



Research for Innovation and Equity

Impact Analysis:
Strategic Initiative on
Centres of Excellence and Clusters

8 April 2024

Small Globe Inc.
Toronto, Ontario, Canada
Halla Thorsteinsdóttir
Email: halla@smallglobe.org

TABLE OF CONTENTS

EXECUTIVE SUMMARY	3
ACKNOWLEDGEMENT	7
1. INTRODUCTION	8
1.1 BACKGROUND	8
1.2 PURPOSE AND OBJECTIVES OF THE IMPACT ANALYSIS	9
1.3 METHODOLOGY	9
2. BRIEF DESCRIPTION OF THE CoEs	10
2.1 EDDA	10
2.2 GEORG	11
2.3 IIIM/ VITVÉLASTOFNUN ÍSLANDS	13
3. CONTRIBUTIONS TO RESEARCH	14
3.1 EDDA'S PUBLICATIONS.....	14
3.2 GEORG'S PUBLICATIONS	16
3.3 IIIM'S PUBLICATIONS	18
4. MAIN DOMESTIC IMPACTS OF THE THREE CoEs	20
4.1 IMPACTS ON TRAINING AND CAPACITY BUILDING	20
4.2 IMPACT ON NATIONAL DIALOGUE.....	21
4.3 WIDER SOCIETAL IMPACTS.....	23
4.4 ECONOMIC IMPACT	24
4.5 IMPACTS ON COOPERATION BETWEEN INSTITUTIONS IN DIFFERENT SECTORS	26
5. MAIN INTERNATIONAL IMPACTS OF THE THREE CoEs	28
5.1 INTERNATIONAL EVENTS AND NETWORKS	29
5.2 NOVEL RESEARCH AGENDAS	29
5.3 MAIN FACTORS AND CONDITIONS SHAPING THE COES' INTERNATIONAL IMPACTS.....	31
6. SUSTAINABILITY OF THE CoEs	32
7. RECOMMENDATIONS	34
APPENDIX A - DETAILS OF THE IMPACT ANALYSIS METHODOLOGY	37

Executive Summary

The *Science and Technology Policy Council* decided in 2007 to establish a strategic policy aimed at promoting centres of excellence (CoEs) and cluster development in Iceland. The goal was for the centres to become outstanding in an international context and meet the following objectives:

- Promote scientific and technological research in the respective fields of the centres;
- Encourage effective cooperation between the various actors at national and international levels; and
- Encourage value creation and investment in research and innovation in the economy.

Rannís was tasked with managing the implementation of the policy and issued a call that led to the establishment of three CoEs:

- The Centre of Excellence in Gender Equality and Diversity Research (EDDA);
- The International Geothermal Research Cluster (GEOthermal Research Group, GEORG); and
- The Icelandic Institute for Intelligent Machines (IIIM; Vitvélustofnun Íslands ses).

The Centres began operating in 2009 and the last disbursement from *Rannís* was for the 2015/2016 fiscal year.

As all three CoEs are still in operation, there is an opportunity to conduct an impact analysis to evaluate the contribution of the CoEs to research and development in Iceland. The purpose of this impact analysis was to analyse the academic, social and economic impacts of the existing CoEs in order to inform potential future governmental emphasis on CoEs in general, and to provide recommendations on how to promote these types of centres. The objectives of this impact analysis were to investigate if and how the existing CoEs have:

- Promoted research in their respective fields;
- Had effective national cooperation between institutions in different sectors of society;
- Created value and investment in research and innovation that meets the needs of Icelandic society and its economy; and
- Had effective participation in international cooperation.

Methods: The main methods used in this impact analysis were:

- Quantitative methods to analyse the research contributions of the CoEs reflected in publications; key media coverage of the Centres; and the Centres' funding sources after the support from the strategic CoE policy ended.
- Qualitative interviews to gather further data on the impact of the Centres where an emphasis was placed on receiving inputs from experts who observed the Centres from very different perspectives. The interviews were with: Directors of the Centres, other members of the Centres, Icelandic stakeholders active in the fields the Centres cover, a *Rannís* representative, and international experts in the fields of the Centres. A total of 35 interviews were conducted.

Brief description of the Centres: EDDA was, and is, led by the *University of Iceland* and received 35 million ISK a year during the seven years of the grant's operation. It has a wide focus with its main objective to be a platform for interdisciplinary critical contemporary research on (in)equality and diversity; societal and political ruptures; the welfare state; and security and development.

GEORG was initially led by the *University of Iceland* and received 70 million ISK a year from the CoE initiative, during the seven years of the operation of the grant. Its main objectives were to build a sustainable cooperation platform and to build bridges between research on geothermal energy and its applications. After the CoE funding ended GEORG became an independent non-profit organisation.

The IIIM was initially led by the *Reykjavík University* and received 55 million ISK a year during the duration of the grant. Its main objective was to build bridges between research in academia on artificial intelligence (AI), robotics and simulations and the application of these technologies by industry. Shortly after being established the IIIM became a non-profit organisation.

Contributions to research: The Centres have promoted scientific and technological research in their respective fields and their work has led to a sizable number of academic publications. EDDA is the Centre that puts the highest emphasis on academic research and has had the largest publication levels with a strong focus on gender equality, social justice and welfare issues. GEORG has played a pioneering role in fostering research on deep geothermal drilling and IIIM has spearheaded research on applied AI in Iceland. EDDA and GEORG have, through their grants to emerging researchers, built up communities of researchers focused on their respective themes in Iceland. However, the Centres seem to have reduced their contribution to knowledge production in recent years with the rate of the Centres' publications decreasing after the CoE funding ended.

Impacts on domestic cooperation: The Centres have encouraged effective domestic cooperation between various actors. GEORG has played a strong unifying role in the geothermal sector and encouraged close collaboration between universities, and the geothermal industry. This collaboration has made it possible for the sector to engage in large-scale projects managed by GEORG. IIIM works across sectors and is thus not likely to play a unifying role in a specific sector. It has placed an emphasis in its work to provide technological solutions to firms and other organisations and spread the use of AI, robotics, and simulations by organisations in Iceland to promote economic development. EDDA has collaborated with ministries and other governmental entities to promote social development in various areas. After the economic collapse in 2008, this was a particularly important contribution. All three centres have, in different ways, encouraged integrations between research and implementation. Their efforts early on to support emerging researchers have had considerable domestic capacity building impacts in their respective fields.

Impacts on value creation. The three Centres have all had a strong focus on value creation and on social and economic impact in Iceland. Whereas many CoEs have solely an academic focus, implementation has been at the forefront of the agenda of these three Centres. By

being a third-party, GEORG has provided an important platform for the cooperation of energy firms in Iceland. The cooperation has directly strengthened their development, particularly in areas related to deep geothermal drilling. The large-scale European cooperation projects that GEORG has led have also benefited the operation of Icelandic energy firms and attracted funding and expertise for their research and development endeavours. The further plans of GEORG in deep geothermal drilling are highly likely to have extensive future value creation. This is an uncharted territory that reflects highly novel developments.

When IIIM was established, the recognition of AI was limited among Icelandic industries. Now it is becoming clear that firms and other organisations need to harness this enabling technology. It is highly valuable to have a critical mass of experts who have experience in working with industry in value creation that are closely aligned to the needs of Icelandic organisations. EDDA played a large role in contributing to public policy projects by providing direction to the reconstruction after the economic collapse. It is continuing this work and advising governments in the fields of social and gender equality, security issues, constitution-making and the Arctic. Both GEORG and IIIM have further contributed to start-up developments in Iceland. Some of these firms have already generated extensive income for the Icelandic economy with the value of some of the firms exceeding a billion ISK.

The CoEs have also contributed to value creation by encouraging research-informed dialogue in Iceland. EDDA and the IIIM have been particularly active in this public dialogue. The Centres outreach activities have, however, diminished in recent years partly due to lack of funds. As the Centres cover issues of high importance to Iceland, it is important for them to continue fostering public dialogue.

Impact on international cooperation: All Centres have played important roles in international knowledge creation and implementation in their respective fields. On the global scene, the Centres all represent novel areas with exciting possibilities, including deep geothermal drilling; analyses of the welfare state and the me-too movement; and AI self-supervised cumulated learning. According to EDDA's representatives, one of the Centre's outputs is the *GRÓ-GEST (Gender Equality, Studies and Training Program)* which is under the auspices of *UNESCO* but directed by EDDA's Director. It provides training to promote gender equality and social justice focused on low income, conflict, and post-conflict countries. The program reflects Iceland's strong international reputation in this area.

As a result of the formation of the three Centres, Iceland has played a large role in their respective fields. By supporting the creation of a critical mass of people working in the areas of the Centres, Iceland's international contributions and impacts have been amplified.

Recommendations

To support new CoEs

- Considering the beneficial experience of the three CoEs, the *Government of Iceland* should consider the CoE model to advance research and innovation in Iceland on topics of national interest.

- To moderate the financial demands of the CoE initiative, the government needs to choose carefully new CoEs to support and limit the number of centres it supports to no more than three to four. There have to be some domestic strengths in the focal fields of the centres that can be built upon.

To manage the new CoEs

- To promote the CoEs' sustainability and their efforts to seek alternative funding, the government should consider tapered financing where full financing is offered for the first years of the operation of the CoEs but is tapered down for the remaining years.
- To ensure public accountability any new CoE initiatives should include clear instructions on what the funding can be used for and have a structured yearly reporting mechanism.
- To protect the government's investment in the CoEs, it is important, towards the end of the funding period of the CoEs, to evaluate the impacts of the Centres and explore their potential for being sustainable.

To encourage outreach and capacity building

- To reach varied audiences and encourage national dialogue, outreach should be an important component of each CoE.
- With the positive experience of capacity building efforts of the existing Centres, the government should encourage the CoEs to engage in capacity building efforts attuned to the demands in Iceland for human resources in the focal fields of the Centres.
- To reap continued benefits from the existing Centres and encourage further outreach activities, the *Government of Iceland* should consider providing a relatively small amount of financial support to the existing Centres to fund outreach and other activities that are not financed by project-based funding.

To encourage stakeholders' involvement

- To encourage closer alignments between the CoEs and their stakeholders, the government should encourage the new CoEs to form close ties with industries or other stakeholders whose work can be informed by the research and expertise of the CoEs.
- To strengthen the ties and knowledge flows between the *Government of Iceland* and the CoEs, the government should prescribe that a panel or advisory board is formed for each Centre with representatives from ministries or other governmental bodies relevant to the work of the CoEs.
- In order to be attuned to the needs and preferences of the general public, the government should recommend that the CoEs consider ways to engage the general population in their work.

ACKNOWLEDGEMENT

The author appreciates the opportunity to conduct this impact analysis and is grateful for the support provided by *Rannís* to carry it out and produce this report. Special thanks go to Sigurður Óli Sigurðsson for thoughtful advice on designing this project and critical input when writing up the results and to Sigurður Björnsson and Ragnhildur G. Gunnarsdóttir for all their assistance. I am also deeply grateful to the Directors of the Centres of Excellence, Irma J. Erlingsdóttir (EDDA), Hjalti P. Ingólfsson (GEORG) and Kristinn R. Thórisson (IIIM) for patiently responding to all kinds of information requests throughout the process of this impact analysis and for generously sharing their experience and expertise. My gratitude is also extended to the Chairs of the Centres' Boards, other members of the Centres, stakeholders in Iceland and international experts who, despite hectic schedules, were more than forthcoming with their time and insights. Many thanks go also to Baldvin M. Zariob at the *University of Iceland* for providing publication and other data needed for this work. Any possible errors in this report are solely those of the author. The views expressed herein do not necessarily represent those of *Rannís*.

1. Introduction

1.1 Background

At its meeting in December 2007, the *Science and Technology Policy Council* decided to establish the *Strategic Policy 2009-2015 for Centres of Excellence and Clusters*.¹ This was originally introduced within the framework of the *Law on Public Support for Scientific Research*.² The rationale for this initiative was that Icelandic society was experiencing several challenges demanding strength in research and innovation to address. Strategic efforts with close cooperation between firms, universities, research organisations, public entities, and other stakeholders would be needed to overcome these challenges. The Council thus decided to organise a competitive call for proposals for the creation of three to four CoEs. A two-stage process was to be followed. In the first stage, an open call for a *Letter of Intent* was announced. Ten groups would then be given the opportunity to submit a full application based on *Letters of Intent* and these groups would receive a grant to work on the application. *Rannís* was tasked with organising the selection process and implementing the policy, in cooperation with the *Science and Technology Policy Council*.

The goal was for the CoEs to become outstanding in an international context. The objectives were to:

- Promote scientific and technological research;
- Encourage effective cooperation between the various actors at national and international levels; and
- Encourage value creation and investment in research and innovation in the economy.

The call for the establishment of the CoEs was issued in April, 2008³. *Rannís* received 82 *Letters of Intent*. Of those, 10 were invited to submit a full application. Three applications were then accepted and received funding from the initiative:

- Centre of Excellence in Gender Equality and Diversity Research (EDDA);
- International Geothermal Research Cluster (GEOthermal Research Group, GEORG); and
- The Icelandic Institute for Intelligent Machines (IIIM; Vitvélastofnun Íslands ses).

The CoEs started their operation in mid-2009. It was a challenging time in Icelandic history, shortly after the financial collapse of 2008. The COEs received grants for seven

¹ Rannís (2008). Markáætlun 2009-2015 Um Öndvegissetur og Klasa (Strategic Plan 2009 – 2015 for Centre of Excellence and Clusters. <http://www.rannis.is/sjodir/markaaetlun-um-ondvegissetur-og-klasa/>

² Presented in Lög um opinberan stuðning við vísindaránnsóknir (Law on Public Support for Scientific Research) from 2003, Number 3.3. February <https://www.althingi.is/lagas/nuna/2003003.html>

³ Rannís (2009) Úthlutun úr markáætlun um öndvegissetur og klasa, <https://www.rannis.is/frettir/nr/1776>

years, with the last disbursement being in 2015/16. Since then, all the CoEs have continued their operations.

1.2 Purpose and objectives of the impact analysis

The purpose of this impact analysis was to evaluate the academic, social and economic impacts of the existing CoEs in order to inform potential governmental emphasis on CoEs in general, and to provide recommendations on how to promote CoEs. Emphasis was placed on analysing the academic impact of the CoEs but also their wider impact on innovation, and socio-economic development. The results of this analysis could, among other things, be useful for the policy-making of the newly formed *Science and Innovation Council*.⁴

The objectives of this impact analysis were to investigate if and how the CoEs have:

- Promoted research in their respective fields and effective participation in international cooperation;
- Had effective national cooperation between institutions in different sectors of society;
- Created value and investment in research and innovation that meets the needs of Icelandic society and its economy.

The following was also considered in the analysis:

- What main factors and conditions have shaped the extent to which the CoEs have been successful in promoting research and innovation in Iceland;
- The potential differences between the CoEs and what factors and conditions have shaped these differences;
- To what extent the structure of the CoEs has contributed to their impact;
- If and how the CoEs have contributed to gender equality; and
- What lessons can be learned about how CoEs in general become sustainable.

1.3 Methodology

Both quantitative and qualitative methods were used to address the objectives of this impact analysis.

The main methods used were:

- Bibliometric analysis of the publications of the CoEs from 2009 to 2022;
- Analysis of key media coverage on the CoEs from 2010 to 2016;
- Analysis of the CoEs' funding sources from 2017 to 2023;
- An interview with a Rannís representative who managed the CoE initiative;

⁴ Vísinda- og nýsköpunarráð, <https://www.stjornarradid.is/verkefni/visindi-nyskopun-og-rannsoknir/visinda-og-nyskopunarrad/>

- Interviews with CoEs' Directors and other members of each Centre to gather further data for the impact analysis (N = 15);
- Interviews with stakeholders in Iceland active in the Centres' respective fields (N = 10);
- Interviews with international experts active in the CoEs' respective fields (N = 10).

2. Brief Description of the CoEs

2.1 EDDA

EDDA is a platform for interdisciplinary critical contemporary research. It has a wide focus on research on (in)equality and diversity, societal and political ruptures, the welfare state, and security and development. EDDA's objectives are to:

- Stimulate critical thinking and innovative transdisciplinary approaches in the humanities and social science;
- Promote and support research activities, to offer research grants, and to provide academic facilities;
- Become a platform for interdisciplinary and transnational collaboration between academics, policy makers, governmental institutions, non-state and corporate actors;
- Have impact on knowledge production in academic research and on public policy and societal developments,⁵

EDDA's research agenda is informed by diverse scholarly frameworks in sociology, gender studies, history, literary criticism, geography, political science, philosophy, and cultural studies. It encompasses the following three research areas and six themes:

Area 1- The Politics of Anxiety

Theme 1: Conceptions of differences and renegotiations of equality;

Theme 2: Societal and political ruptures: Past ideologies, the politics of memory, and democratic renewal;

Area 2 - The Welfare State, Citizenship, and Social Justice

Theme 3: Societal change and human well-being;

Theme 4: Trajectories of social and economic inequalities;

Area 3 - Transnational Engagements: Conflict, Development and Sustainability

Theme 5: Transnational discourses on development, conflict, and security;

Theme 6: The geopolitics of climate change, representations of the "North," and regional and human development. ⁶

⁵ EDDA (2023). The EDDA Research Center, University of Iceland. Presentation to the Romanian National Council for Scientific Research

⁶ EDDA: Research Program. <https://edda.hi.is/research/>

A total of 35 million ISK a year were allocated to EDDA for seven years as a part of the CoE initiative. The application for EDDA was led by the *University of Iceland*. Its Steering Board is chaired by a faculty member from the *University of Iceland* and includes three other members from the university. EDDA has had the same chair since it was established. The Centre had an Advisory Board since it was established until 2014, with representation both from within Iceland and from the *University of Linköping* and the *University of Utrecht*. The Advisory Board also had an entrepreneur and a representative from either the *Ministry of Foreign Affairs* or the *Prime Minister Office*. The role of the Advisory Board was to strengthen ties with partner institutions and enterprises, assist in the building of research clusters, approve grants awarded by the Centre and seek additional grant resources. EDDA's Director is the faculty member at the *University of Iceland* who led the application for the Centre.

EDDA has placed a central focus on academic research in its operation. Early on, it arranged calls for proposals in its areas of research where it mostly supported research projects of students and early career researchers. EDDA awarded a total of 40 research grants to address its three research areas from various different perspectives.⁷ It also has emphasised policy impacts and has worked on a number of projects with ministries in Iceland and with the *City of Reykjavík* and provided consultations based on its research. The Centre played a large role in contributing to public policy projects by providing direction to the reconstruction after the economic collapse. The main areas EDDA provides advice on are in the fields of social and gender equality, welfare issues, security issues, constitution-making and the Arctic.⁸ Outreach has also been a large component of EDDA's work, often involving collaboration with ministries or other organisations in Iceland. According to EDDA's representatives, one of the Centre's outputs is the *GRÓ-GEST (Gender Equality, Studies and Training Program)* which is under the auspices of *UNESCO* but directed by EDDA's Director. Its mission is "to use a multidisciplinary approach to promote gender equality and social justice in low income, conflict and post-conflict countries."⁹

2.2 GEORG

GEORG's objectives were to build a sustainable cooperation platform and to build bridges between research on geothermal energy and its applications. Its goals were to:

- "Reduce worldwide greenhouse gas emissions by contributing to a significant increase in sustainable energy production/utilization from geothermal sources.
- Make Iceland a case study for a near-total energy independent and carbon-neutral society.
- Create a platform for entrepreneurship and export of geothermal energy resources and education, both for partners in the group and in the ensuing creative environment established through its national and international operations.

⁷ EDDA (2017). Annual Report 2016.

⁸ EDDA (2023). The EDDA Research Center, University of Iceland. Presentation to the Romanian National Council for Scientific Research

⁹ GRÓ-GEST (2024). About: Mission. <https://www.grocentre.is/gest/about-us/mission-gest>

- Contribute to the Sustainable Development Goals (SGD7, SDG9 and SDG13 – respectively related to affordable and clean energy, industry, innovation and infrastructure, and climate action).¹⁰

A total of 70 million ISK were allocated each year for seven years to GEORG as a part of the CoE and clusters initiative. The original application for establishing GEORG was led by the *University of Iceland*. GEORG has 22 partners that represent diverse organisations working in the geothermal sector in Iceland¹¹. They include universities and research organisations; private sector and energy firms; as well as organisations from France, Germany, New Zealand, Sweden, the US and the UN. GEORG has a Governing Board with representation by up to nine of its partners. It also has a Science Academy, which provides advice for research policy and priority setting, and approves projects, funding policy and selection procedures of the grants that GEORG has allocated to emerging researchers in the field. The Chair of its Governing Board has been the same from the beginning, a faculty member from *the University of Iceland*. GEORG hired early on a Managing Director in a fulltime position. He has an engineering background and still manages GEORG.

As a platform for cooperation, the main services GEORG provides are:

- Project management for large international geothermal research projects and networks;
- Strategy and policy in shaping and supporting programmes aimed at accelerating the utilisation of geothermal with a strong focus on Europe.;
- Grant application assistance at the European and international levels; and
- Outreach and dissemination.

GEORG also has supported three accelerators to encourage start-up development in the geothermal field and directly supported 21 start-ups.^{12,13} GEORG emphasized capacity building in its early years and organized several calls for proposals supporting student research.

GEORG has actively supported Iceland's participation in the EU Framework programmes by working on applications and managing several large-scale grants, as well as by participating in committees such as the *European Technology & Innovation Platform on Geothermal (ETIP-Geothermal)* and the *HORIZON 2020 Energy Committee*. The participation in the platform and the committee makes it possible for GEORG to influence the EU's agenda in energy research. GEORG has also provided management services for what is now called the *GEOTHERMICA* Initiative, a network of 20 geothermal research and innovation entities in 16 countries.

¹⁰ GEORG: About GEORG. <https://georg.cluster.is/about-georg/>

¹¹ Stoklosa, A. W. (2023). GEORG: Geothermal Research Cluster. Presentation TCI visit, 7.Nov. 2023

¹² Garðarson, S. M. (2018). Áhrif markáætlunar í að styrkja stöðu Íslands í alþjóðlega jarðhitageiranum. Rannsóknáning Rannís og Vísinda- og tækniráðs 2018. <https://www.rannis.is/media/rannsoknathing/georg-rannsoknathing-2018-final.pdf>;

¹³ Garðarson, S. M. (2024). GEORG: Rannsóknaklasi í jarðvarma. GEORG's Gleði, 15. Mars 2024.

GEORG started out as a centre based at the *University of Iceland*, but since 2016 it has operated as an independent non-profit organisation. GEORG's largest project was the *DEEPEGS*, supported by a Horizon 2020 grant, which has successfully drilled the deepest well in Iceland on the *Reykjanes* peninsula. Now GEORG is leading the development of the *Krafla Magma Testbed* project, with a group of international experts and stakeholders. It is intended to be the world's first international facility for magma observation and experiments, situated in Northern Iceland.

2.3 IIIM/ Vitvélastofnun Íslands

The IIIM has a strong emphasis on building bridges between research in academia on artificial intelligence (AI), robotics and simulations and the application of these technologies by firms and other organisations. IIIM's main goals are to:

1. Create a self-sustaining, internationally known research centre;
2. Advance the fields of artificial intelligence and simulation, and their broad fields of application;
3. Provide industrial participants with tangible returns;
4. Facilitate international academic collaboration and industrial collaboration;
5. Generate and keep high-technology industry in Iceland.¹⁴

A total of 55 million ISK were allocated yearly to IIIM for the seven years of the operation of the policy promoting CoEs and clusters. The application for IIIM was led by the *Reykjavik University* but shortly after its foundation, IIIM became a non-profit organisation, based at the University but with independent status. A 10 year contract between the two institutions was signed to solidify their relationship. IIIM's founding members spanned representation from academia and industry. They included representatives of the *Reykjavik University's Centre for Analysis and Design of Intelligent Agents (CADIA)*, its *School of Computer Science* and the gaming company *CCP*. IIIM's Governing Board is chaired by a representative from a law firm in Iceland who has extensive experience in working with technology-based firms. He has been a board member since IIIM was established and chaired it since 2011. The board also has regularly had members that represent *Reykjavik University* and technology intensive firms in the country. IIIM also has an Advisory Board with representation both from within Iceland and organisations such as the *Massachusetts Institute of Technology (MIT)* and the *German Research Center for Artificial Intelligence (DFKI)*. IIIM's Director is the faculty member at the *Reykjavik University* who led the original application for the Centre.

The main activities of IIIM involve:

- Research and development on AI, robotics, and simulation;
- Providing analysis on technology-based solutions for industry and other organisations;
- Developing tools and methods to address challenges by its clients; and
- Outreach activities.

¹⁴ IIIM (2017). IIIM Annual Operations Report 2016.

To work on its projects, IIIM has attracted experts in the field from outside of Iceland. The CoE had, by 2020, worked on over 50 projects with organisations in diverse fields, as well as with public sector organisations.¹⁵ IIIM clients are mostly based in Iceland but also come from other countries. The private sector firms include *Össur*, *Trackwell*, and *CISCO Systems*, and public sector entities such as the *Icelandic Parliament*, *National Commissioner of Police in Iceland*, and *Statistics Iceland*. The CoE is also working on a project for a globally leading researcher at *Reykjavík University* on youth addiction. It involves developing a tool that would facilitate transdisciplinary collaboration and lead to improving modeling, enabling public policy making evaluation, and enhance social science education.¹⁶ The potential of AI and simulation technologies can be applied in all walks of lives, which reflects the diversity of fields IIIM has worked in.

3. Contributions to research

The CoEs have, since they were established, contributed considerably to research. Still, they differ vastly in the emphasis they place on research as a key activity.

3.1 EDDA's Publications

EDDA has actively promoted publications on its focal issues (see Figure 3.1). Publications started early on by those affiliated with the CoE, with 2010 and 2011 being the years with the highest numbers of publications. This relatively strong publication activity early on may partly be due to the research grants EDDA allocated, mostly to early career researchers, at that time. There is also a spike in publications in 2016, at the end of the CoE funding. However, EDDA's publication rates have declined in the last two years included in the analysis.

Book chapters were the most common type of EDDA publication (45%), followed by articles (33%), conference papers (9%), reports (6%) and books (5%). The books are mostly edited books. The publication pattern by EDDA affiliates is quite different from the other two CoEs, with a relatively heavy emphasis on publishing books and book chapters. Sole authored publications are also quite common by EDDA researchers, whereas those are almost non-existent for the other two CoEs. These publication patterns are particularly common in the humanities and many of EDDA's researchers come from humanities fields. There are also many more publications in Icelandic by EDDA's researchers than by the other CoEs.

¹⁵ Þórisson, K. R. (2021). *Vitvélstofnun Íslands: Valin verkedni 2012-2020*.

¹⁶ Basílio, S, Thórisson, K.R., Carvalho, G., Meyers, C.U., Burger, B, Guðjónsson, S., Hlynsson, K., Sigfúsdóttir, I.D., Meyer, C., Kristjánsson, Á., and Ólafsson, S. (2023). *Agent-Based Simulation Framework, for Substance Abuse Prevention in Youth*. Technical Report IIIMTR-20230901

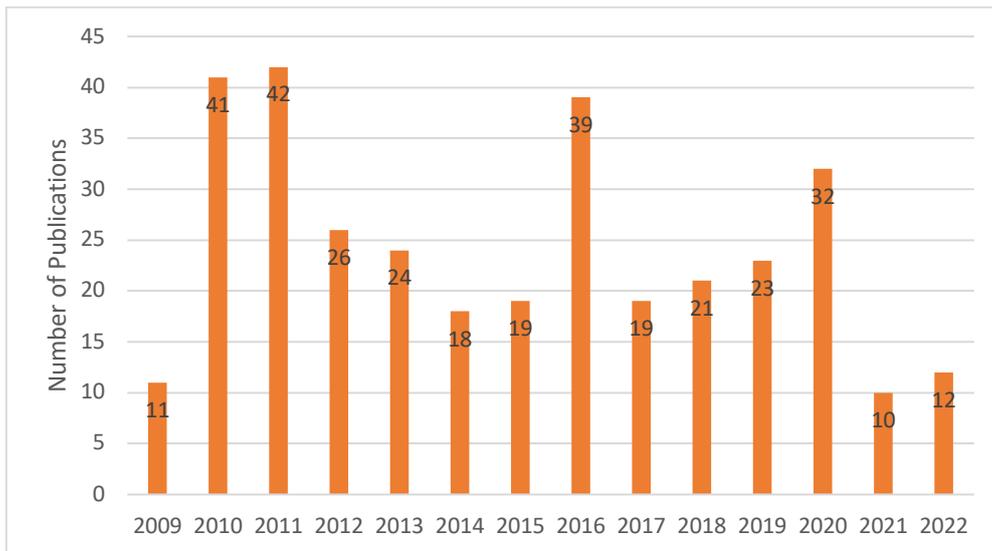


Figure 3.1 EDDA's Publications from 2009 to 2022¹⁷

Less than 20% of EDDA's publications (books, book chapters, articles, and conference papers) included explicit EDDA affiliations of authors. Often book chapters do not include affiliation of the authors but instead have a separate section describing contributors. If EDDA was mentioned in these latter descriptions, we counted them as an EDDA affiliation.

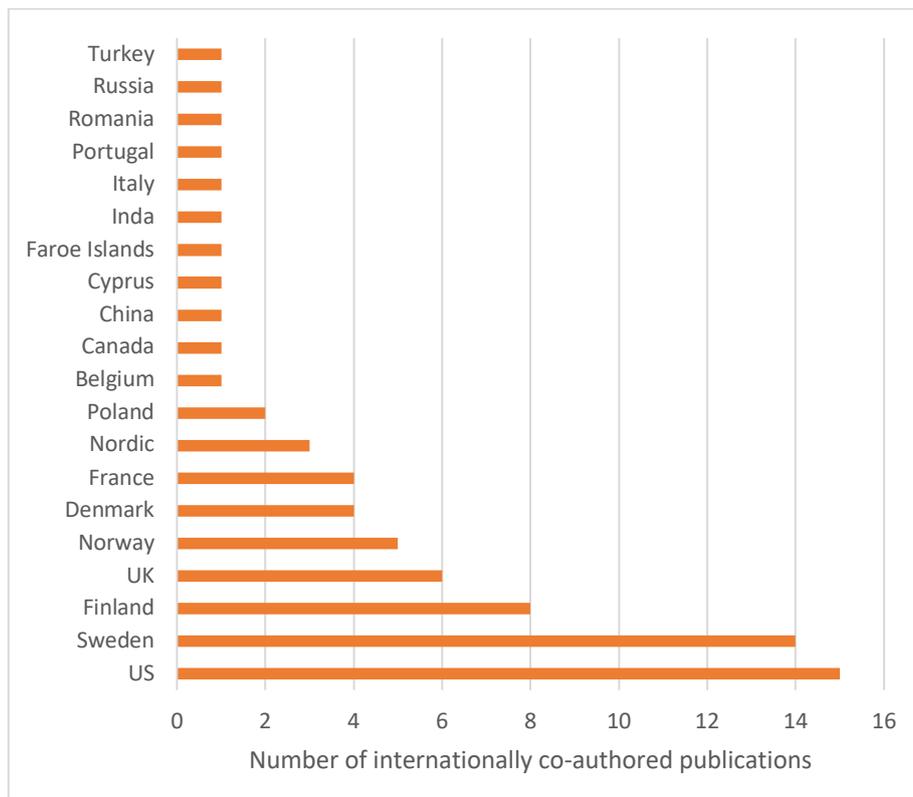


Figure 3.2. Main international collaborators for EDDA's publications 2009-2022¹⁵

¹⁷ Source: An analysis done by Small Globe on publication data from EDDA's websites and from the University of Iceland. Division of Science and Innovation

We looked at the proportion of EDDA’s publications including authors from institutes in Iceland other than the *University of Iceland* as a proxy for EDDA’s role in encouraging domestic collaboration. Only a few EDDA publications, or about 5%, involved domestic collaboration in the sense of including authors outside of the *University of Iceland*. We also measured international collaboration as a co-authorship between EDDA’s researchers and authors affiliated with institutions outside of Iceland and around 17% of publications had international co-authorship. The US is the main international collaborator of EDDA researchers (Figure 3.2).¹⁸ In the case of EDDA’s publications, Sweden is almost as frequent a collaborator as the US. In general, collaboration with Nordic countries is much more common with EDDA researchers than with the researchers affiliated with the other two CoEs. Measuring domestic and international cooperation through co-authorship is, however, likely to underestimate research collaboration in the humanities, as co-authoring publications is not as common a practice among these researchers as with researchers at the other CoEs. As will be discussed in section five, EDDA’s researchers have been engaged extensively in international collaboration.

3.2 GEORG’s publications

As for the number of publications attributed to GEORG, there is a relatively steep increase in publications during the early years of GEORG, whereas a decline is evident since 2016. It is possible that we are observing the effect of GEORG allocating grants mostly to new researchers in the field during its early years of operation. As a result, there was a relatively high level of publications early on after the CoE was established. It is also possible that GEORG stopped tracking the publications after the CoE grant ended as GEORG was no longer required to report publications to Rannís after that date.

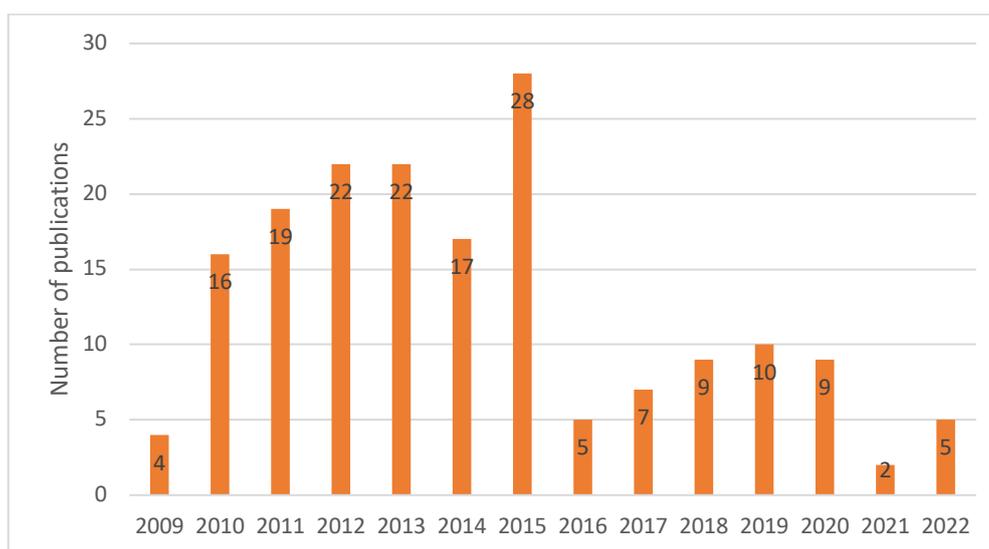


Figure 3.3. GEORG’s Publications from 2009 to 2022¹⁹

¹⁸ In some books published by Nordic organisations, no author affiliation was included. For those we classified the EDDA collaboration as being Nordic.

¹⁹ Source: An analysis done by Small Globe on publication data from GEORG’s Websites and the Book of Publications DEEPEGS Geothermal, 2020.

Of those publications, articles published in international peer reviewed journals, were most common (41%), followed by conference papers (40%), reports (17%) and 2% were book chapters (2%). We looked further at the articles, conference papers and book chapters and observed that approximately 8% of these publications listed GEORG as an affiliation. It appears that members of GEORG only list their primary affiliation in their publications. However, when members of the core group based at the office of GEORG publishes papers, they typically list GEORG as their affiliation.

We looked also at the extent to which the articles, conference papers and book chapters included authors that were based at domestic organisations other than the *University of Iceland*. This is a proxy for measuring the extent that GEORG encouraged collaboration between domestic organisations. The results show significant involvement of diverse organisations in Iceland, with approximately 48% of the articles including authors not affiliated with the *University of Iceland*. We looked at international co-authorship as a proxy for international collaboration. The international involvement of GEORG’s publications was also considerable, with around 37% of them involving international collaboration. The main collaborating countries were the United States, France, and Germany. All three countries are members of the *GEOTHERMICA Initiative*, and the latter two reflect the strong emphasis on European cooperation by GEORG.

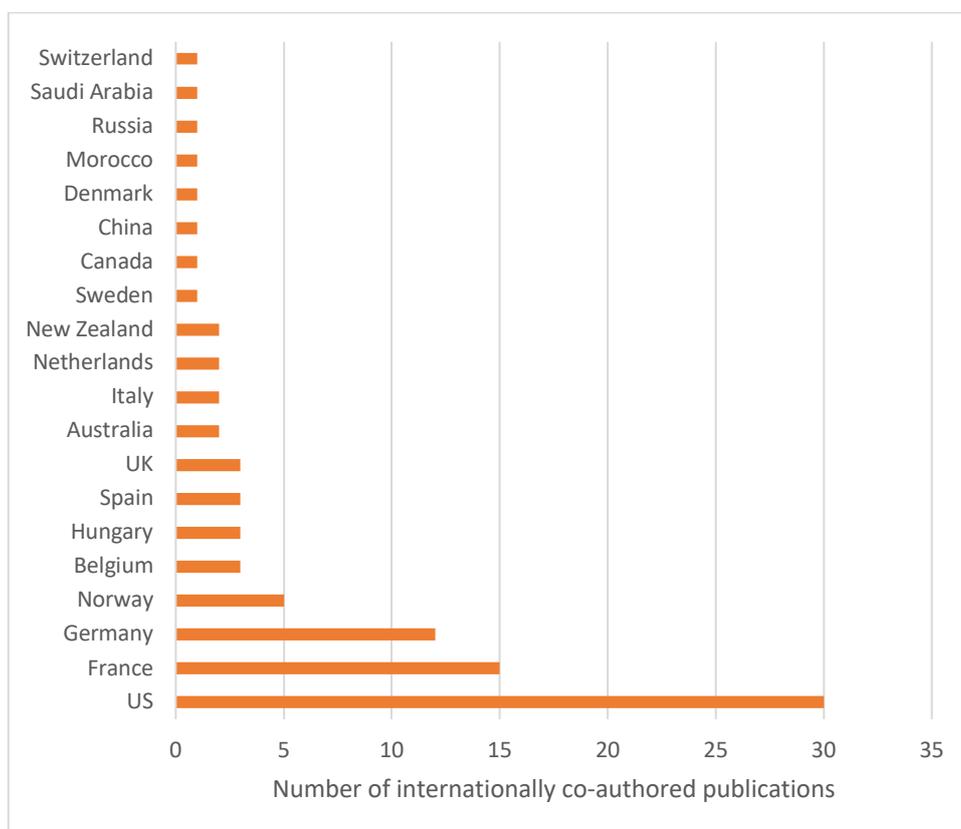


Figure 3.4. Main international collaborators for GEORG’s publications 2009 to 2022²⁰

²⁰ Source: Small Globe analysis on publication data,

GEORG's main objective is not to produce scientific publications, but to promote research and development activities in geothermal fields. Staff members of GEORG facilitate research but are typically not direct participants in research projects.

3.3 IIIM's Publications

The IIIM publication levels are moderate, and their numbers fluctuate from year to year (see Figure 3.5). The largest number of publications appeared in 2012 and 2013 and the lowest number of publications was in 2019 when IIIM published only two articles. IIIM did not provide grants to researchers, which may have resulted in relatively fewer publications during the first years of operations as compared to the other two CoEs.

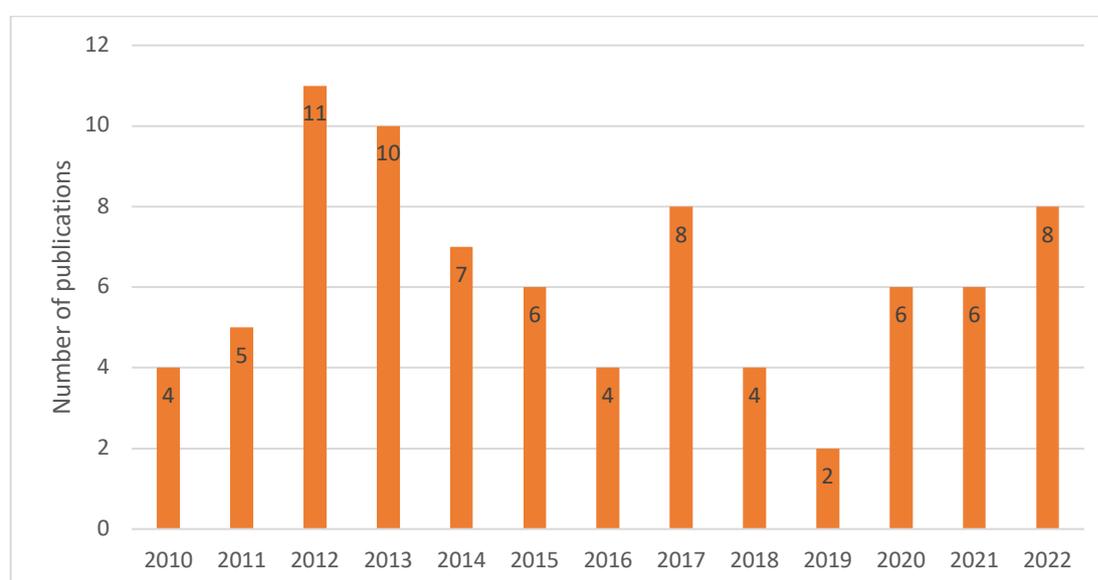


Figure 3.5 IIIM's Publications from 2010 to 2022²¹

Conference papers were the main type of publication (61%), followed by articles (18%) and reports (8%). In addition, there were a few editorials and one review. All IIIM publications surveyed included the CoE as an affiliation of at least one author. A large proportion, or around 76%, of the publications, were authored or co-authored by its Director, which shows his central role in the Centre's research output.

We looked at the extent that the conference papers, articles, and book chapters involved domestic authorship outside of the *Reykjavik University*. Only 3% of the papers involved other Icelandic organisations than IIIM, so the CoE has not encouraged much domestic collaboration in its research activities. We further looked at the level of international co-

²¹ Source: An analysis by Small Globe on publication data from IIIM's Websites.

authorship in the Centre’s publications as a proxy for international collaboration. The publications had extensive international co-authorship with 45% of the papers involving authors from outside Iceland. The United States is the most frequent collaborator (Figure 3.6) but IIIM also collaborates widely, with other frequent collaborators coming from Italy, Spain and Switzerland

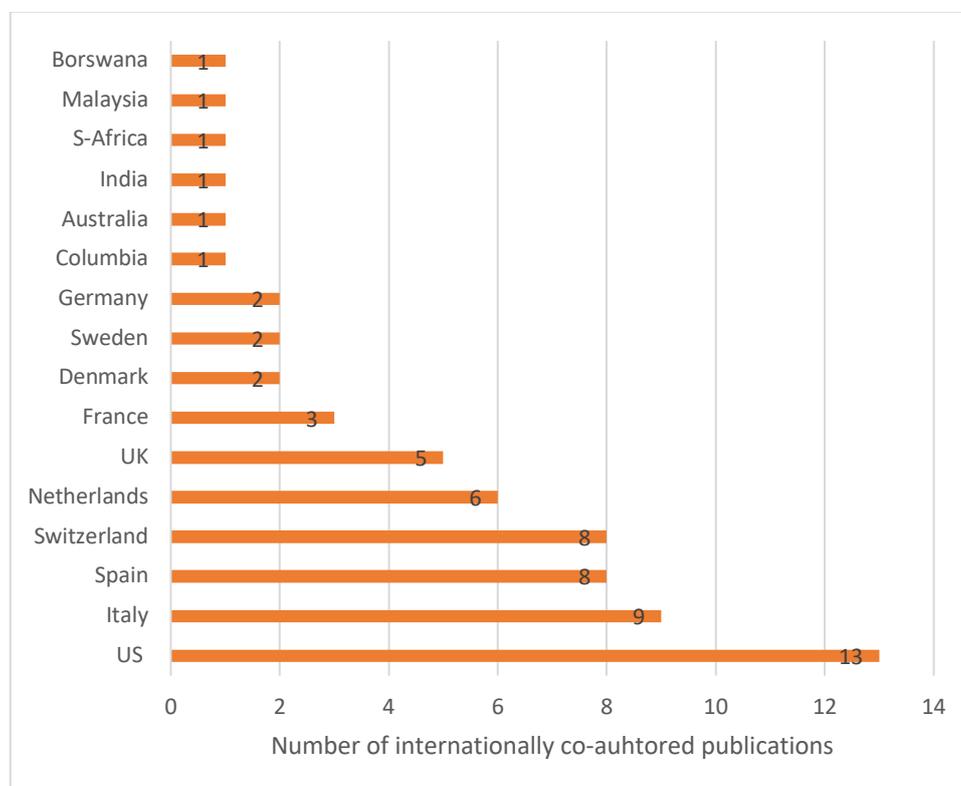


Figure 3.6. Main international collaborators for IIIM’s publications 2010 to 2022²²

The publication analysis shows a considerable contribution to academic research by all three CoEs. EDDA is the Centre with the most output, which reflects its emphasis on academic research. Through its grants to emerging researcher, EDDA built up a community of researchers focused on the Centre’s themes. What also seems to be happening is that when the CoE funding ceased, the academic contributions, particularly of GEORG and EDDA, have reduced. This analysis also reflects the heavy emphasis GEORG places on domestic collaboration. Because of very different publication patterns across the fields that the CoEs’ researchers belong to, we cannot say, based on publication analyses alone, that the other Centres do not have active domestic collaboration. It is also evident that all the CoEs are extensively engaged in international collaboration.

²² Source: Small Globe analysis on publication data,

4. Main Domestic Impacts of the Three CoEs

We evaluated the main domestic impacts of the CoEs through interviews with various experts in Iceland corroborated with the review of annual reports from the Centres and other available material on the Centres, including from websites and presentations.

4.1 Impacts on training and capacity building

Training the next generation of researchers in their respective fields has been an impact of the CoEs. As mentioned above, both EDDA and GEORG organised calls for proposals early on in their operation. As EDDA's representative said: *"We needed to start by building the community."* So instead of putting all the resources in supporting the research of EDDA's core team, the decision was to provide seed funding to a much larger group. A GEORG representative expressed the same sentiment that providing seed funding was important for the geothermal sector. One of the main drivers for GEORG was the lack of regeneration in the sector. Those who had been pioneering the use of geothermal energy in the country were getting close to retirement around the time the Centre was formed and there was a lack of a younger generations in the sector.

By 2018, GEORG had supported the research of 38 masters' students, 35 PhD students, 4 postdoctoral fellows and 2 undergraduates.^{23,24} One start-up firm in active operation is *Carbfix*, a world leader in technologies for capturing carbon dioxide, established by a team who had received an early research grant from GEORG. EDDA organised three calls for proposals and through them supported 40 students/early career researchers.²⁵ As mentioned above, IIM did not organize calls for proposals, but supported capacity building in the field through other means. Students at *Reykjavík University* joined IIM-projects on a short-term basis, often as summer students. This exposed them to research and new ideas in the field and to the needs of firms for technological solutions. IIM also attracted student interns from abroad.

The interviewees underscored that this capacity building is currently having an impact in Iceland. Those who were supported by grants and other means early on in the developments of the CoEs have now taken up important positions, in public organisations, including universities and private sector firms. As one GEORG representative noted: *"One of the things I am proudest of is seeing that the people we supported in their studies, they are the ones who are running the sector today."*

²³ Garðarson, S. M. (2018). Áhrif markáætlunar í að styrkja stöðu Íslands í alþjóðlega jarðhitageiranum. Rannsóknáning Rannís og Vísinda- og tækniráðs 2018. <https://www.rannis.is/media/rannsoknathing/georg-rannsoknathing-2018-final.pdf>

²⁴ Garðarson, S. M. (2024). GEORG: Rannsóknaklasi í jarðvarma. GEORG's Gleði, 15. Mars 2024.

²⁵ EDDA (2017) Annual Report 2016.

4.2 Impact on national dialogue

As mentioned above, the CoEs have all emphasised outreach activities and influencing the dialogue in Iceland on their respective fields and focus areas. To do so, they have used various tools, such as open houses, newsletters, websites, social media, seminars, workshops, and national and international conferences.

The CoEs started their operation shortly after the financial collapse of 2008. For EDDA this was, a great opportunity to analyse the new reality that Icelandic society was going through and to examine social and political reconstruction potentials and participatory democratic processes. With an increasing public awareness of the importance of reviewing the social and political systems in Iceland this was also an opportunity for EDDA to engage with the general public and policy-makers to discuss the challenges that society was going through. EDDA has been active in organising events and during its first seven years it organised a total of 76 conferences workshops, symposia and seminars aimed at both academic audiences and the general public.²⁶ With establishing EDDA, there was a critical mass of people working on these topics in the country. By being a CoE, their visibility was enhanced and EDDA's experts could be more easily approached.

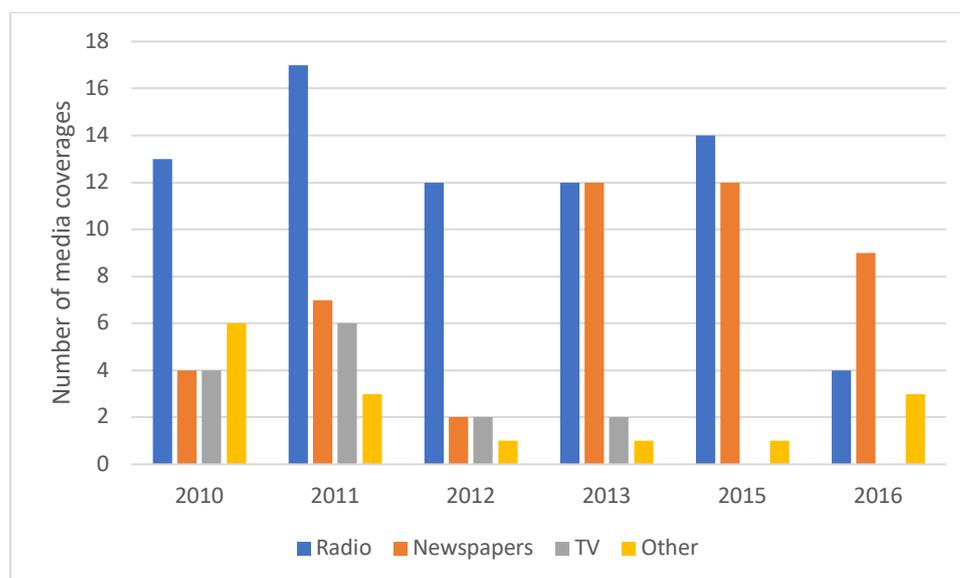


Figure 4.1 EDDA media coverage 2010-2016²⁷

As can be seen in Figure 4.1, EDDA's activities were covered considerably in media, particularly in radio and newspapers. Typically, this media coverage would involve discussing

²⁶ EDDA (2017) Annual Report 2016.

²⁷ "Other" refers to magazines and online media. Information on media coverage was missing in EDDA's Annual Report for 2014. Source: Small Globe's analysis of media data presented in EDDA's Annual Reports for 2010-2016.

research that EDDA’s researchers were conducting. When EDDA had international conferences there were also frequent interviews with international experts participating in the conferences, reflecting the input of international experts to the dialogue in Iceland through EDDA.

The media coverage on IIIM activities appears to be increasing during the time period, apart from the last year the Centre received the CoE funding. IIIM organised outreach activities, by, for example, regularly holding AI festivals, together with *CADIA*, and by publishing a newsletter. The AI festivals garnered quite a bit of interest with some attracting around 300 people. At the time IIIM started operation, in general there was not much media coverage on AI, robotics and related themes, neither in Iceland nor elsewhere. IIIM, therefore, didn’t benefit from a strong public interest in its activities. It wasn’t until around 2016 – 2017 that interest in AI in general started to increase.²⁸ One IIIM stakeholder remarked: *“Possibly the seed was planted a little bit too early in the spring. Then the AI summer came a bit later”*. IIIM was, thus, not likely to be helped by general interest in its areas of specialisation early on in its operation.

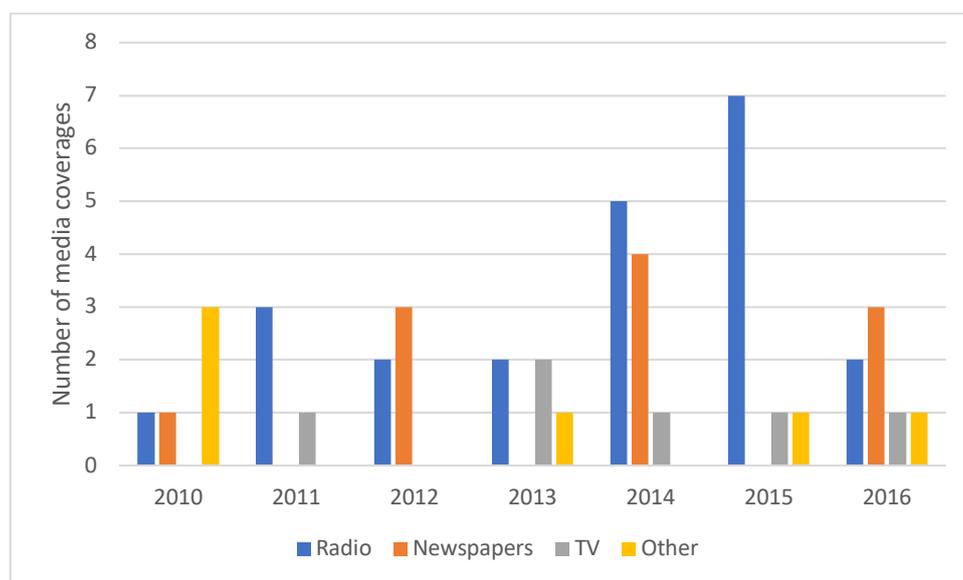


Figure 4.2 IIIM media coverage 2010-2016²⁹

GEORG did not include information on its coverage in Icelandic media as a part of its annual reporting during the reporting period, so we are unable to measure the extent of its coverage. The CoE developed regular outreach activities and, for example had annual open houses. While the topic of geothermal energy has been of interest to the general public in Iceland for decades, it is not likely to be of as much public interest as the topics that EDDA has been researching. The media attention is therefore likely to have been less for GEORG than for EDDA.

²⁸ Based on Google Trends searches, <https://trends.google.com/trends/explore?date=2010-01-01%202024-02-15&q=artificial%20intelligence&hl=en>

²⁹ Source: Small Globe’s analysis of media data presented in IIIM’s Annual Reports for 2010-2016.

Interview evidence suggested that after the CoE funding period, the Centres have had a very limited budget for outreach activities and thus their contributions to the public dialogue in Iceland have diminished. One director noted: *"It is extremely difficult to get funding for these kinds of activities. There are no grants earmarked for this and the outreach had to be cut to a large degree."* Several interviewees commented that they missed the outreach activities and felt that this had led to less interaction within their fields. One IIM stakeholder commented, for example about the AI festivals that were held, that they were: *"Really useful because you meet other firms who were considering the same issues"*. Not everyone agreed that lack of financing should deter organising outreach activities and argued that they could be continued with limited funding.

4.3 Wider societal impacts

Apart from impact on the dialogue in Iceland, there have been some other social impacts of the CoEs. By having a strong focus on social and political issues, EDDA has contributed in different ways to socio-political development in the country. As mentioned above, the applications for the CoEs were submitted before the economic collapse in Iceland and, their activities had to be scaled down to adjust to a smaller grant than planned. EDDA's team recognised that these were extraordinary times that they needed to respond to. As one EDDA member said: *"Everything was turned around and we sat down and realised we had to directly respond to this [the economic collapse] and use this project to do it.... This came totally at the right time for us and encouraged us. This was a very important moment"*. In response, they mapped the social effects of the economic collapse on many different groups. With EDDA's research there was, thus, detailed knowledge available about the impact of the collapse on different parts of society, that could inform the government's actions. This included looking at the impacts of the collapse on the welfare state and to compare Iceland's response to those of other countries. It further included research on the democratisation process and the development of a new constitution. With the collapse there was a search for new opportunities which included potential harnessing of the Arctic. EDDA's researchers were, therefore, also involved in examining Arctic issues and developing a new Arctic strategy for Iceland. The different parts of government were seeking out EDDA's researchers and asking about directions for dealing with this new reality.

Another example of societal impact is that early on in EDDA's operation, it provided support to an emerging researcher to focus on research on violence against women. The researcher has been able to continue this work and is now a faculty member at a university in Iceland after having completed both a PhD and a post-doctoral fellowship. Through this work, the researcher has been able to work with policy makers in developing an action plan to address violence against women and amend the legislative environment. These contributions were all informed by EDDA's research. Before EDDA, issues around violence against women were under-researched in the country. Continued support to this emerging researcher has, together with interest by policymakers, allowed this work to flourish and the researcher to mature and have direct impact.

It is not just EDDA that is focused on having societal impact. AI is an example of an enabling technology that can be used in a diversity of sectors. While many IIIM's projects seem to aim at economic gains, some are focused more on societal benefits, such as, work for the Icelandic Parliament, the work in finding people who are lost in the Icelandic interior or the ongoing work the Centre is doing on improving modeling of youth addiction. IIIM has also contributed to societal development by being one of the first AI centres to develop, in 2015, a Civilian AI Ethics Policy for Peaceful R&D.³⁰ There, the Centre declares its intention to advance scientific understanding and to enable the application of this knowledge for the benefit and betterment of humankind, to be ethical in all its conducts and not to accept military funding for its activities. When the policy was first presented it attracted international media attention as it was one of the first policies of this type globally.

While GEORG's mandate was not explicitly to engage with societal issues in Iceland, the Centre's activities by default include a societal element as geothermal energy is such a core part of Iceland's infrastructure.

By selecting a centre with a strong focus on researching gender and diversity issues, the *Strategic Initiative on Centres of Excellence and Clusters* from 2007 has undoubtedly had impacts on enhancing gender and diversity development in Iceland. The proportion of women on the CoEs' governing boards is 50% for EDDA, 33% for GEORG, and 40% for IIIM, and women have been hired to be in key positions in all three CoEs. All the Directors of the CoEs said they have paid attention to gender and diversity issues in running the CoEs and emphasised inclusion. For instance, when giving out the grants to emerging researchers, GEORG emphasised funding women researchers. One member of GEORG said: *"There were a lot of young women who got into it [the geothermal energy field] through the grants. Impressive women who now are powerful and in key positions."*

4.4 Economic impact

Both GEORG and IIIM have a strong private sector emphasis in their activities and include members and board members who are representatives of private sector firms. Firm representatives agreed that GEORG had contributed to economic impacts in Iceland. For example, the large-scale European projects attracted both substantial resources and expertise to the country which have strengthened the firms' operations. One firm representative noted: *"We don't have the manpower to look for ideas out in the world that could be of great use to us. We just don't have the capacity. But GEORG has this radar and can connect them with domestic actors."* The interviewees felt that even the smaller grants allocated to emerging researchers have had an economic value. They noted that many students have approached them about project ideas and the organisations have been able to direct those students to areas of economic importance to those organisations. Many energy firms in Iceland have hired GEORG's representatives or have on staff people that GEORG has supported earlier in their careers. Other economic contributions stem from the deep

³⁰ IIIM (2015). Civilian AI Policy. <https://www.iiim.is/2015/08/ethics-policy/>

geothermal drilling projects GEORG has been leading. It takes a while to harness the opportunities afforded by deep drilling for geothermal energy, but the projects have been accruing knowledge and experience that will facilitate harnessing Icelandic geothermal energy in future projects.

As noted above, IIMM has provided services to over 50 organisations, mostly in Iceland. Being a bridge between academic research and industrial needs is a core emphasis of IIMM. When talking to firms it became evident that firms in Iceland were interested in applying AI technologies. In the first years of the operation of IIMM, firms were more sceptical of the use of AI but by the end of the CoE funding period they have increasingly been approaching IIMM for technical solutions to their challenges. One firm representative stated: *"It is a key for firms to learn to use AI, to use it daily to develop products. They cannot just be consumers of the technology."* The interviewees felt that not even software firms would be likely to initially have the expertise or time in-house to harness AI for their operations. It has, thus, been important for firms in Iceland to be able to contact IIMM, a non-profit organisation, to gain access to specialised expertise. One service IIMM has offered to firms is to provide analysis of areas where the firms could effectively use AI and related technologies. As a part of this service IIMM would suggest a few ideas to harness the technologies that are closely adjusted to the firms needs and conditions.

There was generally a consensus among the interviewees of the importance of Iceland being active in research and development of AI technologies. *"It is a question about being doers, not just consumers.... It is important that we get a bit of the AI cake."* The need to adjust AI to Icelandic reality was emphasised by several interviewees. One representative of a firm that has worked with IIMM speculated that it would perhaps have been possible to access the expertise outside Iceland but noted: *"It would have been a much bigger and heavier project. The communication would not have been as easy, and the communication routes longer. It definitely would have been much more expensive."* When asked to summarise the impacts of the IIMM a firm representative noted that the impacts have been: *"Much more dissemination of AI solutions and a better understanding by firms that AI is not a threat but a tool."* By improving access to the digital technologies offered by IIMM, Icelandic firms have increased possibilities to harness AI to their products and processes and thus to reap significant economic impacts.

Whereas GEORG and IIMM are structured so as to facilitate a knowledge flow between academia and the private sector, this is not the case for EDDA. As EDDA is focused on humanities and social sciences, there is not potential for as much private sector engagement in their work. At the time EDDA was established, it would have been challenging to find an organisation whose work was relevant to its research focus. With new private sector developments, more firms are working on the subject areas of EDDA, such as in enhancing gender and diversity development or strengthening the democratic process. In Iceland a good example is *Alda*, a software firm, established in 2022, that is developing an analysis and training platform for diversity, equity, and inclusion (DEI). The firm analyses the DEI situation in public and private sector organisations and provides training. *Alda* has had some ties to the *University of Iceland* but a representative from the firm expressed interest in establishing ties

with EDDA. Closer links with firms working in research areas related to EDDA could potentially encourage more knowledge flow into private sector development.

Both GEORG and IIIM have included activities to encourage and strengthen start-up development in Iceland. GEORG, together with *Landsvirkjun*, *Arion-Bank*, *the Innovation Centre Iceland*, established *Startup Energy Reykjavík*. It is an investment program facilitated by *Klak Innovit* and the *Iceland Geothermal* and focused on energy-related businesses. *Startup Energy Reykjavík* provides seed funding and mentorship, as well as access to networks, in return for 10% equity.³¹ GEORG had supported the development of 21 start-up firms in the energy sector.³² According to interview evidence, at least three of those have flourished and have now created a value of over 1 billion ISK each.

IIIM has also supported the development of start-up firms. Together with *CADIA*, it offers the *High-Tech Highway*, which helps start-ups evaluate the technological options they can utilise and harness newest technology in software design, big data, AI and complex systems simulations³³. It also offers the *Accelerator*, which provides further training for graduates of the *High-Tech Highway*. By the end of 2016, six start-ups had gone through the IIIM accelerator programs.

Not all start-up firms mature and become successful, so many start-ups do not provide consistent economic impact. Still, some have, and GEORG representatives mentioned that the CoE already was starting to earn income from exiting a start-up.

4.5 Impacts on cooperation between institutions in different sectors

All three CoEs have contributed towards effective cooperation between different sectors of society within Iceland. However, the ways they have done this, and the ways the impacts are expressed differ extensively.

There was strong consensus among representatives from members of GEORG that the Centre had successfully integrated the different actors in the geothermal sector, so they were effectively cooperating with each other. A GEORG representative said: "*GEORG streamlined the need and got academia to come closer to the needs of the industry.*" When asked what main impacts GEORG has had, these integrations were typically mentioned as the CoE's key impact. As one private sector interviewee said, for example, "*GEORG is the glue that holds the sector together.*" It can be challenging for energy firms to collaborate on projects as it can be seen as a violation of the competition laws. By providing a third-party platform, GEORG has made it possible for the firms to cooperate. As one GEORG representative noted: "*GEORG helped energy firms to talk to each other through a neutral party and for them to work together on projects which they can collaborate on.*"

³¹ Startup Energy Reykjavík. <https://www.startupenergyreykjavik.com/>

³² Garðarson, S. M. (2024). GEORG: Rannsóknaklasí í jarðvarma. GEORG's Gleði, 15. Mars 2024.

³³ IIIA. Fyrir sprota. Icelandic Institute for Intelligent Machines. <https://www.iiim.is/2015/01/fyrir-sprota/>

Some representatives of firms compared GEORG to another organisation intended to integrate the sector, the Iceland Renewable Energy Cluster, a membership-based cluster, and felt that GEORG was more successful in its efforts to encourage cooperation within the sector.

What made GEORG able to have this impact, apart from the CoE financing, was that it was a Centre that included strong representation from the various sectors among its founding members. Being a Centre meant it had a critical mass of experts. As one GEORG representative remarked *"One needs to have some sort of apparatus to back one up and some energy."* There had also been a regeneration in the geothermal sector and highly educated people are actively contributing across different types of organisations. This regeneration was partly supported by grants from GEORG, as noted above. It also helped that GEORG didn't have any direct interests to pursue but was focused on whatever would strengthen the sector, first as a university centre and after the CoE funding ran out as a non-profit organisation.

IIIM has also emphasised cooperation between different types of organisations as a part of its agenda to be a bridge between academic research in its focus areas and applications by private and public sector organisations. By providing technology solutions to many organisations in Iceland, the Centre has encouraged knowledge flow and cooperation between institutions in different sectors. Before starting a project with a collaborating organisation, the organisation signs a contract that allows IIIM to use any technological solutions it develops for the collaboration organisation later in its work with others. In return, IIIM commits to not provide these same solutions to the collaborating organisation's direct competitors for two years. This allows IIIM to reuse technological solutions across different contracts and encourages faster technological development in Iceland. As one IIIM representative said: *"We [Iceland] are so small that it matters to make the most of every króna."*

The challenge for IIIM becoming an integrative force like GEORG is that IIIM is working with diverse organisations from a wide range of sectors. AI and the other technologies IIIM focuses on are enabling technologies that can be used widely in society and thus the impact of IIIM is felt in many sectors.

What has made IIIM be able to have these impacts is largely the fact that they have a critical mass of highly qualified experts. They have recruited high-level staff from outside of Iceland who have experience working with industry and specialised expertise in the field. As an IIIM representative noted: *"IIIM is a knowledge magnet that has attracted many international scientists to Iceland. They have had enormous impacts, far beyond the Centre."* It also has helped IIIM to be a non-profit organisation, focusing on disseminating the technologies rather than making profits. Another contributing factor is that firms in Iceland have become more open to the idea of harnessing AI and related solutions. Their openness is partly because these technologies are becoming more accepted globally and because IIIM has relentlessly promoted their use.

EDDA's domestic cooperation is mostly seen in its contribution to the work of policy makers representing government and the *City of Reykjavik*. Many of the international conferences that EDDA has organised have, for example, been co-sponsored by ministries and

representatives from these same ministries have taken part in the programmes. EDDA's ties with local policy makers are also reflected in their cooperation in developing and amending policies and legislations. In the aftermath of the economic collapse in Iceland, several of EDDA's researchers were also working closely with ministries in restructuring efforts. EDDA's members provided, for instance, extensive inputs into planning social welfare in the country and in developing Iceland's Arctic policy. The cooperation of an EDDA researcher in developing governmental actions to address violence against women, discussed in Section 4.1 above, is also a good example of this cooperation.

Some of the factors that have contributed to EDDA's success in having these cooperation impacts have been the high-quality research conducted by EDDA's researchers and the dire need of policy makers in Iceland to develop alternative plans after the economic collapse from what had existed before. EDDA is also very interdisciplinary, which has been needed in dealing with the complexity of the situation. By being a Centre, EDDA has a critical mass of experts working together in an interdisciplinary fashion and their work became highly visible to policy-makers in Iceland.

The other CoEs have also had ties with policy makers in Iceland and successfully influenced policies. However, in EDDA's case this has been more of a defining feature of their domestic cooperation than in the cases of the other two CoEs. EDDA's cooperation with policy makers may have somewhat weakened over the years. When talking to policy makers, there appeared to be some confusion about what EDDA was and stood for, versus the two other Centres at the *University of Iceland* managed by EDDA's members, *GRÓ-GEST* focused on gender equality studies and training and *RIKK* focused on research and dissemination of gender equality studies and difference. Stronger branding efforts and more outreach activities may therefore be likely to result in more widespread recognition of EDDA.

In general, based on this analysis, it can be argued that all the CoEs have contributed to and fostered effective national cooperation between institutions in different sectors and contributed to Icelandic society in a number of varied ways. Continued presence in their respective sectors and stronger dissemination and branding effects are likely to further enhance these impacts.

5. Main International Impacts of the three CoEs

As mentioned above, all three CoEs have had considerable international presence, which is reflected in activities such as co-publications with international authors and by organising international conferences. Interviews with international collaborators of the CoEs revealed widespread consensus that the Centres have high international credibility and stellar reputations.

5.1 International events and networks

All three CoEs have organised a number of international workshops and conferences. These events have frequently attracted leading researchers in their respective fields. Examples of these conferences are the first *Mee Too* conference in 2019 and the „*States of Exception*“ and *the Politics of Anger* conference in 2018 by EDDA, and *The World Geothermal Congress* in 2020 organised by GEORG. Interviews with international collaborators of the CoEs underscored the importance of these international conferences for the dialogues in their respective fields - and in some cases for their own careers. They were also very impressed by the ability of the CoEs to attract leading global thinkers to conferences. In the case of EDDA, this was also a theme of the operation of the *GRÓ-GEST* programme. As one EDDA collaborator stated: *“I’m astounded at how many really top international scholars have come to speak, to teach under GRÓ-GEST to provide public lectures, to the international conferences. I mean, when I look at the amount of conferences that have been hosted, by EDDA and the programme is just uncanny. Really, you know, it’s really, it’s really impressive”*

The CoEs have also played leading roles in international networks in their respective fields. EDDA, for example, was one of the founders of *RINGS*, the *International Research Associations of Advanced Gender Studies*, and its Director has been on the Executive Board of *RINGS*.

As mentioned above, GEORG has taken on the role of managing the *GEO THERMICA* Initiative. Its role has not just been to run the office, but it has been instrumental in its strategic planning. As one international interviewee stated, GEORG together with the *GEO THERMICA* network have played a key role *“in the fact that geothermal is on the map in Europe, way higher than it has been. This impacts the amount of research funding into geothermal, which was always minimal in the past. You would have one project a year, maybe if you’re lucky. Now, it’s being really taken seriously on the research side, but also on the implementation side.”*

In addition to the *GEO THERMICA* initiative, GEORG has also encouraged emphasis on putting geothermal energy on the map in Europe by participating in committees such as the *European Technology & Innovation Platform on Geothermal (ETIP-Geothermal)* and the *HORIZON 2020 Energy Committee*. These networks and committees have made it possible for GEORG to influence the EU’s agenda in energy research. As one GEORG representative remarked: *“We have reached very deep into the European funds. We have influenced how the calls are written ... In this sector Icelanders have managed to get the deepest in the EU funding environment.”*

5.2 Novel research agendas

The CoEs all have had highly novel research agendas that can lead to unforeseen opportunities.

EDDA's researchers have done pioneering work in analyses of post-recession reconstruction, the open democratisation process, welfare state development, Arctic development and gender and diversity issues. They have led the publication of several internationally edited books on these topics that have been published by high-impact publishers such as *Routledge* and *Oxford University Press*. Many of these book projects started at EDDA's international conferences, where groups of people took on further developing their work under the leadership of EDDA's researchers. One example is that EDDA published in 2020 the first major book on the Me-too movement, *The Routledge Handbook of the Politics of the #Metoo Movement*. Iceland has been ranked as the most gender equal country in the world, for the 14th consecutive year by the *World Economic Forum's Gender Gap Index*. One of the international interviewees argued that as a result of this high ranking, Iceland has an ethical duty to promote gender research and share its results in international fora.

GEORG, for instance, has contributed to international large-scale projects in the area of deep geothermal drilling. The work GEORG has managed under the EU-supported project *DEEPEGS* and is planning under the *Krafla Magma Testbed (KMT)* is cutting edge according to both domestic and international interviewees. One representative from an Icelandic energy firm said that setting up KMT was akin to setting up the *European Organization for Nuclear Research Facility in Particle Physics (CERN)*. An international expert said: "*It's kind of like sending, a spaceship to a comet, ... it's that good... And traditionally, geologists don't do that. ... they tend to work on their own little projects, and they are not particularly into big sites in the same way as astronomers are.*" The *KMT* project is a large-scale infrastructure project that demands international cooperation, as Iceland will not be able to provide funding on its own. If successful, *KMT* will lead to much better understanding of magma and enhanced possibility to harness cleaner, more sustainable energy solutions, not just in Iceland but around the globe. Working with higher temperatures than ever before will require innovation in material, sciences which could have important implications for development in other fields.

IIIM and its Director are known internationally to be leading forces in AI self-supervised cumulated learning research, which is a kind of AI that is able to learn efficiently on its own and continue to learn. This is a machine learning process that will require much less computer power than existing paradigms and could provide much more reliable technology. It is a novel approach that so far has not attracted as much attention as more mainstream approaches in AI. There was a consensus among the international experts interviewed for this impact analysis that IIIM's research was novel and of high potential importance in terms of use and financial implications. One international interviewee noted that: "*I think that it's going to be very, very big in the coming years, you know, so it's one of those things. It's a long time for everything to kind of gel and, you know, for the industry to be ready, but the industry is begging for [IIIM's] kind of solutions.*"

At least two of the Directors of the CoEs have subsequently received international awards. The Director of IIIM has, for example, twice received the *Kurzweil Awards* given to individuals or organisations that have made significant contributions to artificial intelligence. The Director of EDDA was, for instance, listed in *Apolitical's 100 Most Influential People in Gender Policy in 2019* by the *Apolitical Organisation*.

5.3 Main factors and conditions shaping the CoEs' international impacts

There are different factors and conditions that have made these international impacts possible. The 2008 economic collapse and the subsequent reconstruction attracted a lot of international interest that benefited EDDA. International researchers were keen to visit Iceland and take part in Icelandic conferences to learn more about restructuring efforts. EDDA has also benefitted from Iceland's status as a relatively gender equal country. There is a strong focus on gender issues in Iceland's foreign policy. When stakeholders were asked if EDDA had contributed to this gender emphasis by Iceland's *Ministry of Foreign Affairs*, they argued that the reasons were rather because of the strong grassroot emphasis on gender in Iceland and Iceland's high ranking on international gender equity indices. However, having a CoE focused on gender issues was considered an asset. As one stakeholder noted: "*Having a centre of excellence in gender issues has made us more professional. When Icelanders are speaking at international fora, it is with some pride that we can say that we have founded a research center in equality.*" The shared emphasis on gender issues both in research and foreign policy in Iceland reflects policy coherence that can reinforce the impacts of each party. The fact that Iceland has also established the *GRÓ-GEST* training program focusing on gender education also contributes to the strong international status Iceland has on gender issues.

The Director's of GEORG ability to work with the EU programs and to become a member of committees that write the call for proposals has also amplified the international impacts of the Centre. GEORG has also benefitted from the rich geothermal resources in Iceland and the country's strong standing in research and utilisation of geothermal energy. There is interest outside the country to research Icelandic geothermal areas and learn from the Icelandic experience in managing the resource. The fact that Iceland has a long history in international geothermal education and has now established the *Geothermal Training Programme (GRÓ-GTP)* also reflects policy coherence between research and foreign policy in Iceland that can strengthen the Centre's impacts.

The international impacts of the IIIM have not benefitted from the country's foreign affairs activities. Instead, the Centre has benefited from the strengths and innovativeness of its Director's research which the international experts felt was ground breaking. The Centre has also active networks that span North American and European countries,

These three CoEs all play important roles in international knowledge creation and implementation in their respective fields. All the CoEs benefitted from being Centres and having a critical mass of researchers. By creating a critical mass of people working in these areas their international contributions have been enlarged and impacts amplified.

6. Sustainability of the CoEs

Although the CoE funding ran out in 2016, all the Centres are still in operation. To look at how the CoEs have been funded, we asked the Directors to indicate what proportion they have received from different funding sources since 2017 (Figure 6.1). It is evident from that information that the CoEs have pursued very different funding pathways.

GEORG has relied heavily on funding from European grants. Since it was established, GEORG has received 665 million ISK in EU grants.³⁴ The projects that GEORG has been involved in applying for have, however, cumulatively received 17,182 million ISK and Icelandic entities have received 3,344 million ISK of these. GEORG has thus played a large role in generating funding for geothermal research and development in Europe. The 'Other sources' that GEORG received were a grant from the *International Continental Drilling Programme* and funding from the *Government of Iceland* to prepare the *Krafla Magma Testbed* project.

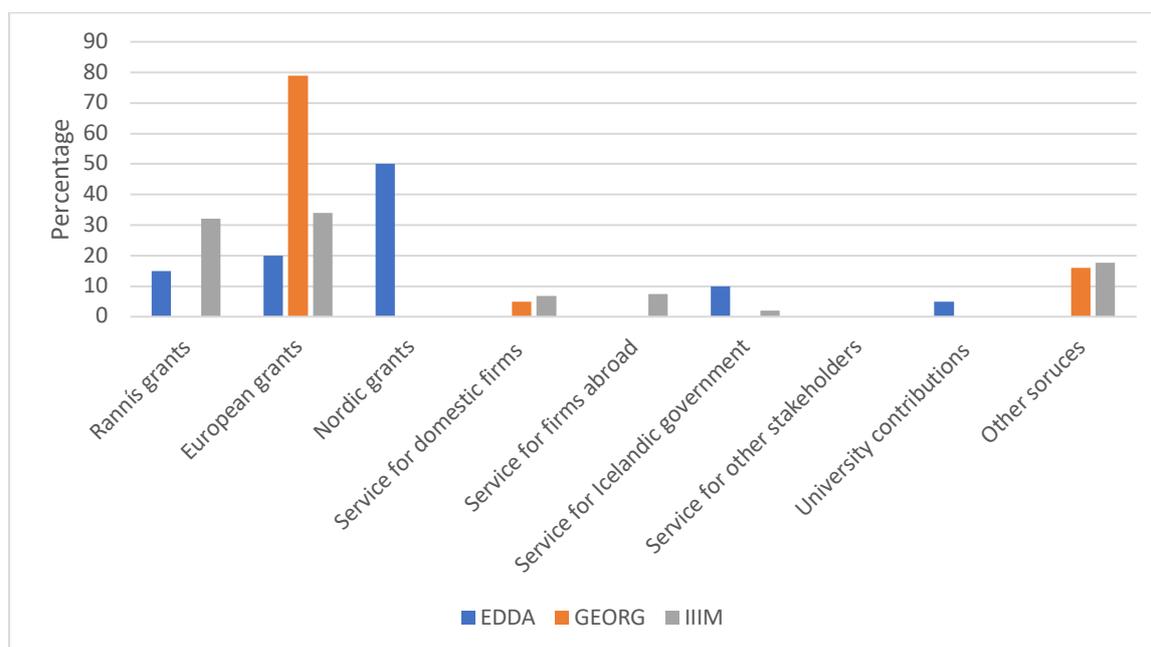


Figure 6.1 Proportion of CoEs' financing from different sources 2017 to 2023.

IIMM funding sources are more spread out with grants from Rannís and grants from European sources providing most of the funding. The 'Other sources' category refers to grants received from outside of Europe. In EDDA's case, Nordic grants are the largest funding source. EDDA represented one of six universities in Nordic countries that received a grant from NordForsk for the *ReNEW (Reimagining Norden in an Evolving World)* project to enhance cooperation in

³⁴ These numbers are from personal communication with a representative from GEORG.

the Nordic region. It runs from 2018 to 2024. Another example of a grant that EDDA has received is from the *EEA and Norway Grants* scheme which funds among other things a research cooperation with Romania on democracy, memory politics and post-crisis reconstruction.³⁵

Both GEORG and IIIM have received funding by providing services to private sector firms in Iceland. In both cases, this is a relatively small funding stream or 5% of GEORG's financing and almost 7% of financing for IIIM. EDDA has received the largest proportional funding for providing services to the Icelandic Government, with 10% of its funding provided through this route.

The Government's plan for the CoEs was to fund them for seven years but they would become sustainable and eventually fund themselves. All the CoEs have been able to raise funding and for various projects and continue their operation. This has not been easy task for any of the Centres. A GEORG representative remarked, for instance, *"Yes GEORG is sustainable, but it has not been easy to keep the Centre going. It has required lot of efforts. If we take the eyes off the road we will immediately drive into a ditch."* The same sentiment was expressed by an IIIM representative: *"Yes, IIIM is run on the plus side, but not quite in the manner we had imagined."* It seems, thus, that their project-based funding approach has not enabled them to continue in the same manner as before. There is an indication that the research outputs of at least EDDA and GEORG have diminished. It also seems that the Centres are not continuing to take part in the dialogue on their respective issues in Iceland as they did before. As issues such as renewable energy, AI, and gender and diversity are important for the country's further development, it would be valuable to have strong centres that could lead these discussions. Public engagement on these issues is particularly important to ensure that the developments in these areas continue in a constructive fashion.

Another area that has suffered after the CoE grant ended is marketing. In order to disseminate AI and related technologies to Icelandic firms, strategic marketing efforts are needed. This is required for any firm marketing software solutions. There is a lot of work in convincing firms and other organisations that they would benefit from enlisting the services the Centre can offer. After the CoE grant ended it has been difficult for the Centres to obtain funding for marketing efforts and they have diminished.

When we look at other CoEs that have been established in similar areas in the past, continued governmental funding has been important. *The German Research Center for Artificial Intelligence (DFKI)*, for example, was established in 1998 with core funding from the *German Federal Ministry of Education and Research (BMBF)*. As of 2022, it had over 900 professionals (and over 600 graduate students) working in eight locations across Germany³⁶. Its annual budget in 2022 was 82.6 million euros. *DFKI* has varied funding sources, including competitive research grants, services for industries and governmental funding. In 2022, *DFKI* was

³⁵ EDDA (2023). The EDDA Research Center, University of Iceland. Presentation to the Romanian National Council for Scientific Research.

³⁶https://www.dfki.de/fileadmin/user_upload/DFKI/Medien/Ueber_uns/DFKI_im_Ueberblick/Unternehmensprofil/20240118_DFKI_Unternehmensprofil_EN.pdf

evaluated and based on this the *BMBF* decided to offer *DFKI* up to 11 million euros a year, to be matched with state funding from the states the organisation is operating in³⁷. The expectation is that *DFKI* will continue to play a key role in implementing the German government's AI strategy. The funding will be directed to specific application-oriented basic research projects that a committee from the Ministry will choose.

Considering that the *Government of Iceland* has invested considerable resources in establishing these three CoEs, it would be beneficial for it to consider ways to further strengthen their continued operation. The continued investment would not have to be large, as all the CoEs have demonstrated being capable of obtaining grants and other income from a variety of sources. With relatively small grants the Government could, for instance, strengthen outreach activities of the CoEs and allocate resources to particular priorities of the Government.

7. Recommendations

This impact analysis has provided evidence to suggest that the main objectives of the CoEs that were established to implement the *Strategic Policy to Promote Centres of Excellence and Clusters from 2007*, have been met. The CoEs have promoted scientific and technological research in their respective fields. They have also encouraged effective cooperation between the various actors at national and international levels. This cooperation has allowed diverse actors to benefit from the scientific and technological research in the focal fields of the CoEs. They have also encouraged value creation and investment in research and innovation to benefit the society and the economy. There is often a risk that CoEs are only focused on knowledge production and have limited social and economic impacts. In the discussion above we have demonstrated ample impacts of the knowledge production that has taken place in the three CoEs.

In the interviews we also asked the members of the CoEs and various stakeholders about their views on whether the *Government of Iceland* should continue to support centres of excellence as a strategy to promote research and innovation. Almost all the interviewees enthusiastically agreed that this would be a good strategy for promoting research and innovation in Iceland. While this group may be somewhat biased towards CoEs they provided thoughtful suggestions on approaches to promote CoE development. The interviewee emphasised that any new CoE would have to be grounded in strategic needs for research input and the Centres should be focused on issues of national importance, where they can have impacts. As one stakeholder remarked: "*One cannot launch something that is just a one-time fireworks show.*"

Based on this impact analysis and interviewees' suggestions we recommend the following:

³⁷ <https://www.dfki.de/en/web/news/successful-evaluation-federal-and-state-governments-to-fund-further-development-of-dfki-with-up-to-22-million-euros-annually>

To support new CoEs

- Considering the beneficial experience of the three Centres, the *Government of Iceland* should consider the CoE model to advance research and innovation. The CoEs should be focused on nationally important issues that need a critical mass to be addressed appropriately. They should be funded for at least seven years to give them a scope to meet their goals.
- To moderate the financial demands of the CoE initiative and ensure that it has the most impacts, the government needs to choose carefully new centres to support and limit the number of centres they support to no more than three to four. There has to be some domestic strengths in the focal fields of centres that can be built upon. Attention should be paid to both possible economic and social contributions of the Centres. Some of the new topics of national importance that could benefit from developing a critical mass of experts and close integration between different actors in Iceland include: safety of information, energy exchange, reception of refugees, management of tourism, the blue economy, development of new materials, capturing industrial carbon dioxide, etc.

To manage the new CoEs

- To stimulate the CoEs sustainability and their efforts to seek alternative funding, the government should consider tapered financing where full financing is offered for the first four to five years of the operation of the Centres but is tapered down for remaining two to three years.
- To ensure public accountability of the CoEs, any new CoE initiative should include clear instructions on what the funding can be used for and have a structured yearly reporting so there is full transparency in how the Centres operate. This is important for continued public support for the initiative.
- To protect the government's investment in the CoEs it is important to evaluate the impacts of the Centres towards the end of the initial funding period of the CoEs and explore their potentials of being sustainable. Those Centres that have made successful contributions to social and economic development in Iceland should be considered for future support, to finance important activities not funded by project-based funding resourced from research grants or services.

To encourage outreach and capacity building

- To reach varied audiences and encourage national dialogue, outreach should be an important component of each Centre. With the expertise the Centres accrue and the high-quality personnel onboard, they should play leading roles in Iceland to promote research informed dialogue in their respective fields.

- With the positive experience of capacity building efforts of the existing Centres in the form of grants to emerging researchers, the government should encourage capacity building efforts attuned to the demands in Iceland for human resources in the focal fields of the Centres. This can strengthen regeneration of the focal fields of the Centres.
- To reap continued benefits from the existing CoEs and encourage further outreach activities, the *Government of Iceland* should consider providing additional financial support to the existing Centres. The funding can be relatively small, but it should make it possible for the Centres to finance important activities not funded by project-based funding typically resourced from research grants or services. To administer funding the existing CoEs need to submit an application that is rigorously reviewed.

To encourage stakeholders' involvement

- Considering the importance of value creation based on the CoEs research and other activities, the government should encourage the Centres to form close ties with industries or other stakeholders whose work can be informed by the research and expertise of the CoEs. This can be in the form of representatives of industries, or other stakeholders, being members of the governing or advisory boards of each Centre. This encourages knowledge flows between the Centres and their stakeholders and enhances the potentials of the Centres to align their operation to their stakeholders' needs.
- To strengthen the ties between the *Government of Iceland* and the CoEs, and to encourage government policy to be informed by research, the government should prescribe that a panel or an advisory board is formed for each Centre with representatives from ministries or other governmental bodies relevant to the work of the CoE and to the work of the members of the Centres. The panels should meet once or twice a year. This would encourage knowledge flows between the Centres and relevant government entities and strengthen the potential for the Centres' research results to be implemented.
- In order to be attuned to the needs and preferences of the general population in their respective fields, the government should recommend that the CoEs consider ways to engage the population in their work. This could involve including representatives of the general public on their governing, or advisory boards as citizen board members. This can give the general public a stronger voice in the operation of the Centres and closer alignment to their needs.

Appendix A - Details of the Impact Analysis Methodology

Document review

At the outset of the impact analysis, we reviewed documents and all other available information about the *Strategic Plan for Centres of Excellence and Clusters* and the three Centres of Excellence (CoE) supported to implement the plan. The purpose was to gain in-depth knowledge on the CoE initiative and insights into the Centres' outcomes, impacts and challenges. The document review included examining annual reports, mid-term evaluation reports, websites, as well as several presentations of the Centres' operations.

Quantitative analyses

Bibliometric analyses: To conduct analyses of the CoE's publications we built a database of the Centres' publication outputs from 2009 to 2022. We started by relying on lists of publications of the Centres which were listed on their websites. We also invited the three Directors of the CoEs to send us additions to these lists, if needed. In the database we included articles, books, book chapter, conference papers, editorials, reports, and reviews.

Currently there are only a few examples of book publications presented on EDDA's website, but from 2010 to 2016 the Centre presented fuller publication lists on its website. Since 2016 EDDA however, has not kept track of the publications of its members. To get a fuller list of publications of EDDA's members we relied on older versions of its websites archived at Vefsafn.is, and on publications of EDDA's members listed on the *Reimagining Norden in an Evolving World (ReNew)* website.³⁸ We also received lists of publications of EDDA's researchers from the *University of Iceland, Division of Science and Innovation* for the years 2017 to 2022. When there was any doubt about whether the publications were likely to be EDDA contributions, we contacted the researchers to verify. For GEORG, we relied on GEORG's website to build a database of its members' publications. We also supplemented the list with publications listed in the *Book of Publications, DEEPEGS Geothermal, 2020*. For IIM, we relied on publications listed on the Centre's website. For all the CoEs we did internet searches to identify any additional publications to include in the database.

For each publication in our database, we checked whether the CoE was listed as an affiliation or not. Some book chapters do not include affiliations of the authors but instead have a separate section describing contributors. If the CoE was mentioned in these latter descriptions, we counted them as a CoE affiliation. We also checked whether each publication included authors from institutes in Iceland other than the institutes that the Centres originated from, and if the publication did include authors from other institutions, we looked at these publications as involving domestic collaboration. The originating institute for EDDA and GEORG was the *University of Iceland* and the originating institute for IIM was the *Reykjavik University*. Lastly we checked whether each publication included authors from institutes outside of Iceland, and if the publication did include authors from other countries we looked

³⁸ www.helsinki.fi/en/researchgroups/reimagining-norden-in-an-evolving-world/contributions

at these publications as involving international collaboration. For those, we reported which countries the authors were affiliated with.

To analyse the publications, we looked at the number of publications per year for each centre; the percentage of types of publications (i.e. articles, conference papers etc); the extent of domestic collaboration; the extent of international collaboration; and the number of publications per collaborating country.

Analyses of media coverage: To look at the contributions of the CoE to media discussions in Iceland we examined the media discussions involving the Centres from 2010 to 2016. To obtain the data we relied on the Centres' yearly annual reporting. GEORG didn't include information on its media coverage, so that Centre was excluded from this analysis.

We classified each media entry according to the types of media involved: newspapers, radio, TV and other. "Other" refers to magazines and online media.

Analysis of funding sources: To look at how the CoEs have been funded after the initial CoE funding ran out, we asked the Directors of the Centres to indicate what proportion they have received from different funding sources from 2017 to 2023. The categories we provided the Directors with were: *Rannís*; European funds; Nordic funds; services for domestic firms; services for firms abroad; services for Icelandic governments; services for other stakeholders; contributions from universities; other financing.

An interview with a Rannís representative

To better understand the impetus and expectations for the CoE initiative, and its broader context we interviewed a representative from Rannís who planned and managed the CoE initiative. The interview was conducted in a face-to-face setting, at the *Rannís* premises. It was conducted in Icelandic and lasted around 50 minutes. The interview was digitally recorded. In the interviews+ we asked questions about the management of the initiative, its main impacts, key challenges running the initiative and main lessons learned about structuring and running a CoE initiative.

Interviews with members of the CoEs

To understand the main contributions of the CoEs we conducted semi-structured interviews with the Directors of the Centres, the Chairs of the CoEs Governing Boards, and other members of the Centres. The potential members to interview were selected after reviewing the Centres annual reports and by soliciting recommendations from the Centres' Directors. An attempt was made to interview members from different sectors of society. All except one interview were conducted in face-to-face settings at the offices of the interviewees or at a Rannís meeting room. One interview was conducted over Zoom. The interview guides were adjusted to the different roles of the members. The interviews lasted approximately 30 to 60 minutes and were digitally recorded. In total we conducted 15 interviews with the Centres' representatives. All except one interview were conducted in Icelandic with one interview being conducted in English. In the interviews we asked questions on the CoEs main impacts, the

impetus for their creation, what factors and conditions have shaped the Centres' impacts, their operations, main challenges of running the Centres and the views and recommendations for establishing more CoEs in Iceland, etc.

Interviews with stakeholders in Iceland

To explore the wider perspectives of the impacts of the CoEs, we interviewed stakeholders in Iceland knowledgeable about the areas the Centres operate in. They were representatives from ministries relevant to the Centres operations, and firms operating in their respective fields. The potential stakeholders to interview were selected after soliciting recommendations from *Rannís* representatives and from the Centres' Directors. A criterion was that they would know about the Centres' operations and impacts. The interview guides were adjusted to the different roles of the interviewees. The interviews lasted approximately 30 to 45 minutes, were conducted at the premises of the interviewees, and were digitally recorded. In total we conducted 10 interviews with stakeholders. All the interviews were conducted in Icelandic. In the interviews we asked questions on the interviewees experience in working with the CoEs , the main impacts of the Centres, the perceived needs for CoEs in the three fields and the interviewees' views and recommendations for establishing more CoEs in Iceland, etc.

Interviews with international experts

To explore international perspectives of the impacts of the CoEs, we interviewed international experts in the fields the Centres operate in. They came from different parts of the world, Europe, North America and Africa. The potential experts to interview were selected after soliciting recommendations from the Centres' Directors. A criterion was that the experts would know about the Centres' operations and impacts. The interviews lasted approximately 30 minutes, were conducted over Zoom, and were digitally recorded. In total we conducted 10 interviews with international experts. All the interviews were conducted in English. In the interviews we asked questions on the interviewees' experience in working with the CoEs , the main international impacts of the Centres, the international reputation of the CoEs, and the interviewees' views and recommendations on establishing CoEs in general.

Analysis and Reporting

To address the objectives of this impact analysis, we conducted the quantitative analysis described above and a thematic analysis of the interview input. We compared the interview according to the relations of the interviewees with the Centres. We also used data from the documents we reviewed, particularly from the annual reports of the CoEs, to triangulate the analysis when appropriate,