by grant recipients in 2006–2015 (1307 of 6492 articles). The impact of the journal has been normalized for the scientific field and year of publication.

TABLE 4: THE 10 JOURNALS IN WHICH THE FOUNDATION'S GRANT RECIPIENTS PUBLISH MOST OFTEN

Journal	Number of articles	Percentage of articles based on Foundation grants awarded in open competition	Percentage of publications by the research centres supported by the Foundation	Percentage of publications by Steno Diabetes Center	Percentage of publications based on stand-alone grants	Journal impact
1. PLoS ONE	349	36	35	21	9	0.80
2. Diabetologia	201	15	24	49	12	1.59
3. Diabetes	151	31	32	37	0	2.01
4. Journal of Clinical Endocrinology & Metabolism	140	38	34	20	8	1.52
5. Journal of Biological Chemistry	116	42	58	0	0	1.05
6. Proceedings of the National Academy of Sciences	93	49	41	0	10	2.65
7. Diabetes Care	87	18	0	67	16	2.33
8. European Journal of Endocrinology	61	54	0	46	0	0.91
9. Diabetic Medicine	57	24	0	76	0	0.73
10. Nature	52	21	65	0	14	14.78

12.0

SCIENTIFIC COLLABORATION ON PUBLICATIONS

Research is increasingly created across national borders and across public and private organizations. Research collaboration can increase the dissemination of knowledge and is thus becoming increasingly important in determining the impact of the research results in scientific environments and in society. This chapter analyses the patterns of collaboration of the grant recipients through the list of authors for joint publications of research teams, and the collaboration is registered based on the affiliations stated in the publication.

12.1

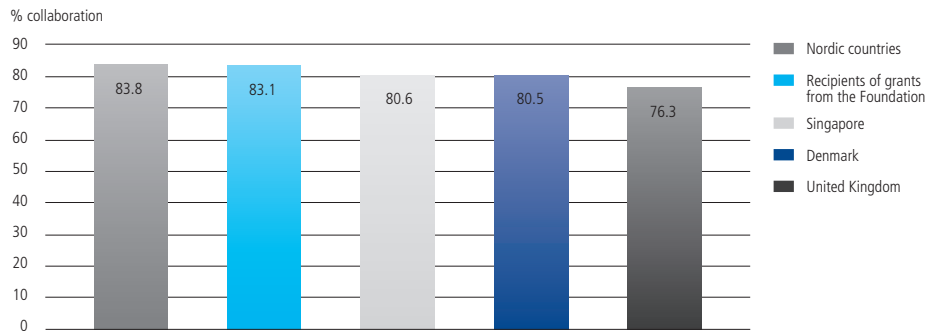
PROPORTION OF COLLABORATION IN PRODUCING RESEARCH PUBLICATIONS

The Foundation's grant recipients publish 83% of research publications in collaboration with researchers from other research institutions (Figure 31). This proportion is comparatively high internationally and contributes to increasing Denmark's average.

Figure 32 shows the trend in the number of research articles created in collaboration between researchers from different organizations. The Foundation's grant recipients increasingly publish articles in collaboration with other organizations. The proportion of publications created in collaboration between organizations increased from 74% in 2006 to 83% in 2013. Denmark has a similar trend generally, with an increase from 69% in 2006 to 76% in 2015 within the same field.

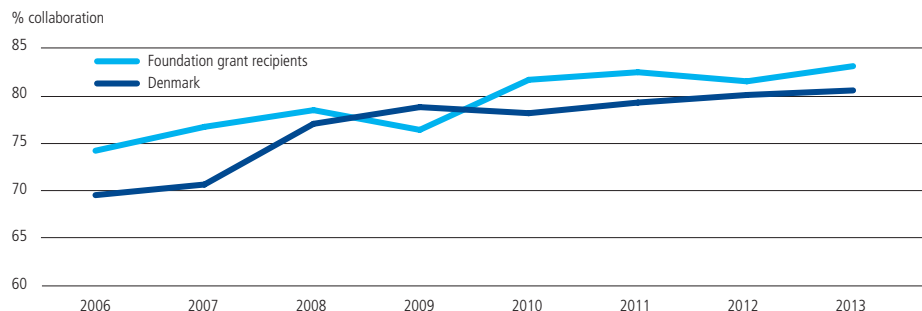
Note: The proportion of publications published by the Foundation's grant recipients based on research collaboration is compared here with the average for Singapore, the United Kingdom, the Nordic countries and Denmark in biomedical and health sciences in the Leiden Ranking. The proportion of publications based on collaboration has been calculated for the 1253 research publications published in 2013 by the Foundation's grant recipients.

FIGURE 31: PROPORTION OF FOUNDATION'S GRANT RECIPIENTS PUBLISHING IN COLLABORATION WITH RESEARCHERS FROM OTHER RESEARCH INSTITUTIONS



Note: The percentage of publications produced through research collaboration within biomedical and health sciences in the Leiden Ranking in 2006–2013 is compared between the Foundation's grant recipients and Denmark as a whole. The percentage of collaboration has been calculated based on 4261 research publications published in 2006–2013 by recipients of grants from the Foundation.

FIGURE 32: PERCENTAGE OF RESEARCH PUBLICATIONS PRODUCED IN RESEARCH COLLABORATION BETWEEN ORGANIZATIONS BY RECIPIENTS OF GRANTS FROM THE FOUNDATION AND IN DENMARK AS A WHOLE, 2006–2013



12.2

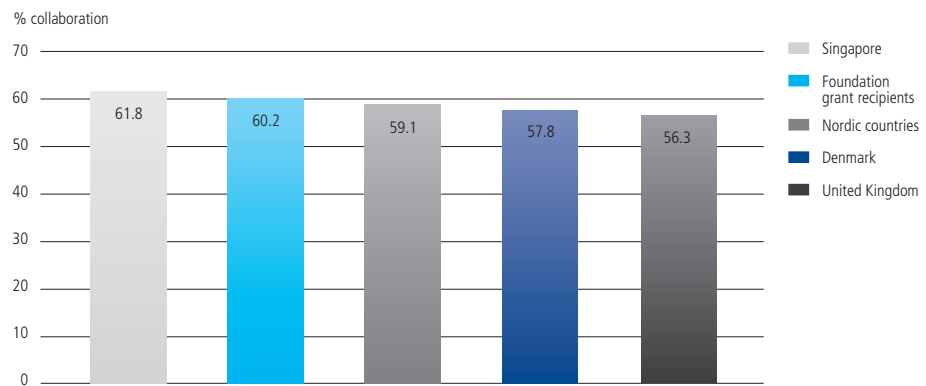
PERCENTAGE OF RESEARCH PUBLICATIONS PRODUCED IN INTERNATIONAL RESEARCH COLLABORATION

Figure 33 shows that 6 of 10 research publications published by the Foundation's grant recipients in 2006–2013 were produced in collaboration with researchers from research institutions outside Denmark.

Figure 34 shows the trend over time in the number of research publications produced in international collaboration. The Foundation's grant recipients published about 55% of their research publications in collaboration with researchers from research institutions outside Denmark in 2006–2012. This percentage rose substantially by more than 5 percentage points to 60% from 2012 to 2013. The figure for Denmark in general rose more evenly, from 53% in 2006 to 57% in 2009, after which it was stable until 2012. From 2012 to 2013, the proportion of articles in journals published in collaboration with researchers from research institutions outside Denmark increased by 1 percentage point to 58%. The number of international scientific co-publications is an indicator in the Innovation Union Scoreboard, and Denmark has a high score compared with the EU average.

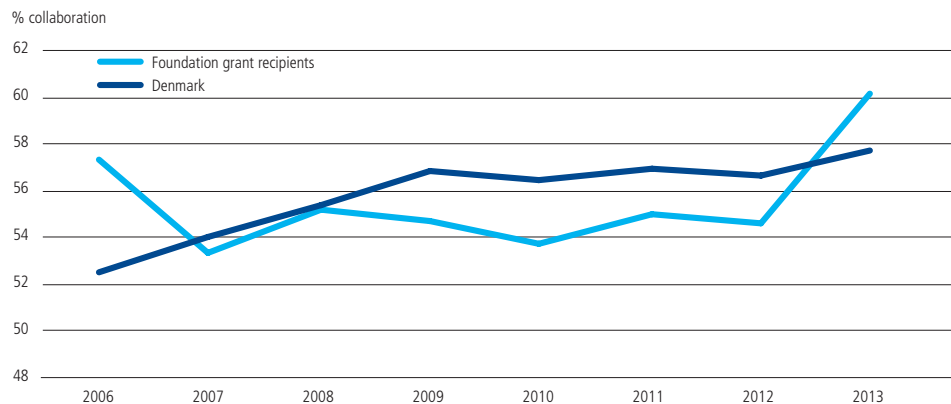
Note: The percentage of publications produced in international research partnerships is compared between the Foundation's grant recipients, the average for the United Kingdom, Singapore, the Nordic countries and Denmark in biomedical and health sciences in the Leiden Ranking. The percentage collaboration has been calculated based on 1253 research publications published in 2013 by recipients of grants from the Foundation.

FIGURE 33: PERCENTAGE OF RESEARCH PUBLICATIONS PRODUCED IN COLLABORATION WITH RESEARCHERS FROM RESEARCH INSTITUTIONS OUTSIDE DENMARK BY RECIPIENTS OF GRANTS FROM THE FOUNDATION AND IN OTHER COUNTRIES, 2013



Note: The percentage of publications produced in international research collaboration is compared between the Foundation's grant recipients and the average for Denmark in biomedical and health sciences in the Leiden Ranking in 2006–2013. The percentage of international collaboration has been calculated based on 4261 research publications published in 2006–2013 by recipients of grants from the Foundation.

FIGURE 34: PERCENTAGE OF RESEARCH PUBLICATIONS PRODUCED IN COLLABORATION WITH RESEARCHERS FROM RESEARCH INSTITUTIONS OUTSIDE DENMARK BY RECIPIENTS OF GRANTS FROM THE FOUNDATION AND IN DENMARK AS A WHOLE, 2006–2013



12.3

PERCENTAGE OF RESEARCH PUBLICATIONS PRODUCED IN COLLABORATION WITH INDUSTRY
 About 12% of the research publications published by the Foundation’s grant recipients are produced in collaboration with researchers from industry (Figure 35). Just under 30% of the publications produced through industrial collaboration are produced together with Novo Nordisk A/S and Novozymes A/S, which together account for about one third of the private research carried out in Denmark. Since companies do not publish systematically like researchers but choose instead to have employees co-publish for other reasons, the actual level of collaboration would be expected to be higher than the measured level.

Figure 36 shows the trend over time of the percentage of research publications produced through industrial collaboration. Despite fluctuation, the percentage appears to have increased significantly from 9% in 2006 to 12% in 2013. Conversely, the percentage of research publications prepared in collaboration with industry in general in Denmark fell from 12% to 11% from 2006 to 2013. The number of public–private co-publications per million population is also an indicator in the Innovation Union Scoreboard. Here the Foundation’s grant recipients contribute to a high average for Denmark (Figure 37). Denmark has a high average compared with researchers in general from the Nordic countries and from the United Kingdom (Figure 35).

Note: The percentage of research publications produced in collaboration with industry in biomedical and health sciences in the Leiden Ranking in 2013 is compared between the Foundation’s grant recipients and the United Kingdom, the United States, Singapore, the Nordic countries and Denmark. The percentage collaboration has been calculated based on 1253 research publications published in 2013 by recipients of grants from the Foundation.

FIGURE 35: PERCENTAGE OF RESEARCH PUBLICATIONS PRODUCED IN COLLABORATION WITH RESEARCHERS FROM INDUSTRY BY RECIPIENTS OF GRANTS FROM THE FOUNDATION AND IN OTHER COUNTRIES, 2013

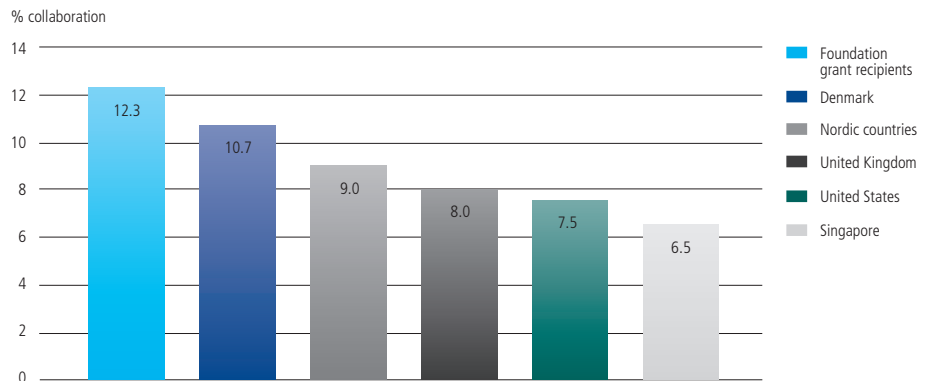


FIGURE 36: PERCENTAGE OF RESEARCH PUBLICATIONS PRODUCED IN COLLABORATION WITH RESEARCHERS FROM INDUSTRY BY RECIPIENTS OF GRANTS FROM THE FOUNDATION AND IN DENMARK AS A WHOLE, 2006–2013

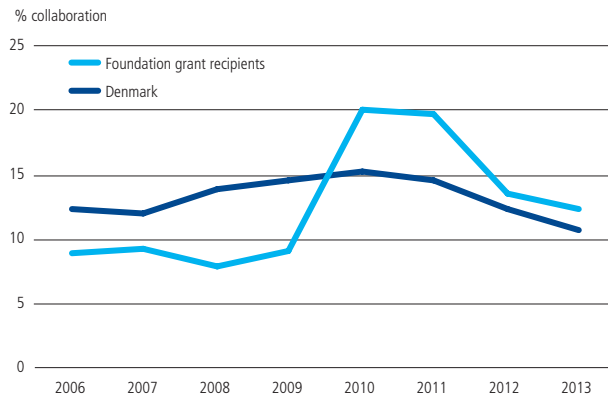
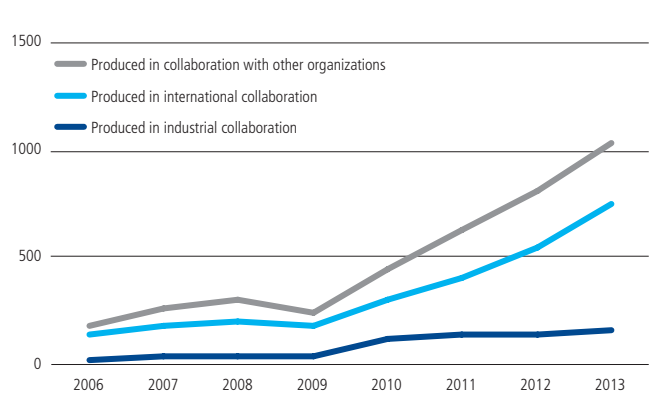


FIGURE 37: NUMBER OF RESEARCH PUBLICATIONS PRODUCED THROUGH VARIOUS TYPES OF COLLABORATION BY RECIPIENTS OF GRANTS FROM THE FOUNDATION, 2006–2013



Note: The percentage of research publications produced in collaboration with industry in biomedical and health sciences in the Leiden Ranking in 2006–2013 is compared between the Foundation’s grant recipients and Denmark as a whole. The percentage collaboration has been calculated based on 4261 research publications published in 2006–2013 by recipients of grants from the Foundation.

13.0

KNOWLEDGE SHARING AND INFLUENCE ON POLICIES

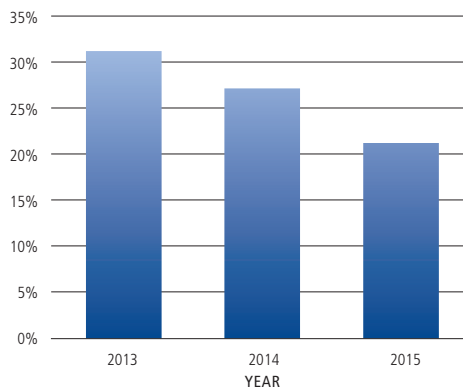
In addition to creating knowledge, many grant recipients also have activities intended to disseminate the knowledge they have obtained in their research activities. It takes time between a grant being awarded and the initiated research activities leading to new knowledge that may be communicated. It then takes time before knowledge can influence treatment methods, guidelines for hospitals and institutions, new policies, etc.

Figure 38 shows that the percentage of the Foundation's grants that result in knowledge dissemination activities and influence health guidelines, public commissions, committees and counsels, new legislation on health etc. increases with the duration of a grant. Of the researchers receiving a Foundation grant in 2013, 31% have reported that they have participated in a knowledge dissemination activity or have influenced the formulation of a new policy at least once. This figure was only 21% for the recipients of grants in 2015.

The recipients of grants awarded in open competition that are in progress have reported nearly 100 examples of influence on health guidelines, participation in public positions in health promotion and clinical practice, etc. The reports cover a wide range of activities. Examples include contributing to the Danish Health Authority's programme for following up on lung cancer and participation in the First WHO Ministerial Conference on Global Action against Dementia in 2015.

Apart from this, more than 800 education activities have been registered and cover a wide range of activities. For example, some grant recipients have disseminated their knowledge at Research Day at the Regional Research Unit of Region Zealand in Denmark. Others have provided consultation to a team of students from Copenhagen Business School and Virginia Polytechnic Institute and State University preparing for Venture Cup. The team then won. Finally, there have been many presentations at international conventions and conferences.

FIGURE 38: PERCENTAGE OF RECIPIENTS OF GRANTS FROM THE FOUNDATION REPORTING KNOWLEDGE SHARING AND INFLUENCE ON POLICIES, 2013–2015



14.0

SCIENTIFIC IMPACT

Researchers' production of new knowledge can be measured by the number of research publications in scientific journals and books, but the impact of scientific articles is measured by how often the articles are cited in other research publications. New knowledge is based on existing knowledge. A researcher using and building on the knowledge of other researchers cites their publications. If a scientist's publications are cited often, this does not necessarily indicate the article's quality but rather indicates that the article is relevant for others and therefore is read and used as a basis for other researchers' work.

This chapter shows the scientific impact of research articles that the Foundation's grant recipients have published in scientific journals. The benchmarks are the best universities in the world and in Europe and the average for the world, for the Nordic countries and for Denmark. The data have been retrieved from Thomson Reuters' international database *Web of Science*¹⁰. The indicators used have been developed at the Centre for Science and Technology Studies at Leiden University.

Each journal in *Web of Science* is characterized by one or more of 250 subject categories (subject areas). Every article is placed in one or more subject categories. The biometrics calculations for the same year are standardized or normalized relative to the world average within the scientific subject categories. This compensates for possible differences in citation and publication practices between disciplines. This also enables the scientific impact to be compared across scientific subject categories, universities, regions and countries.

The international standard for bibliometric analysis of citations is that citations are first counted two years after the date of publication, which means that the bibliometric statements in this report are from 2013¹¹. The articles that can be identified in the *Web of Science* are included. This means that book chapters and conference articles are not included in the citation analysis.

¹⁰ *Web of Science* is an online article search system maintained by Thomson Reuters, where you can access citation information about research publications.

¹¹ Waltman, L. (2016). A review of the literature on citation impact indicators. *Journal of Infometrics*, 10(2), 365-391. arXiv:1507.02099.

The percentage of scientific articles among the 10% most frequently cited scientific articles globally – pp(top 10%) – is also an indicator in the Innovation Union Scoreboard. Denmark is in the top 3 in the Innovation Union Scoreboard in scientific impact measured relative to pp(top 10%). The analysis shows that the Foundation's grant recipients contribute positively to improving Denmark's performance and thus to Denmark's high position in the Innovation Union Scoreboard (Figures 39 and 40).

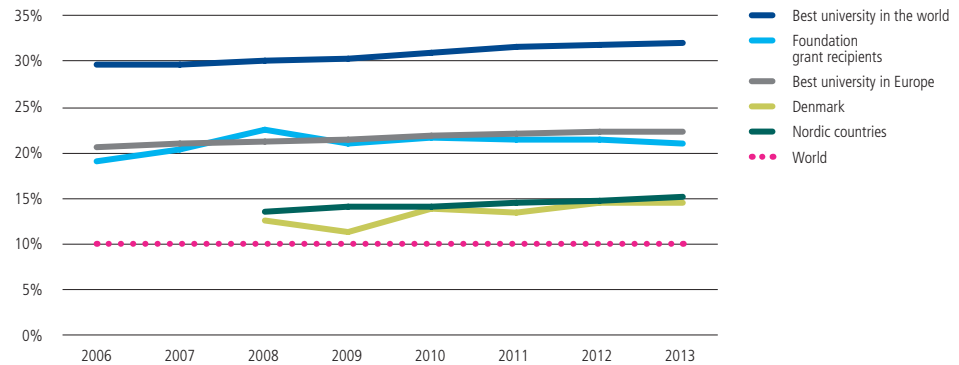
14.1

IMPACT OF RESEARCH PUBLICATIONS

Figures 39–42 show the impact of research publications by the Foundation's grant recipients on international scientific environments in 2006–2013. As a group, the Foundation's grant recipients have an above average scientific impact in Denmark and the Nordic countries equivalent to those of the best universities in Europe.

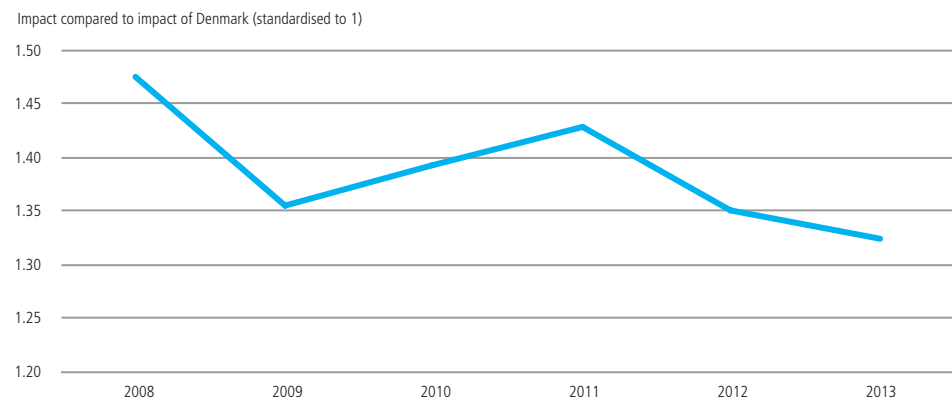
Note: The figure includes research publications from 2006–2013 from the Foundation's grant recipients compared with the best university in Europe and in the world within biomedical and health sciences in the Leiden Ranking. The benchmark for the Nordic countries is for all research disciplines.

FIGURE 39: PERCENTAGE OF RESEARCH PUBLICATIONS AMONG THE 10% MOST FREQUENTLY CITED IN THE WORLD, RECIPIENTS OF GRANTS FROM THE FOUNDATION VERSUS BENCHMARKS, 2006–2013



Note: The data in the figure stem from the data set for the Foundation's grant recipients and Denmark from Figure 39.

FIGURE 40: PERCENTAGE OF RESEARCH PUBLICATIONS AMONG THE 10% MOST FREQUENTLY CITED IN THE WORLD, RECIPIENTS OF GRANTS FROM THE FOUNDATION VERSUS BIOMEDICAL AND HEALTH RESEARCH OVERALL IN DENMARK, 2008–2013

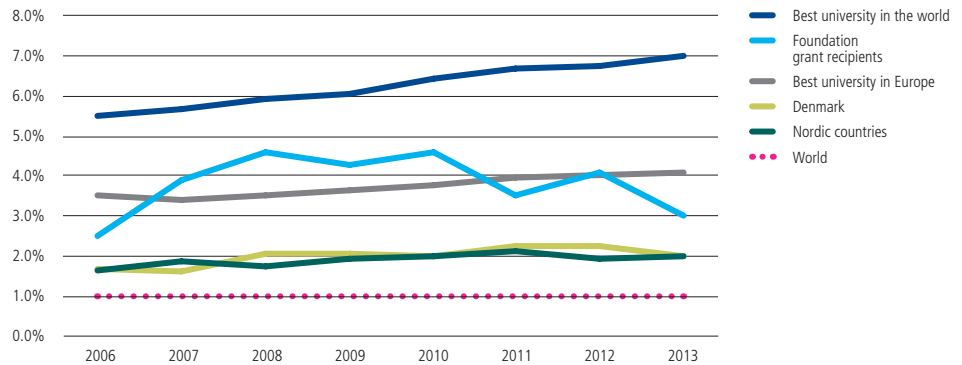


Compared with the global average, in 2013 the Foundation’s grant recipients had twice as many research publications as the global average among those 10% most frequently cited and three times as many as the global average among the 1% most frequently cited research publications. This indicates that a few recipients of grants from the Foundation, with publications among the 1% most frequently cited, considerably improve the proportion of top-10% publications.

The average number of citations per publication of the Foundation’s grant recipients is 2.2 times higher than the global average (Figure 42) within biomedical and health sciences in the Leiden Ranking. Seen as a combined group, the Foundation’s grant recipients thus have a citation score equivalent to that of the best university in Europe.

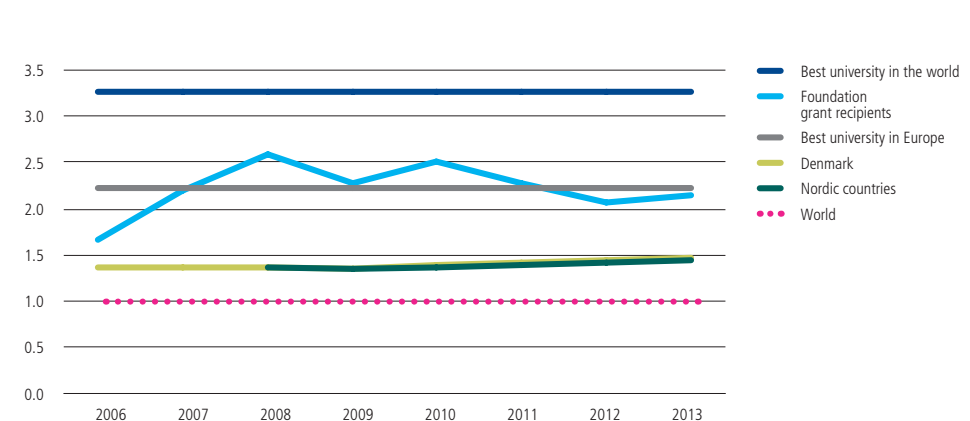
Note: The figure includes research publications from 2006–2013 by the Foundation’s grant recipients compared with the best university in Europe and in the world as well as Denmark in biomedical and health sciences in the Leiden Ranking. The benchmark for the Nordic countries is for all research disciplines.

FIGURE 41: PERCENTAGE OF RESEARCH PUBLICATIONS AMONG THE 1% MOST FREQUENTLY CITED IN THE WORLD, RECIPIENTS OF GRANTS FROM THE FOUNDATION VERSUS BENCHMARKS, 2006–2013



Note: The figure includes research publications from 2006–2013 from the Foundation’s grant recipients compared with the best university in Europe and in the world within biomedical and health sciences in the Leiden Ranking. The benchmarks for the top university in the world and in Europe are estimated from Leiden Ranking data for 2008–2011.

FIGURE 42: NUMBER OF CITATIONS OF RESEARCH PUBLICATIONS BY THE RECIPIENTS OF GRANTS FROM THE FOUNDATION VERSUS THE GLOBAL AVERAGE, 2006–2013



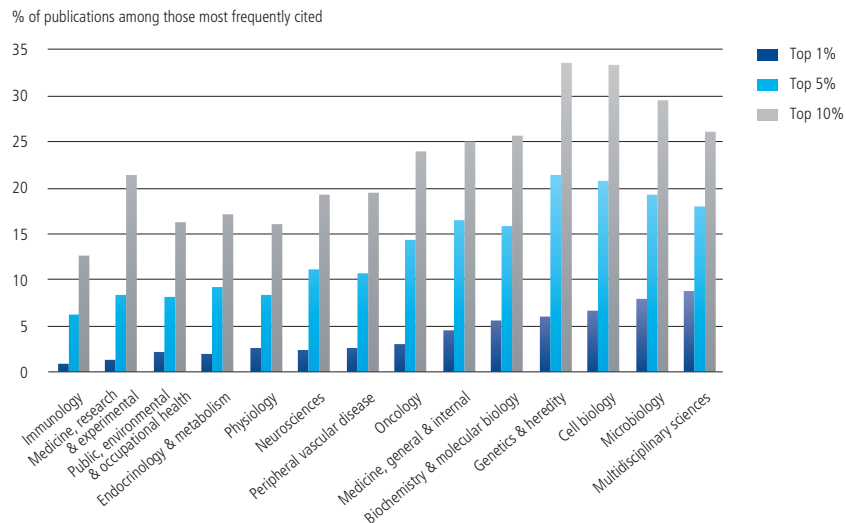
14.2

IMPACT IN SCIENTIFIC SUBJECT CATEGORIES

The scientific impact has also been measured for 14 scientific subject categories in which the Foundation's grant recipients have delivered the most important production of research publications (Figures 43 and 44). Based on the proportion of research publications among the world's 1%, 5% and 10% most frequently cited publications within the same subject category and the same year, the research publications of the Foundation's grant recipients have had a particularly important scientific impact in molecular biology, genetics and heredity, cell biology, microbiology and within multidisciplinary sciences. The reason for multidisciplinary sciences was mostly that the research publications in Nature and Science are categorized as being multidisciplinary sciences. Research publications within immunology and experimental medicine have had the least impact but are still above the global average.

Note: The figure shows the percentage of research publications that are among the 1%, 5% and 10% most cited research publications within their scientific field in the period 2006–2013. About 60 journals, including Science, Nature and Proceedings of the National Academy of Sciences of the United States of America, are classified as publishing multidisciplinary sciences since they publish articles across various disciplines. The articles in these journals are classified as multidisciplinary sciences even though many are highly specialized.

FIGURE 43: PERCENTAGE OF RESEARCH PUBLICATIONS AMONG THE MOST FREQUENTLY CITED GLOBALLY WITHIN THE RESEARCH FIELDS IN WHICH THE FOUNDATION'S GRANT RECIPIENTS PUBLISH MOST FREQUENTLY



Note: The figure shows the relationship between the top-1%, top-5% and top-10% research publications compared with the global average within their scientific field in 2006–2013. A top 1% global average value of 8 means that the Foundation's grant recipients within this field have 8 times as many publications within the 1% most frequently cited globally relative to the global average.

FIGURE 44: TOP PUBLICATIONS BY RECIPIENTS OF GRANTS FROM THE FOUNDATION RELATIVE TO THE GLOBAL AVERAGE

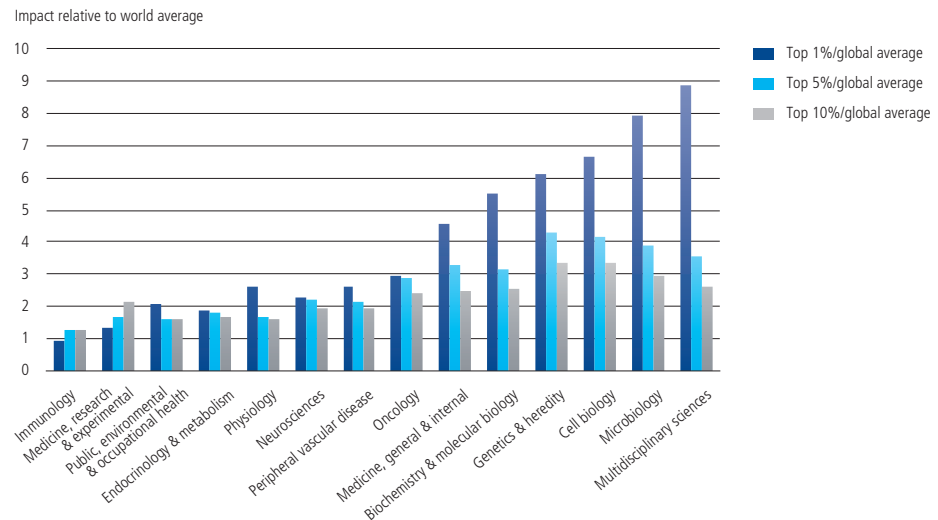


Figure 44 shows that recipients of grants from the Foundation publish many top-1% articles within general and internal medicine, molecular biology, genetics and heredity, cell biology and microbiology, which, in turn, significantly increases the general impact. In other scientific fields such as endocrinology and metabolism, physiology, neurosciences, peripheral vascular disease and oncology, the general level is improved by a larger number of top-10% articles, while there are relatively fewer top-1% articles within these research fields. Overall, the fields of cell biology, molecular biology and endocrinology and metabolism account for the most top-10% articles (Figure 45).

14.3

IMPACT OF THE FOUNDATION’S VARIOUS GRANT CATEGORIES

Analysis of citations shows that the research publications of the Research centres supported by the Novo Nordisk Foundation that conduct research on proteins, stem cells, metabolism and biosustainability have high scientific impact (Figure 46).

FIGURE 45: WEB OF SCIENCE SUBJECT CATEGORIES WITH THE MOST FREQUENTLY CITED PUBLICATIONS PRODUCED BY RECIPIENTS OF GRANTS FROM THE FOUNDATION

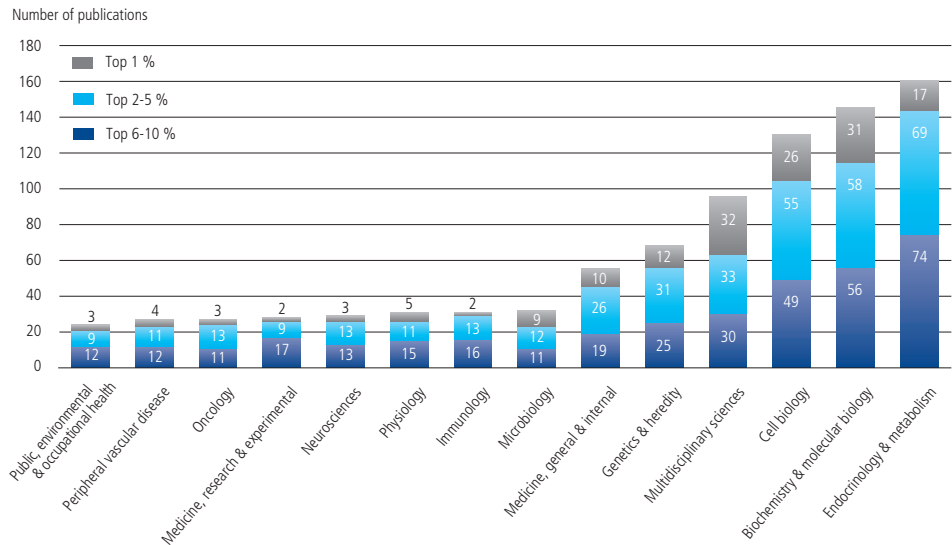
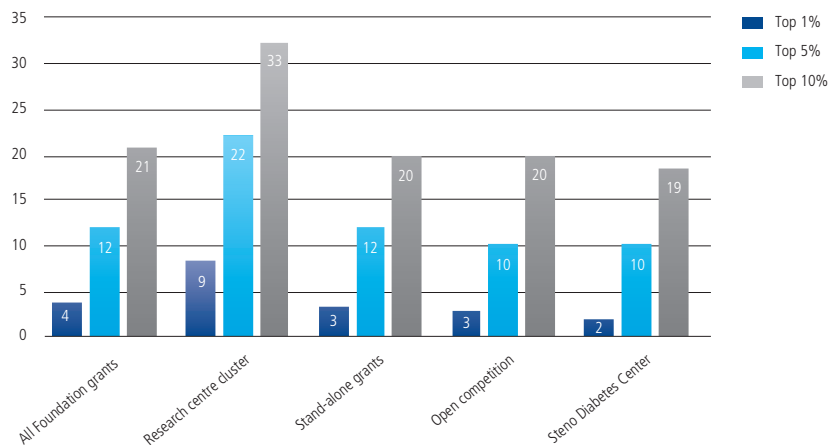


FIGURE 46: SCIENTIFIC IMPACT OF RESEARCH PUBLICATIONS ACCORDING TO THE FOUNDATION’S GRANT CATEGORIES



Of the research publications prepared by the Foundation research centres, 33% are among the 10% most frequently cited globally, and 9% are among the 1% most frequently cited worldwide. Thus, the research centres perform as well as the best universities in the world. Further analysis is needed to assess how the research centres perform relative to other similar research centres worldwide. In general, 4% of the articles published by the Foundation's grant recipients are among the 1% most frequently cited globally, 12% are among the 5% most frequently cited and 21% are among the 10% most frequently cited.

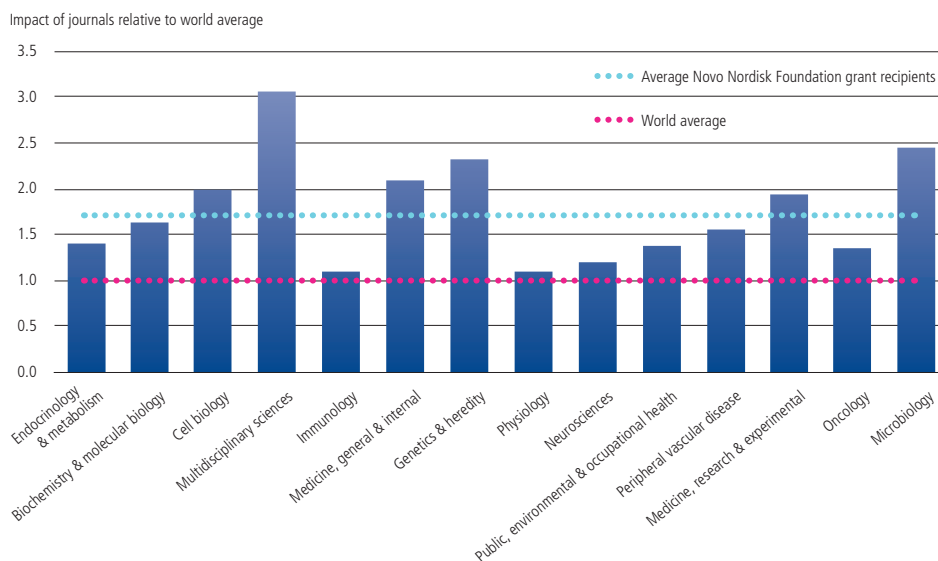
14.4

SCIENTIFIC IMPACT BY PUBLICATION FIELD

Figure 47 shows the average impact of the scientific journals in which the Foundation's grant recipients have published. The grant recipients have published in journals with high impact, especially within cell biology, general and internal medicine, genetics and heredity and microbiology. The high impact within multidisciplinary sciences results from many publications in journals with high impact such as Nature.

Note: The average impact has been normalized so that it always has the value of 1, shown with the red dotted line. The average impact in the journals in which the Foundation's grant recipients have published is shown with the blue dotted line (the average impact in 2013 was 1.7). About 60 journals, including Science, Nature and Proceedings of the National Academy of Sciences of the United States of America, are classified as publishing multidisciplinary sciences since they publish articles across various disciplines. The articles in these journals are categorized as multidisciplinary sciences even though many are highly specialized.

FIGURE 47: IMPACT OF JOURNALS PUBLISHING WITHIN THE 14 MOST FREQUENT WEB OF SCIENCE SUBJECT CATEGORIES



15.0

IMPACT OF RESEARCH COLLABORATION FOR RE-SEARCH PUBLICATIONS BY RECIPIENTS OF GRANTS

Research collaboration with researchers from research institutions or companies inside and outside one’s country can accelerate knowledge of the research outside the research institution’s own walls. It will increase the likelihood that new knowledge has more impact in international research environments and in society in general. Research collaboration also enables learning from more skilled researchers and gaining access to new research data and methods. This chapter analyses the impact of research publications produced by the Foundation’s grant recipients in collaboration with other research institutions.

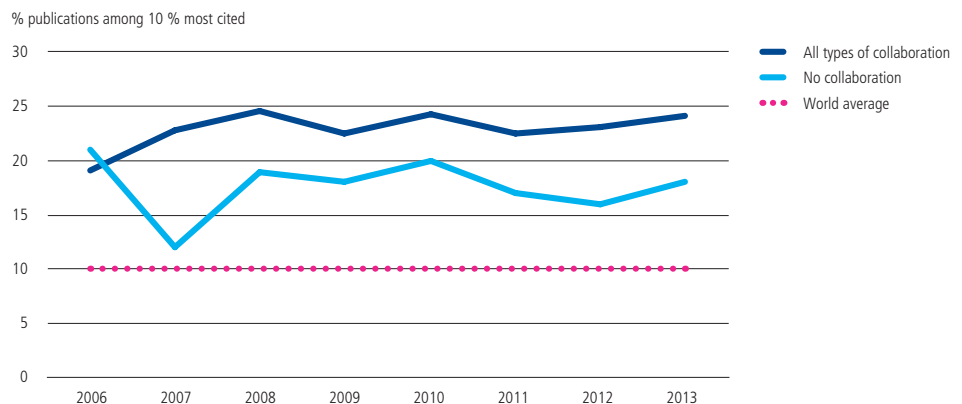
15.1

IMPACT OF RESEARCH COLLABORATION WITH OTHER RESEARCH INSTITUTIONS

The average scientific impact of research publications produced by the Foundation’s grant recipients in collaboration with other research institutions is 50% higher than those produced by a single institution (Figure 48). Thus, the collaboration with another institution seems to increase the impact of the scientific work such that the research publications are cited more often.

Note: The percentage is shown for both scientific articles by recipients of grants from the Foundation in collaboration with researchers from other institutions (in their home country and elsewhere) and the average for all research publications worldwide.

FIGURE 48: PERCENTAGE OF ARTICLES BY RECIPIENTS OF GRANTS FROM THE FOUNDATION THAT ARE AMONG THE 10% MOST FREQUENTLY CITED PUBLICATIONS PRODUCED THROUGH COLLABORATION, 2006–2013



15.2

IMPACT OF INTERNATIONAL RESEARCH COLLABORATION

Of the research publications produced by recipients of grants from the Foundation in collaboration with researchers from another country, 20–30% are among the 10% most frequently cited in the field. This is 25% more than if all publications produced through collaboration are measured (Figure 49). This suggests that international collaboration helps to improve the impact of research publications.

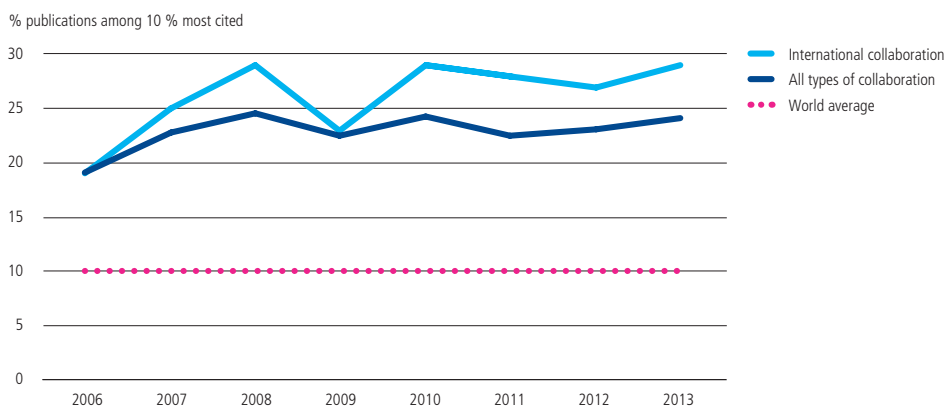
15.3

IMPACT OF INDUSTRIAL RESEARCH COLLABORATION

Scientific articles published in collaboration with researchers from industry have a higher impact in scientific environments than other publications produced through collaboration. In 2013, the articles originating from collaboration with researchers from industry were almost four times as frequent among the 10% most cited in the world relative to the global average (Figure 50).

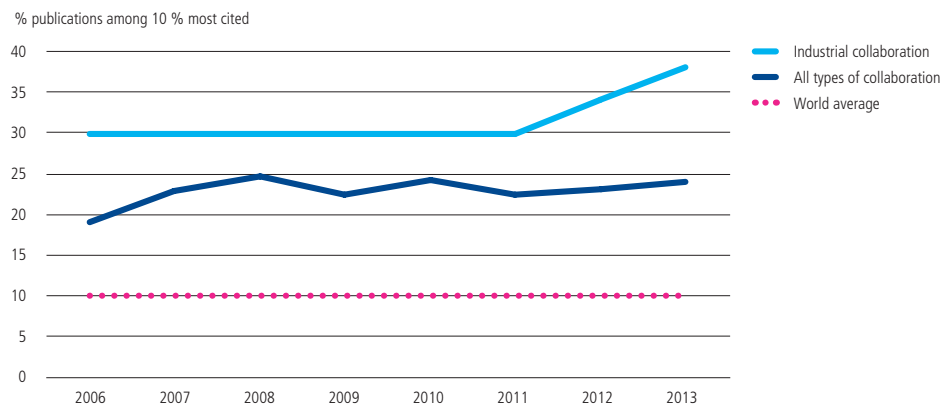
Note: The percentage is shown for research publications produced by the Foundation's grant recipients in collaboration with international researchers, in collaboration with researchers in the home country and elsewhere and the average for all research publications in the world.

FIGURE 49: PERCENTAGE OF ARTICLES BY RECIPIENTS OF GRANTS FROM THE FOUNDATION THAT ARE AMONG THE 10% MOST FREQUENTLY CITED PUBLICATIONS PRODUCED THROUGH INTERNATIONAL COLLABORATION, 2006–2013



Note: The percentage is shown for research publications by the Foundation's grant recipients' in collaboration with researchers from industry, in collaboration with both public and industrial research entities respectively as well as the global average for all research publications. Since only about 12% of all research publications are produced in collaboration with industrial researchers, the statistical material from 2006–2011 is insufficient to calculate the annual scientific impact. A combined average for 311 publications is therefore shown for this period.

FIGURE 50: PERCENTAGE OF ARTICLES BY RECIPIENTS OF GRANTS FROM THE FOUNDATION THAT ARE AMONG THE 10% MOST FREQUENTLY CITED PUBLICATIONS PRODUCED THROUGH INDUSTRIAL COLLABORATION, 2006–2013



16.0

APPLYING RESEARCH

Knowledge can be used to create new treatment methods, inventions, innovations, companies, etc. Time elapses between initiating research activities and producing useful knowledge. The percentage of grant recipients who can report activities in developing and/or using products, patents, inventions and treatment methods etc. is therefore expected to increase with the number of years that pass since the grant was awarded.

Figure 51 shows that 7% of the grant recipients with grants awarded 1 year previously report that they have used knowledge for products, treatments, intellectual property, spin-outs, etc. This proportion increases over time. Thus, 16% of the grant recipients awarded grants in 2013 reported that they had used their acquired knowledge for products, treatments, intellectual property, spin-outs etc.

In an innovation perspective, recipients of grants from the Foundation have reported 34 commercialization activities covering patent applications, patents and licences and spin-out businesses. Grant recipients have also reported 19 medical products and interventions or clinical trials.

The Foundation provides the Nordic countries with access to the exploratory pre-seed grant programme and aims to accelerate the commercialization of research in biomedicine and biotechnology with the aim of developing new diagnostic methods, treatments, medical equipment and technologies.

The Exploratory Pre-seed Grant programme was established in 2010 and about 20 grants are made annually with a total value of DKK 10 million. Exploratory pre-seed grants initiated in 2013–2015 that have reported supplementary funding have obtained supplementary funds equivalent to nearly 150% of the Foundation's grants (Figure 52). Successful exploratory pre-seed projects can be considered for the Foundation's pre-seed grants. The pre-seed portfolio contains 20 active pre-seed projects. Since the pre-seed programme was established, six projects have subsequently received seed investment from Novo Seeds. Projects may also freely choose to receive seed investment outside Novo Seeds. Novo Seeds has 16 active seed businesses.

FIGURE 51: PERCENTAGE OF RECIPIENTS OF GRANTS FROM THE FOUNDATION REPORTING USING ACQUIRED KNOWLEDGE

Note: The figure shows the percentage of the Foundation's grant recipients with at least one reported activity within the use of acquired knowledge, defined as development and/or use of products, intellectual property, inventions, treatment etc. There are too few data to be able to allocate them into the above-mentioned sub-categories.

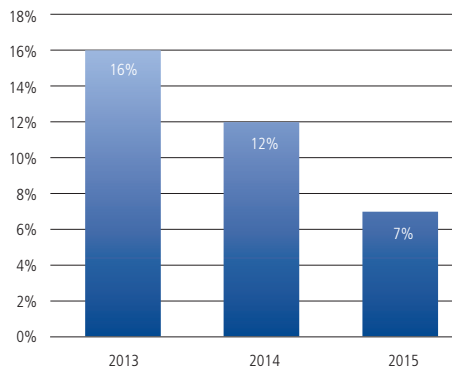
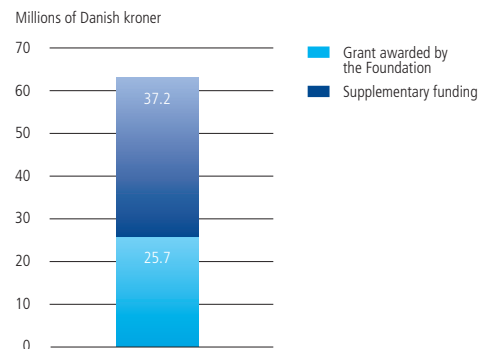


FIGURE 52: RECIPIENTS OF EXPLORATORY PRE-SEED GRANTS INITIATED IN 2013–2015 WHO HAVE REPORTED SUPPLEMENTARY FUNDING



DEFINITIONS OF CONCEPTS IN THE HEALTH AND NATURAL SCIENCES

Biochemistry is the study of chemical structures and processes in living organisms.

Biomedicine is an interdisciplinary research area between biology and medicine. Biomedicine focuses on developing new forms of treatment by analysing why and how diseases develop.

Biophysics applies physical methods to explore biological phenomena and mechanisms.

Biotechnology focuses on using and manipulating living organisms to produce new products and processes.

Cell biology is a branch of biology studying cell structure and function, such as physiological properties, metabolic processes and interaction with the surroundings.

Clinical research is research taking place in the clinic, such as trials of various courses of treatment. Clinical research is required before a new drug can be approved for standard treatment.

Endocrinology focuses on glands in the various parts of the human body that secrete hormones directly into the blood and on diseases related to these glands, such as diabetes, which can result from insufficient insulin production in the pancreas.

Environmental and occupational health is a discipline in the health sciences that explores the relationship between people's health and environmental and working conditions.

Experimental medicine is basic applied research that increases knowledge of new pharmaceutical products, diagnostic products, medical devices and non-pharmaceutical treatments. The research is characterized by involving the patients.

Genetics and heredity is the study of genes, genetic variation and heredity in living organisms. In modern genetics, studies of the variation and distribution of genes in a population have given rise to subdisciplines such as epigenetics and population genetics.

Haematology is a medical speciality that addresses disorders of the blood and the blood-forming organs.

Immunology focuses on the immune system and its structure and function in both healthy and sick people. Immunology also focuses on how the immune response can be used to defend individual people against diseases and how an overactive immune response can be dampened.

Internal medicine is a medical discipline addressing the prevention, diagnosis and treatment of diseases of the internal organs, such as the heart, lungs, kidney and liver. Much of the research is therefore done in hospitals.

Metabolism refers to a range of biochemical processes in the cells of living organisms in connection with converting food molecules to energy or to building blocks for biosynthesis of complex chemical molecules and their breakdown.

Microbiology focuses on biological organisms, such as fungi and bacteria, that are usually only visible under a microscope.

Molecular biology is a branch of biology focusing on macromolecules, especially proteins, DNA and RNA and their functions in the cell.

Multidisciplinary sciences: about 60 journals, including *Science*, *Nature* and *Proceedings of the National Academy of Sciences of the United States of America*, are classified as publishing multidisciplinary sciences according to the Web of Science, since these journals publish research publications across various disciplines. The articles in these journals are categorized as multidisciplinary sciences even though many are highly specialized.

Nanotechnology is an interdisciplinary science drawing on elements from chemistry, physics and biology. Nanotechnology works with objects with a magnitude of 0.1–100 nanometres; a nanometre is 0.000000001 metres.

Neurosciences is a broad term for the specialized fields focusing on the nervous system and brain.

Oncology is a medical speciality addressing cancer.

Peripheral vascular disease occurs when arteries constrict or close, which may limit blood flow to such organs as the kidneys, brain, heart, legs and feet.

Physiology is the study of how organisms (people, animals and plants as well as microorganisms), organs, cells and biomolecules perform chemical or physical functions.

Protein research (proteomics) is the study of proteins and their structures and functions.

**IMPACT OF THE NOVO NORDISK FOUNDATION
ON PUBLIC RESEARCH 2015**

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NOVO NORDISK FOUNDATION
Tuborg Havnevej 19,
DK-2900 Hellerup,
Denmark

Telephone: +45 3527 6600

E-mail: nnfond@novo.dk
www.novonordiskfoundation.com

NOVO NORDISK FOUNDATION

Tuborg Havnevej 19

DK-2900 Hellerup

Denmark

Telephone: +45 3527 6600

nnfond@novo.dk

www.novonordiskfoundation.com

The Novo Nordisk Foundation is an independent Danish foundation with corporate interests. The Foundation has two main objectives:

- 1:** to provide a stable basis for the commercial and research activities conducted by the companies in the Novo Group; and
- 2:** to support scientific, humanitarian and social purposes.

The vision of the Foundation is to contribute significantly to research and development that improves the health and welfare of people. The foundation supports the entire research food chain - from education to innovation - though mainly for public research in bio-medicine and biotechnology.

Read more at www.novonordiskfoundation.com.