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Spending Review 2020

DAFM Competitive Research Programmes

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IGEES

Irish Government Economic and Evaluation Service

Executive Summary

The Department of Agriculture, Food and the Marine (DAFM) supports a broad range of Research and Development (R&D) activities to develop new technologies and practices for the agri-food and forestry sector. DAFM funds three competitive research programmes which are operated by the Research & Codex division:

- Food: Food Institutional Research Measure (**FIRM**)
- Agriculture: Research Stimulus Fund (**RSF**)
- Forest: Competitive Programme for Forest Research and Development (**CoFoRD**)

DAFM leads and implements these three programmes, under which it makes grant awards on a competitive basis for collaborative research projects on foot of 'directed'¹ Calls for Proposals launched periodically (c. 12 – 18 months). The objective of this Spending Review is to evaluate these programmes over the 2010 to 2017 period². Circa €142.6 million was committed in this period to projects under these programmes to cover a range of policy priorities including animal breeding, climate change mitigation and infant milk formula. €99.8m has been drawn down to date, with the remaining funds largely relating to projects from later call years. Total Projects and Funding by programme over 2010-2017 are detailed below:

Programme	Total Projects (%)	Total Projects	Total Funding (%)	Total Funding (€m)
<i>RSF</i>	32.4	73	39.9	56.9
<i>FIRM</i>	55.6	125	52	74.2
<i>CoFoRD</i>	12	27	8.1	11.5
<i>Total</i>	100	225	100	142.6

Key Findings

To evaluate the outputs of the programmes, 93 projects funded in 2010 and 2011 valued at €49.5m were selected for analysis as these were completed and therefore the outputs can be more easily identified. These outputs are summarised for 2010-11 projects, by programme and overall, below:

Output	CoFoRD	RSF	FIRM	Overall
<i>Peer-Reviewed Publications</i>	32	247	463	742
<i>New Products</i>	4	1	18	23
<i>Inventions</i>	1	1	69	71
<i>Patents</i>	0	1	7	8
<i>New Licences</i>	1	0	1	2
<i>New Tech Processes</i>	6	10	69	85
<i>Links with Industry</i>	2	3	88	93

¹ Meaning Calls invite research proposals to address a set of specified topics that have been compiled following stakeholder consultation, which in turn were themselves the product of strategic research agendas, which also involved extensive stakeholder consultation.

² Funding details are provided in full for 2010-17, however outputs/impacts cover 2010-11 awards projects only.

The level and type of outputs achieved varies significantly across each programme as a result of the diverse contexts in which they operate and their respective objectives. Wider contributions to strategic objectives included:

- Provided evidence for policy formulation
- Contributed new knowledge and technology for the sustainable development of farming and forestry practices
- Strengthened links with industry
- Created positive reputational effects for domestic researchers

All programmes have contributed to these outcomes and have enhanced Ireland's overall impact from agricultural research, where:

- Ireland ranks second in the world for agricultural science research quality in the latest Science Foundation of Ireland report³.
- Further, in 2016, Thomas Reuters InCites ranked Ireland as second in the world for *Dairy & Animal Science* research quality/impact⁴.

The spending review highlighted that although the current structures are yielding impressive outputs, there may be further opportunities to improve the effectiveness of the programmes, by:

- Bringing the three Research Programmes under a single consolidated umbrella,
- Increasing the flexibility to respond to DAFM requests,
- Reviewing the existing contract negotiation and award process,
- Developing an improved set of key performance indicators linked to programme objectives,
- Improving communication of funded research,
- Examining the broadening of the list of organisations eligible for Grant Aid, and
- Addressing the increasing degree of overlap across Competitive Research Funding Programmes on whole-of-sector issues
- Monitoring the degree to which funding is distributed across categories of research, in order to balance economic and broader societal returns – i.e. split between:
 - a) Maintenance research (such as climate change mitigation), and
 - b) Productivity research (such as Infant Milk Formula development)

³ Science Foundation Ireland Annual Report 2019, p.16

⁴Science Foundation of Ireland Annual Report 2016. This is the latest relevant global analysis available. This validates the RSF programme in particular, given its predominance in research funding in these areas in Ireland for the period examined.

Glossary of Terms

Term	Definition
CoFoRD	Competitive Forest Research for Development
CRFP	Competitive Research Funding Programme
DAERA NI	Department of Agriculture, Environment & Rural Affairs Northern Ireland
DAFM	The Department of Agriculture, Food and the Marine
DPTC	Dairy Processing Technology Centre
EraNets	European Research Area Network Cofunds
FIRM	Food Institutional Research Measure
FORI	Forest Research Ireland
FRI	Food Research Ireland
GBARD	Government Budget Allocation for Research and Development
GHG	Greenhouse Gas
HRB	Health Research Board
IBR	Infectious Bovine Rhinotracheitis
Ibid.	In the Same Source
KPI	Key Performance Indicator
LHS	Left-Hand Side
NRPE	National Research Prioritisation Exercise
R&D	Research and Development
PRO	Public Research Organisation
RDI	Research, Development & Innovation
RHS	Right-Hand Side
RPO	Research Performing Organization
RSF	Research Stimulus Fund
SFI	Science Foundation Ireland
SHARP	Sustainable Healthy Agri-Food Research Plan
SSAPRI	Stimulating Sustainable Agricultural Production through Research and Innovation
SSTI	Strategy for Science, Technology and Innovation
TRL	Technology Readiness Level

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1. Introduction

This paper seeks to evaluate the three Competitive Research Funding Programmes (CRFPs) administered by the Department of Agriculture, Food and the Marine (DAFM) for the period 2010-2017. This is undertaken with a view to establishing the value for money provided by each respective programme in terms of their objectives, linked to the outputs and impacts generated by their inputs.

The DAFM is a multi-functional organisation which provides a wide range of services both directly and indirectly through specialist state agencies operating under its aegis. Its mission is to lead the sustainable development of the agri-food sector and to optimise its contribution to national economic and social development and the natural environment.

DAFM conducts research and development (R&D) activities in-house (mainly at the central and regional veterinary laboratories) partly supported through its core budget. In addition DAFM funds a broad range of research activities to reflect the topics of most relevance to the agri-food sector which are performed externally. These are comprised of three competitive research funding programmes in food (FIRM), agriculture (RSF) and forestry (CoFoRD) operated by the Research and Codex Division (€18.2m in 2017). Calls for Proposals are launched periodically at approximately, 12 to 18 month intervals for collaborative research projects. These Calls specify topics in which collaborative research projects are invited. The Call process is summarised into an 11-step process in section 4.2 of this report.

The agencies under DAFM's responsibility are also engaged in a broader range of R&D activities with estimates of their 2017 budget and the overall DAFM total for R&D set out below⁵:

- Teagasc - €78.8 million
- Bord Iascaigh Mhara (BIM) - €16 million
- Marine Institute - €10.4 million
- DAFM⁶ - €28 million
- Total GBARD⁷ for Agriculture - €133.2 million (inclusive of the above)

This review relates to expenditure in the 2010-2017 period for DAFM's three Competitive Research Programmes which provide funding, on a competitive basis, to eligible Research Performing Organisations (RPOs) for 'public good'⁸ research undertaken collaboratively over a 1-4 year period.

Food Institutional Research Measure (FIRM)

FIRM is the primary national funding mechanism for food research in Irish research institutes and supports research in areas such as food processing, food safety, product development, food for health and nutrition. Its aims are *'to develop platform technologies that will underpin a competitive, innovative and sustainable food manufacturing and marketing sector some of which can be exploited through more industry facing public support programmes.'* FIRM was established to form part of the Research,

⁵ [Research & Development Funding and Performance in the State Sector 2016-2017](#), Department of Business, Enterprise and Innovation, 2018.

⁶ This includes in-house research and research performed elsewhere, which includes the CRFPs discussed here.

⁷ GBARD refers to Government Budget Allocation for Research and Development. The glossary can be found on p.3 for all further abbreviations and terms in this paper.

⁸ Public goods are defined as those that are non-excludable and non-rivalrous.

Technological Development and Innovation (RTDI) priority response within the National Development Plan 2000-2006. It later formed part of the subsequent National Development Plan for 2007-2013. The continuous inclusion of this area of research as a government priority highlights the importance of the programme in driving agri-food sector development. The objectives of the FIRM programme include to provide a base of expertise in technologies that support innovation and product development in the sector and to assist consumer protection underpinned by food safety and quality issues.

Research Stimulus Fund (RSF)

The RSF provides funding to the Irish research institutes for agricultural production related research. The current aims of the programme are *'to support sustainable and competitive agricultural production practices and policies, and contribute to building and maintaining a knowledge economy and research capability in the primary agriculture sector.'* The areas funded in RSF are intended to complement Teagasc's mainstream research programme activity in the primary agricultural production area funded as part of DAFM's annual block grant-in-aid to Teagasc. The aim of the RSF includes *'to develop knowledge and scientific capability that will enable Irish agriculture to become a vibrant, competitive industry with improved productivity that is also environmentally sustainable.'* This aim, although more broad than those of FIRM, reflect the complementary priorities to develop the Irish agri-food sector along all stages of the *'farm to fork'* chain.⁹

Competitive Forest Research for Development (CoFoRD)

The aims of the CoFoRD programme are research which will *'develop a scientific foundation and support for a sustainable, competitive, market orientated and innovative forest sector.'* The CoFoRD programme was established as a non-statutory agency of the DAFM in 1993 and was later subsumed into DAFM in 2009. Given the operational and administrative similarities across the research funding programmes, the forest research function was transferred from CoFoRD to the Research and Codex Division. Its key objectives include *'to develop research for the forestry sector that contributes to secure long-term industrial viability and optimise social, environmental and economic developments associated with forestry and the wood products sectors.'*

Objectives

Food Institutional Research Measure (FIRM): to develop platform/ 'public good' technologies that will underpin a competitive, innovative and sustainable food manufacturing and marketing sector some of which can be exploited through more industry facing public support programmes.

Research Stimulus Fund (RSF): to support sustainable and competitive agricultural production practices and policies, and contribute to building and maintain a knowledge economy and research capability in the primary agriculture sector.

Competitive Forest Research for Development (CoFoRD): to develop a scientific foundation and support for a sustainable, competitive, market orientated and innovative forest industry.

⁹ FoodWise 2025 : <https://www.agriculture.gov.ie/foodwise2025/>

DAFM's three research funding programmes have evolved to a point where their operation has been consolidated into a single division within DAFM. There have been clear benefits to this e.g. a single cross-stream division responsible for all three programmes provides a more consistent approach thereby improving the efficiency of their administration¹⁰ and control and their effectiveness in terms of 'joined-up' impact. However, given the evolving and complex policy context which will be discussed in Section 3, this Spending Review aims to evaluate their continuing rationale and impact on the sector, and to examine the current award process to identify if further efficiencies are possible.

¹⁰ Estimated staffing costs within this DAFM division are provided in sub-section 4.2.

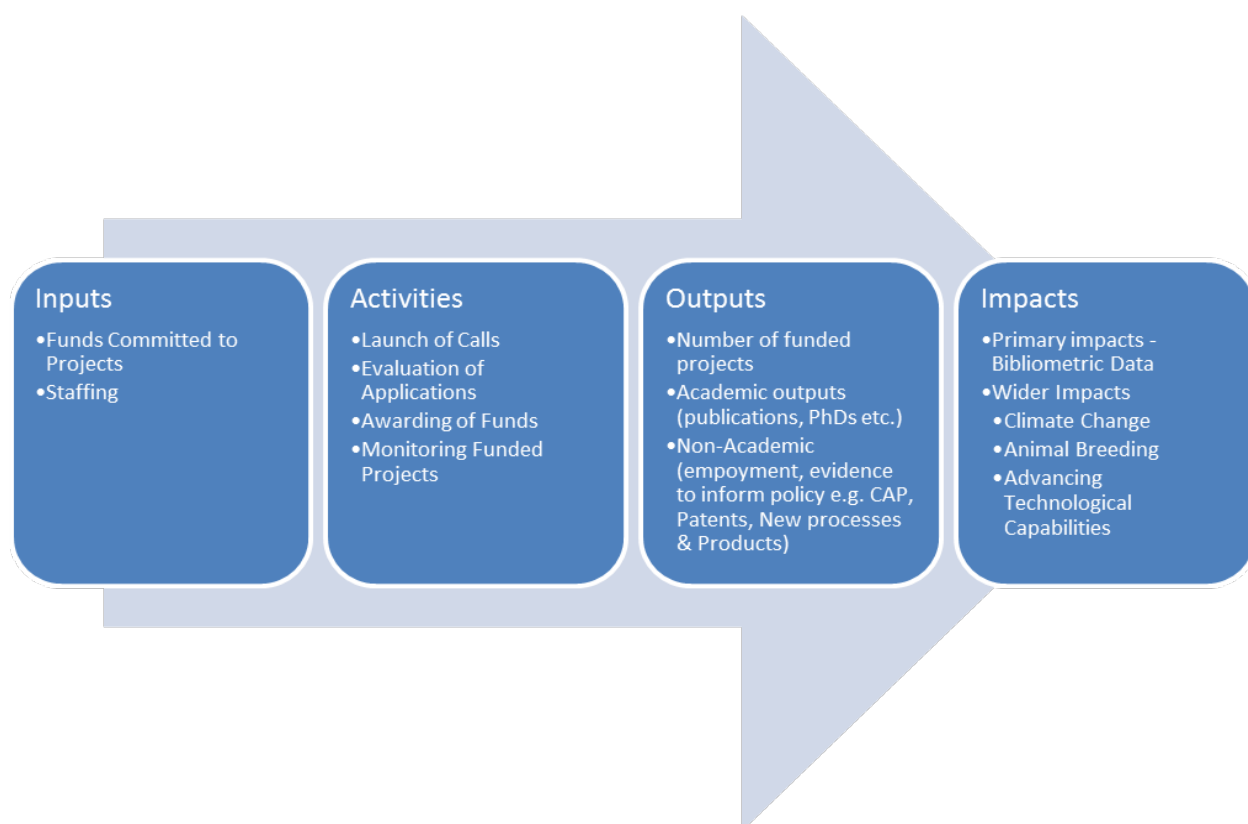
2. Methodology and Limitations

The objective of this Spending Review paper is to evaluate the DAFM's three Competitive Research Funding Programmes (CRFPs), arising from investment over the 2010 to 2017 period. Specifically, it will encompass:

- An assessment of the rationale for investment;
- An analysis the process for the prioritisation of resources;
- An appraisal of their impact and;
- An assessment of the justification for continued investment.

The review was desk-based and undertaken by the DAFM's Economics and Planning Division, and the One Health Support Unit, with significant input from the Research & Codex Division. The process of the review included carrying out a high level examination of the DAFM's competitive research programmes' objectives, inputs, activities, outputs and impacts in order to evaluate their effect and wider coherence. On foot of this approach a set of conclusions and recommendations are derived based on the results. The review follows the principles of the Public Spending Code and adopts a Programme Logic Model (Figure 2.1) to structure the analysis. This model sets out an overarching structure to review how the objectives of DAFM investment in the Research Programmes have performed in the context of the respective inputs, processing of awards, outputs and impacts.

Figure 2.1: Programme Logic Model (PLM) - DAFM Competitive Research Funding Programmes



Linking causality between research inputs and outputs/impacts in a research context is particularly challenging given the associated myriad of confounding factors that influence the outcomes. For example, some outputs may be intangible or can differ from those envisaged at the outset. The time frame is also an important consideration as impacts from research can incur significant time lags due to the relatively slow process associated with research, particularly for peer-reviewed publications, which creates a challenge for measuring impacts. However, notwithstanding these limitations, there are various indicators that may be captured within these DAFM research programmes.

As part of the Spending Review paper, data on inputs and activities around the processing of research awards were collated from a number of sources, including in-house records within DAFM. Data was collated based on a synthesis of formal programme-level reporting, direct engagement with the lead researchers in the area for the purposes of this review and consultation with senior DAFM staff in relevant policy divisions.

To assess the outputs of programmes, details on a sample of the funds committed under the three programmes were collated using in-house records. An evaluation of the data on the outputs of all projects awarded in 2010 and 2011 Calls was undertaken through an examination of the records reported to DAFM by the funded project coordinators at the end of their respective project cycles, and a database was created. These two specific Calls were examined as they were the cohort of projects for which the most 'mature' data was available compared to more recently funded projects, due to the significant time-lag effect. Data for subsequent years (i.e. Calls in the 2013-2017 period) would be incomplete as the projects are on-going, but the data collected for 2010-2011 can be used as an indication of the expected outputs in the subsequent years.

The output indicators included peer-reviewed publications, the number of post-doctorate researchers, and PhD and MSc students and other contract staff employed on the projects. Details on additional funding (national and international) leveraged and new products/processes developed on foot of the research funded on the DAFM projects were also captured. National bibliometric data was used to demonstrate the overall impact of the research in the agri food area. These metrics are standard indicators in analysing the outputs of public agricultural research funding in terms of scientific quality and spillover benefits. These reflect internationally recognised indicators of funding efficacy and core DAFM objectives, which centre on developing public goods via competitiveness, innovation, sustainability and a skilled workforce .

In addition, three key thematic areas were identified to illustrate the impact, namely animal breeding, climate change and infant milk formula related research. These areas spotlight the diversity of DAFM funding interests and impacts, and enable comparative analysis of the efficacy of spending by grouping similar cases. The projects examined in this analysis fall under one of these three overarching areas. The characteristics illustrated in these case studies are generalisable to other projects in their respective funding programme, owing to their mutual objectives and common focus. Output and case study analysis has been employed in this Spending Review to provide a holistic assessment of the specific and broader impacts of the DAFM competitive research funds.

The core Objectives and linked Key Performance Indicators (KPIs) for the CRFPs that will guide this evaluation are:

- **Capacity**

Contribute to building and maintaining physical and human capital to support a knowledge economy and scientific research and innovation capability in agri-food and forestry in Ireland;

- Number of post-grads (Masters and PhD)
- Number of early career researchers (Post-Docs)
- Peer-reviewed publications per researcher/staff member

- **Critical Mass**

Establish and strengthen inter-institutional links both nationally and internationally. Foster links between public research institutes, industry and stakeholders in the agri-food & forestry area. This includes evaluating progress on, and encouraging dissemination of, RDI outputs of the DAFM CRFPs to improve outcomes and ensure maximum benefit/impact;

- Case study evaluations
- Links with industry
- Evidence of institutional collaboration
- New policies enacted using evidence from CRFP projects

- **Capability**

Support training and expertise to build capability among Irish-based agri-food and forestry researchers to enable them to compete for other exchequer and non-exchequer funding, e.g. under other research programmes – both nationally (i.e. SFI, EPA funding) and internationally via e.g. the EU Framework Programme (Horizon 2020)

- Leveraged funding - nationally/internationally
- Bibliometric evidence, i.e. Peer-Reviewed Papers (PRPs)

- **Consolidation**

Add value via the DAFM RDI programmes to the agri-food and forestry sectors. Determine the focus and priorities of the agri-food and forestry sector to maintain international competitiveness, provide sustainable employment, encourage innovation and address policy concerns.

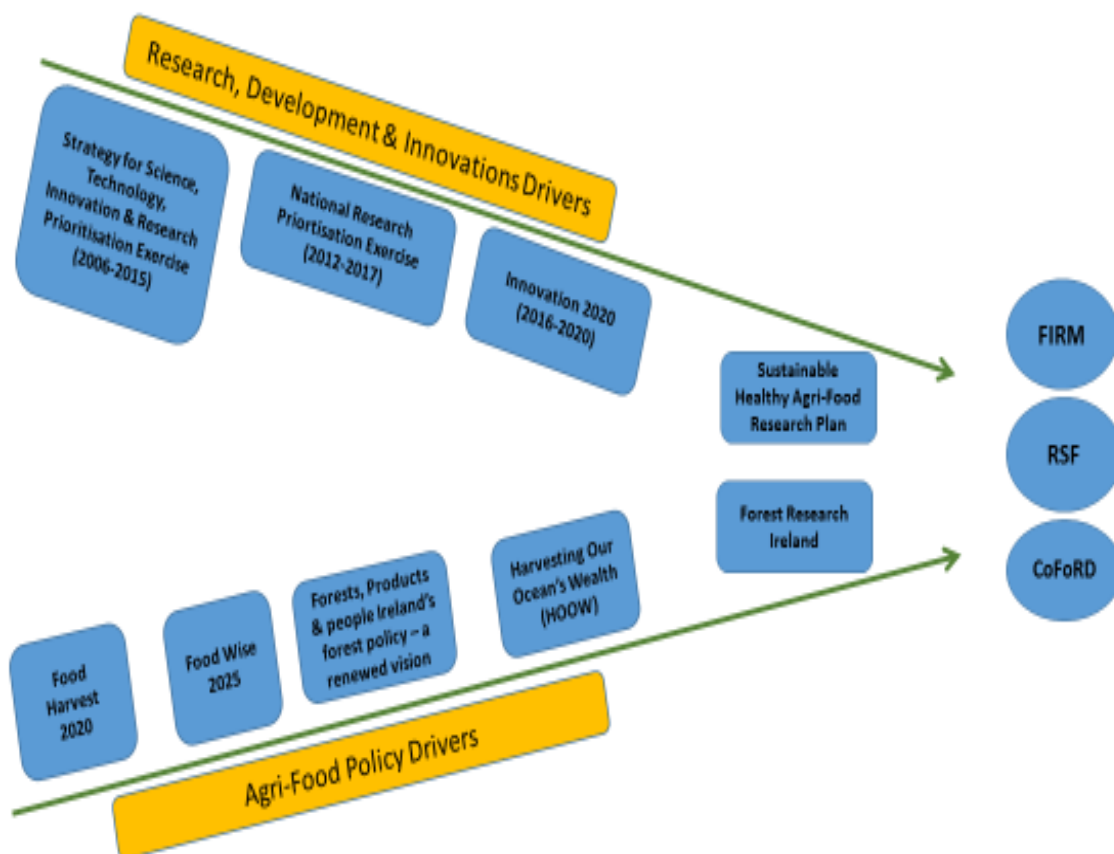
- IP metrics (number of inventions, patents, licences etc.)
- New processes, technologies, products

The KPIs linked to the above objectives are detailed and evaluated in Section Five of this report.

3. Rationale for Public Policy Intervention

This section provides an overview of the wider policy context for agricultural related research as well as specific policies to meet these objectives for DAFM. A number of wider government policies inform DAFM policies which in turn inform the strategic research agenda which guide funding under the three DAFM research programmes (Figure 3.1).

Figure 3.1: Strategies guiding DAFM Competitive Research Programmes



3.1. Wider Policy Rationale

The DAFM Competitive Research Funds are a component in a wider government strategy to ensure sustainable, broad-based socioeconomic progress beyond the short- to medium-term via innovation and knowledge creation. The CRFPs contribute significantly to innovation in a strategically important sector of the Irish economy; the agri-food sector contributed 7.5% to GNI* and the sector represented 7.7% of total Irish employment in 2018¹¹. Preserving this will require consistent agility in response to the challenges and opportunities which face the sector, such as climate change, market volatility and international competition. The time lag associated with R&D, generally, dissuades private investment in such activity and has created a natural role for government in supplying funding to correct for market undersupply to ensure a socially optimal level of agri-food R&D is generated. The public good condition for the projects funded by the CRFs also creates an opportunity to generate positive externalities and focus in areas neglected by the private sector.

In 2011, 5% of worldwide investment in all forms of R&D was directed towards food and agriculture.¹² In 2015, DAFM accounted for 10.3% of the Total GBARD for government departments in Ireland, while agriculture accounted for 12.3% of the Total GBARD in the same year if spending is evaluated by area of research. DAFM's own research represented 2.6% of government department or agency research spending in the same year¹³. Innovations generated by agricultural R&D, along with improved education to foster the best use of the new technologies arising from R&D, have enabled farmers to produce enough food to feed the world, from less land, which has freed up resources to facilitate other economic and environmental functions.¹⁴ The OECD has highlighted that reviving productivity will be key to ensure Ireland's future economic dynamism and to maintain high living standards¹⁵.

Studies evaluating the returns on investment from agriculture R&D have been undertaken by Alston et al. (2010)¹⁶, Gray (2014)¹⁷ and Viaggi (2018)¹⁸, examining the impact and returns on investment from agriculture R&D, which identified four main results:

- Technology change rather than change in land, labour or capital contributes most to increasing production.
- There is a positive correlation between productivity and research expenditure.
- The calculated rates of return on research investment are high on average.
- The time taken by research to exert an effect on productivity is protracted.

¹¹ DAFM Annual Review and Outlook 2019, p.2.

¹² Pardey, P.G., Chan-Kang, C., Dehmer, S.P. and Beddow, J.M (2016) Agricultural R&D is on the move. *Nature*, 537: 301-303.

¹³ DBEI (2017) *The Research and Development Budget (R&D) 2015-16*, pp.11-13.

¹⁴ REVITALIZING AGRICULTURAL RESEARCH AND DEVELOPMENT TO SUSTAIN US COMPETITIVENESS

¹⁵ 2018 OECD [Economic Survey of Ireland](#)

¹⁶ Alston, J.M., M.A. Andersen, J.S. James and P.G. Pardey. 2010. *Persistence Pays: U.S. Agricultural Productivity Growth and the Benefits of Public R&D Spending*. New York: Springer

¹⁷ Gray R. 2014. Solutions to the Agricultural Research Funding Conundrum. *Can. J. Agric. Economics* 62: 7-22

¹⁸ Viaggi, (2018) The impact of Research on EU Agriculture. *Agricultural Economic Society and European Association of Agricultural Economists*. DOI: 10.1111/1746-692X.12182

The three programmes funded by DAFM follow this evidence by systematically prioritising research that contributes to public policy-making. FIRM focuses on the food sector to improve productivity and quality, while RSF and CoFoRD focus on agricultural and forestry production to create technology change and productivity gains. Ireland's relative high ranking for agricultural research noted earlier implies that DAFM's Research Programmes have been effective in contributing to these goals.

3.2 Government Wide Strategies

Two distinct phases of interdepartmental strategies were applicable in the period of focus. This shows how the national innovation system evolves according to changing policy priorities. The relevant strategies are the Strategy for Science and Technology and Innovation (SSTI)¹⁹ and Innovation 2020²⁰

The objectives of the SSTI include:

- Setting a target to increase the number of PhDs and Post-doctoral positions
- Increased focus on public investments within the Higher Education Institutions system that were geared towards increased collaboration of firms
- Aligning funding to the food related priority areas identified in the NRPE in order to help the agri-food sector better deal with challenges and exploit market opportunities.

The objectives under Innovation 2020 include the following:

- To conduct research in strategically important areas that has relevance and impact for the economy and society
- To develop a pool of talent both in Ireland's public research system and in industry that maximises the exchange of knowledge
- To participate in International Research Organisations (IROs)
- To continue to invest in infrastructure and research centres

In 2012 the decision was made to target the majority of future investment in research, development and innovation (RDI), in an attempt to maximise economic returns for the investment under a unified national approach to research prioritisation. The implementation of the [2012 National Research Prioritisation Exercise](#) (NRPE) is a central pillar of the Government's Innovation 2020 strategy,²¹ which provided a template for public investment in research from 2013-2017. The content of the research calls under DAFM's three funding programmes in recent years have been informed by the NRPE. Specifically, two of the 14 priority areas identified were relevant to these programmes, namely, the '[Sustainable Food Production and Processing](#)' (which aligns to all of RSF, and parts of CoFoRD and FIRM funding programmes) and '[Food for Health](#)' (which aligns to the remainder of FIRM).

¹⁹ <https://dbei.gov.ie/en/Publications/Publication-files/Forf%C3%A1s/Press-Release-Strategy-for-Science-Technology-and-Innovation-2006-2013.pdf>

²⁰ <https://dbei.gov.ie/en/Publications/Publication-files/Innovation-2020.pdf>

²¹ Innovation 2020, p.24.

3.3 DAFM Policy Strategies

The CRFs align with the overarching policy strategies outlined by DAFM over the period examined in this review, namely:

- 1) **Food Harvest 2020**, which committed to research funding which would drive sectoral competitiveness, succeeded by
- 2) **FoodWise 2025**, which gave an updated mandate to reflect the central themes of Human Capital, Innovation, Sustainability, Competitiveness, and Market Development.

Four strategic research plans have contributed to informing the content of the DAFM's Competitive Funding Programmes in the scope period of this review – two of which were relevant in the period 2011 – 2014, and subsequently updated and replaced with two new research plans in 2015. The Food Research Ireland (FRI) and Stimulating Sustainable Agricultural Production through Research and Innovation (SSAPRI) informed the content of the FIRM and RSF funded elements of DAFM Calls 2011, 2013 and 2014. The Sustainable Healthy Agri-Food Research Plan (SHARP) and Forest Research Ireland (FORI) informed the content across all three programmes in DAFM's Calls from 2015 onwards.

In Section 5 of this report, the outputs and impacts of the DAFM funding on infant milk formulation, greenhouse gas emission mitigation and animal breeding are examined in more detail. These case studies illustrate the alignment across the supply chain between high-level strategies, CRFs and projects.

3.4 Crowding Out, Deadweight Loss and Additionality²²

A nuanced literature has developed around the issue of opportunity cost related to R&D funding to determine what level and type of public research funding minimizes substitution and maximizes complementarity. This socially optimal level does not 'crowd out' private investment, i.e. substitute resources or replicate funding which would otherwise be effected irrespective of public provision; ideally, this public funding should instead create additionality, i.e. provide funding which would not otherwise exist in that space.

There is increasing evidence contradicting the crowding out principle and supporting the additionality principle around agricultural R&D funding.²³ This core finding is especially applicable to relatively small funds and RPO recipients such as those under the remit of this review.²⁴ The salient World Bank study²⁵ on agri-food R&D spending found that:

²² This section reviews the literature on public agricultural R&D funding impacts, drawing on a World Bank literature review of the evidence, mainly: World Bank Agriculture and Rural Development Department (2010) *Designing and Implementing Agricultural Innovation Funds: Lessons from Competitive Research and Matching Grant Projects*.

²³ Czarnitzki, D. and O'Byrnes, N. *The Impact of R&D on Productivity*, in Sexton, J. et al (2007) *Perspectives on Irish Productivity*, page 322

²⁴ Marino, M. Et al (2016) *Additionality or crowding-out? An overall evaluation of public R&D on private R&D expenditure* in Research Policy Issue 45 pp.1715-1730

²⁵ The World Bank Agriculture and Rural Development Department (2010) *Designing and Implementing Agricultural Innovation Funds: Lessons from Competitive Research and Matching Grant Projects*.

- For every €1 of public agriculture R&D spending, an additional approx. €1 is spent by the private sector in this area
- There is considerable time lag effects, with the first societal impacts generally seen 15-20 years after initial funding is awarded, creating a role for government in sustaining an overarching focus across cyclical volatility
- Contribution rather than attribution is a preferable lens through which to view the intricacies of network interaction in impact generation, which reduces scope for meaningful direct causal analyses between organisations/actors and impacts
- The (Modified) Internal Return on Investment [(M)IRI] lies between 9 – 38% for agriculture R&D spending, depending on whether a distinction is made between ‘maintenance’ and ‘productivity’ research funding (discussed below).

The available evidence supports the general DAFM CRF approach and provides encouraging findings around complementarity for similar funds from international experience²⁶. The literature on agricultural R&D in particular makes several key distinctions applicable to the three programmes in this spending review, namely²⁷:

- Standard economic analyses are increasingly insufficient alone, due to narrowing contemporary public research focus on public good issues such as climate change mitigation and nutrition.
- The economic returns to so-called “maintenance” research, which involves issues such as climate change mitigation that the public sector is naturally geared toward, is lower than “productivity” research. Such research, however, has positive externalities unaccounted for in traditional (economic-focused) return-on-investment assessments and is more likely to be an area of market failure without public policy intervention.
- The Social Impact Assessment framework (SIA) favoured in the literature recognises the importance of stakeholder engagement, as well as knowledge dissemination and application, in generating impacts from research.

Summary

DAFM CRFPs and the methodology employed by this spending review align with the above findings of salient best-practice international reviews, reinforcing the case for public policy intervention²⁸. There is likely, however, to be significant variation in returns to investment owing to the distinction between productivity and maintenance funding focuses. The degree to which funding is distributed across these two categories should be monitored to balance economic and broader societal returns²⁹.

²⁶ Ibid.

²⁷ Ibid.

²⁸ The rationale for public investment in competitive research grants has been previously established in the 2019 IGEES Spending Review on Science Foundation Ireland. See p.34 of Keogh and Hickey (DPER 2019) *Analysis of Science Foundation Ireland Research Grants*.

²⁹ For example, FIRM appears to generate greater productivity-enhancing outputs, as seen in the case of infant milk formula development, whereas CoFoRD is predominantly engaged in maintenance research in areas such as climate change mitigation through forestry.

4. Inputs and Awards Process

4.1 Inputs

Organisations Eligible for Grant-Aid³⁰

Grant-aid is restricted to DAFM approved Research Performing Organisations (RPO).³¹ RPOs currently eligible to apply for funding under these programmes are those institutions which fall within the meaning of Section One of the HEA Act, 1971 (Universities and Institutes of Technologies, etc.), plus Teagasc, the Marine Institute, the Irish Cattle Breeding Federation and Birdwatch Ireland³². Other organisations that do not have partner status may also be involved in projects e.g. Industry can participate on a self-financing basis subject to the need to respect the 'public good' nature of DAFM Research Funding programmes and compliance with the National IP Protocol. One of the current criteria for RPOs to be eligible for DAFM grant-aid³³ is to be a publicly funded organisation whose primary goal (accounts for more than 50% of its activities) is to independently undertake research and innovation activities and widely disseminate findings. This is designed to protect the provision of public goods independent of private interests, however with appropriate additional safeguards for the public good aspect of research, there may be scope for further collaboration with private industry within the terms of existing state aid rules.

DAFM Commitments & Expenditure

The financial commitments of funds under the three programmes are summarised below. Funding is awarded to successful applicants and monies committed are drawn down over the lifetime of the project. Once awards are made under the respective programmes, the funding tends to be drawn down over periods that can be up to six years depending on which of the Call mechanisms is used. Accordingly, DAFM expenditure under its three Research programmes in any given year arises from commitments made under a mix of the various Call mechanisms/instruments deployed and normally comprises a combination of (a) advance payments on new project awards and (b) payment of further instalments on awards committed over the previous 4 – 5 years.

Regarding expenditure when projects are awarded, an advance payment is paid out first to get the project up and running. The project coordinator submits annual progress reports which detail the expenditure and technical progress made on the projects. Payments are released following DAFM review of these progress reports during the lifetime of the project. A proportion of the award is not released until a final project report has been submitted and deemed acceptable by DAFM. Payments

³⁰ The Botanical Gardens have also since qualified for eligibility. DAFM is authorised to administer competitive research funds for "Aid for research and development in the agricultural and forestry sectors (Article 31)" pursuant to *Statutory Instrument No. 98 of 2014; FINANCE ACT 2004 (SECTION 91) (DEFERRED SURRENDER TO CENTRAL FUND) ORDER 2014*.

³¹ [General block exemption Regulation](#)

³² Organisations must apply for eligibility in order to then qualify to apply for funding under national research calls. Governance procedures ensure eligibility criteria comply with EU state aid rules.

³³ [DAFM RPO Eligibility Application](#) (pdf 224 kb)

never exceed the total amount originally awarded, and if projects overspend the research institutions must bear the additional costs.

National Calls Commitments

Approximately €142.6m was committed under the national competitive calls during the 2010 -2017 period. In total, 225 new research projects were funded in this period, with 125 funded under FIRM, 73 under RSF and 27 under CoFoRD. The larger number of projects under the FIRM programme has been alongside a consistently larger proportion of funds (€74.2m overall) committed to food-related research over the 2010-2017 period, equating to 52.1% of the total. RSF received €56.9m (39.9%) and CoFoRD received €11.5m (8%) in awards.

Table 4.1: Award Commitments and Projects under National Research Calls by year of commitment 2010 – 2017

Programme	Metric	2010	2011	2012	2013	2014	2015	2016	2017	Total
FIRM	No. of Projects	0	13	38	34	18	0	22	0	125
RSF	No. of Projects	0	4	26	13	13	0	17	0	73
CoFoRD	No. of Projects	0	6	5	5	6	0	5	0	27
FIRM	Awards (€m)	€4.34	€15.97	0	€17.78	€10.64	€14.91	0	€10.58	€74.22
RSF	Awards (€m)	€2.54	€11.94	0	€12.73	€8.72	€12.35	0	€8.64	€56.92
CoFord	Awards (€m)	€2.82	€2.85	0	€1.57	€ 1.33	€1.93	0	€0.96	€11.46
Overall	Awards (€m)	€9.71	€30.76	0	€32.08	€20.69	€29.19	0	€20.18	€142.61
	No. of Projects	0	24	69	52	37	0	44	0	225

National Calls Expenditure

Over the 2011-2020 period, the total amount of funds paid out (drawn down) on all national projects equates to circa €99.8m, of which €53.9m (54.1%) was paid under FIRM, €36.7m (36.7%) under RSF and €9.1m (9.2%) under CoFoRD. Figure 4.1 summarises the relationship between drawdowns and remaining funds across the programmes and overall from 2011-2020 for 2010-2017 awards³⁴. A full breakdown for the overall total of drawdowns and total funds for 2011-2020 for projects awarded in calls between 2010-2017 is available in Table 4.2. No funds were drawn down in 2010, as the 2010 Calls projects awards were announced in August 2011. Overall, 70% of funds awarded over 2010-2017 have been drawn down as of September 2020. The remaining 30% largely relates to projects from the final three years of awards especially, with more than 90% of 2010-2011 awards drawn down to date. There were no national Calls in 2012 or 2016. A full breakdown by programme is available in the appendix alongside a table for cumulative drawdowns.

³⁴ Year Awarded references the year in which the call and successful applicants were announced.

Figure 4.1: Overall Drawdowns for All Programmes as a Proportion of Awards as of August 2020 for DAFM CRFP funds Awarded 2010-2017.

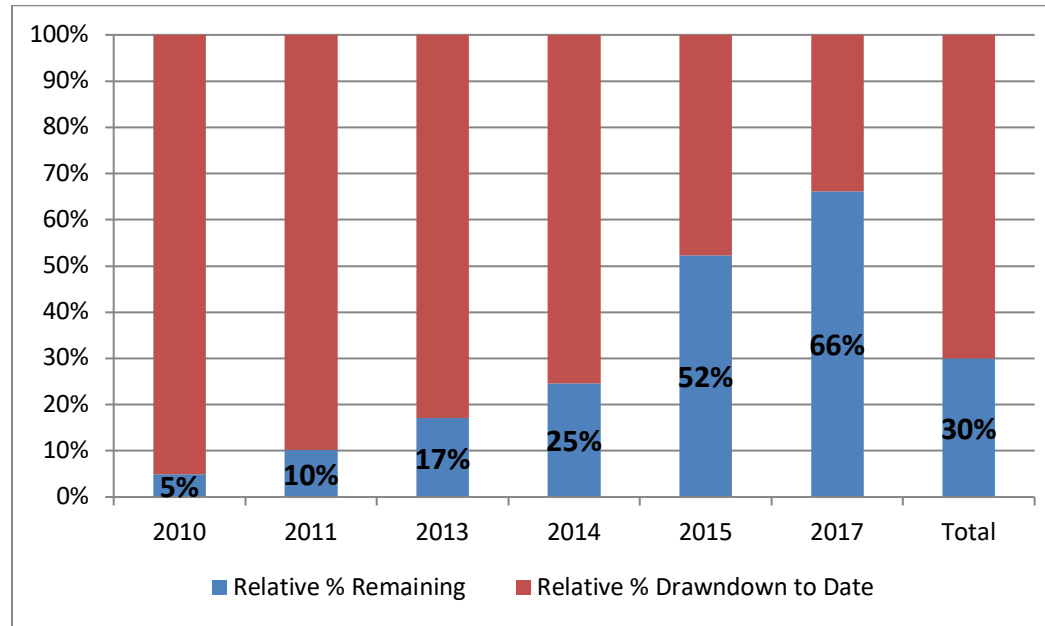


Table 4.2: Drawdowns 2011-2020 for All Programme Awards 2010-2017

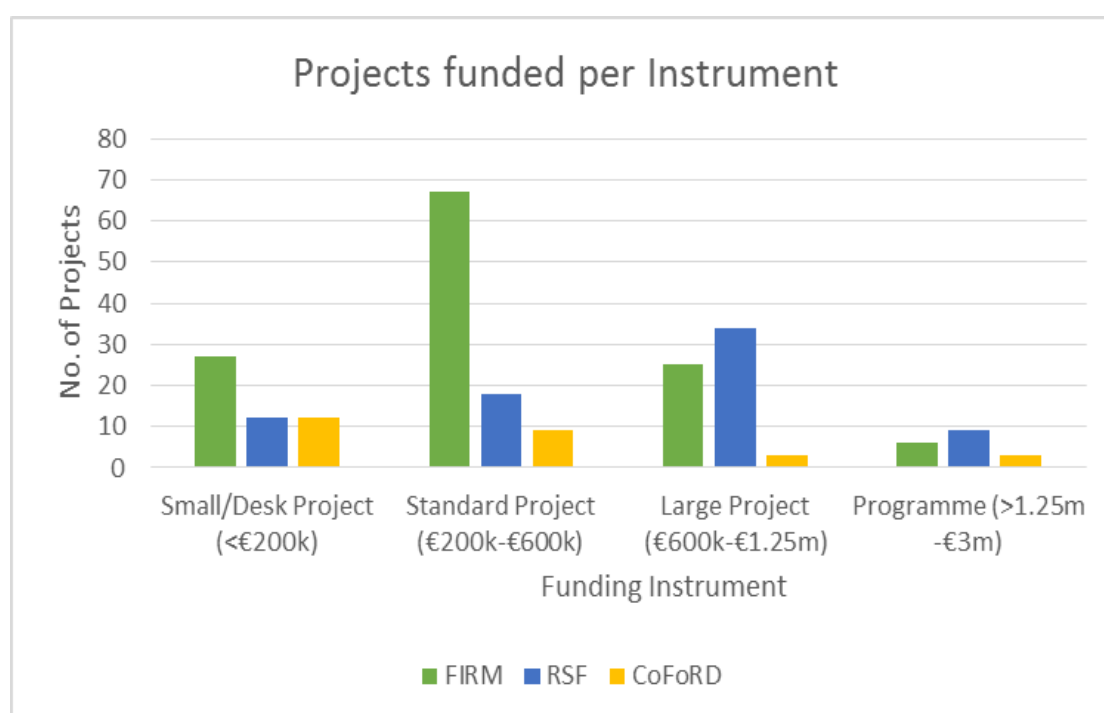
Year -> Spent ↓ Awarded	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020 (Year-to- Date)	Remaining to Drawdown	Total Awards	Total Drawn Down to September 2020
2010	€2,846,799	€216,956	€50,722	€1,843,533	€2,070,063	€631,745	€614,278	€832,342	€124,077	€0	€478,464	€9,708,978	€9,230,514
2011	€0	€11,971,002	€204,734	€458,799	€6,504,347	€2,125,964	€2,536,744	€1,928,364	€1,420,848	€466,674	€3,146,987	€30,764,464	€27,617,476
2013	€0	€0	€12,837,926	€274,457	€1,133,904	€2,998,450	€4,462,014	€2,481,170	€1,126,354	€1,270,352	€5,497,056	€32,081,682	€26,584,626
2014	€0	€0	€0	€8,013,016	€0	€1,064,240	€1,638,498	€2,265,434	€1,824,001	€806,187	€5,074,638	€20,686,013	€15,611,376
2015	€0	€0	€0	€0	€0	€8,513,294	€287,812	€898,564	€2,624,789	€1,592,089	€15,273,370	€29,189,918	€13,916,548
2017	€0	€0	€0	€0	€0	€0	€0	€5,905,171	-€24,163	€960,533	€13,338,807	€20,180,348	€6,841,541
Total	€2,846,799	€12,187,958	€13,093,382	€10,589,805	€9,708,313	€15,333,693	€9,539,346	€14,311,045	€7,095,906	€5,095,835	€42,809,323	€142,611,404	€99,802,081

Funding Instruments/Categories of Projects funded

Under the DAFM Call structure there are a number of categories of projects that can be funded and these are referred to as the funding instruments (Annex A). These instruments classify the grant by award size, the duration of the project and the number of RPO's participating. For example a 'desk project' must have a maximum of two RPOs, must be no longer than two years in duration and have a maximum grant award of €200k. The most common instrument is the 'standard project' which must have a minimum of two RPOs, be no longer than four years in duration and have a maximum grant award of €600k. The largest funding instrument is the 'programme' which must have a minimum of four RPOs, is no longer than five years in duration and has a maximum grant award of €3m. As noted previously, this funding can be drawn down over a six year period. In some instances projects may require an extension (in duration only – no additional funding is allocated) to allow for the completion of the agreed deliverables and therefore the durations of the funding instruments can be extended beyond the time frame as detailed in Annex A.

In terms of funding instruments, the majority of the projects were classified as standard projects (94 in total), followed by large projects (62); small projects (51) and programmes (18). Over half the CoFoRD projects were funded under the Small/Desk Project funding instrument, which partly accounts for the smaller proportion of funds associated with this programme. The full breakdown is provided in Figure 4.3

Figure 4.3: No. of projects funded per funding instrument under the three programmes 2010-2017



Undertaking this analysis highlighted a limitation in the ability of the programmes to deliver policy information when urgently needed. On occasion the Department may need to have relatively small scale mainly desk-based analytical type work carried out by an external body with specialised expertise. This often needs to be organised quickly and undertaken in a short timeframe (e.g. completed in 3 – 6 months or less) and, therefore, is not suited to routine research Calls. This includes policy based research (e.g. an economic analysis of the case for an IBR eradication

programme in Ireland). Consideration could be given to the development of a system of rapid response research to meet potential short-term or urgent research needs of the DAFM currently not catered for by the Calls system³⁵.

Transnational Funding Commitments & Expenditure

In line with the 2012 NRPE, DAFM senior management sanctioned a proposal from Research and Codex Division to use up to 15% of the budget for transnational funding³⁶ initiatives. These include collaborative transnational partnerships in European Research Area Network Cofunds (EraNets), EU Joint Programme Initiatives, and the US-Ireland R&D Partnership.

This funding is aimed at supporting national participation in strategically aligned transnational competitive research Calls. Such participation is justified as it helps leverage expertise and data and will develop skills and networks. EraNets can also help to leverage non-exchequer funding both directly through EU top up funding and, indirectly, by providing a mechanism through which Irish researchers become embedded in European consortia. These are subsequently well placed to compete successfully for awards under Horizon 2020. Therefore, the majority of transnational research funding Calls that DAFM supports are undertaken in conjunction with other EU Member States and the EU Commission (through EraNet Calls and Joint Programming Initiative funding Calls). DAFM support also extends to the US-Ireland R&D Partnership, an arrangement involving DAFM, DAERA NI and the USDA's National Institute of Food and Agriculture (NIFA).

In the period under review, over €8.1m has been awarded to Irish researchers participating in 22 projects under 12 European research area networks and one US-Ireland R&D Partnership (Table 4.3 and Annex B). The majority of transnational funding has been funded under the RSF programme, followed by FIRM and CoFoRD. These commitments by year are provided in Table 4.2. Because many of these projects are still ongoing and the larger amounts have been awarded in more recent years, the drawdown (expenditure) to date is less at €2.4m.

³⁵ Such a rapid response research facility has been implemented by other Research Organisations – such as the Health Research Board and Science Foundation Ireland in response to the Covid-19 pandemic, for instance; <https://www.sfi.ie/funding/funding-calls/covid19-rapid-response/>. Such calls do not require the same form of procurement as standard competitive research calls like the DAFM CRFs examined here.

The EPA has recently submitted its proposals for reform of their research strategy, which includes: “Fast track to Policy Funding looking at providing evidence synthesis, review of policies, best practices to answer urgent emerging policy questions (addressing emerging short-term policy needs)”. Current DAFM draft proposals would address this and are being evaluated to reflect wider developments in this area in PROs.

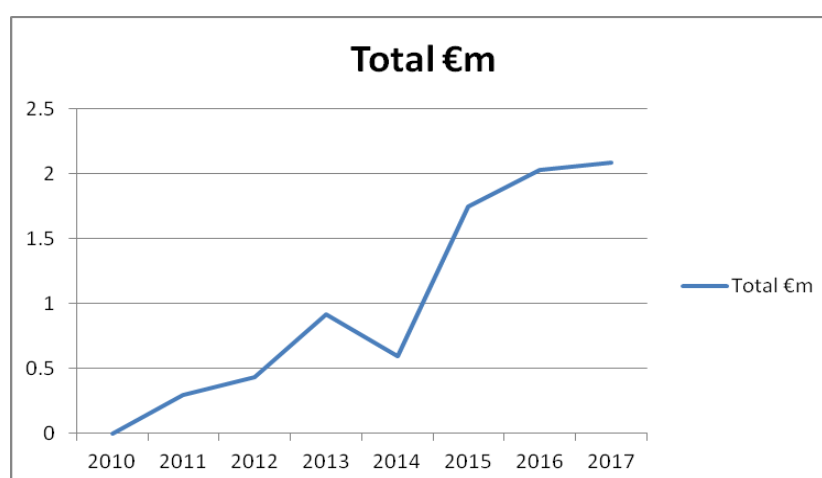
³⁶ DAFM provides funding to support national participation in strategically aligned transnational competitive research Calls where Irish researchers collaborate with a research consortium comprising of researchers from a number of member states in completing transnational projects. Each national partner is funded by their own member state.

Table 4.2: Funds committed 2010-2017 under Transnational Calls across the three programmes

ERA NETs and US IRL	2010	2011	2012	2013	2014	2015	2016	2017	<i>Total</i>
FIRM	0	0	0	0.59	0	1.25	0	1.11	2.95
RSF	0	0	0.43	0.32	0.25	0.50	1.79	0.97	4.26
CoFoRD	0	0.30	0	0	0.35	0	0.24	0	0.90
<i>Total Committed</i>	0	0.30	0.43	0.92	0.60	1.75	2.03	2.08	8.11
<i>Total Expenditure</i>	0	0	0.14	0.08	0.30	0.33	0.80	0.78	2.44
<i>Committed vs. Expenditure³⁷</i>	-	-	3.31	11.5	2	5.3	2.54	2.67	3.24

There was an increasing focus on providing DAFM funds under the transnational calls in more recent years with new funds rising from €300k in 2011 to over €2m in 2017 as illustrated in Figure 4.4.

Figure 4.4: Trend in total value of funds committed under transnational calls 2010-2017



4.2 Awards Process

Overview of Call Process and Awards System

Calls for Research proposals are made in c.16 month intervals for all three funding programmes. The frequency of the Calls ranged from 13 to 21 months over the six Calls that occurred in the 2010-2017 period. Grant awards are made following a robust process of evaluation of applications received on foot of the Calls and through contract negotiations. The process can last 7 to 12 months with an

³⁷ This is the amount of funding committed relative to expenditure (i.e. commitment divided by expenditure).

average of 9 months (see Table 4.3). This timeframe does not include time taken for the formulation of call topics and the preparation of Call documents.

Table 4.3: Frequency of National Calls

<i>Call Year</i>	<i>Call Applications Submitted</i>	<i>Call Awards Announced</i>
Call 2010	Dec-10	Aug-11
Call 2011	Mar-12	Nov-12
Call 2013	Apr-13	Nov-13
Call 2014	May-14	Dec-14
Call 2015	Dec-15	Dec-16
Call 2017	Sep-17	Jul-18

The Call process can be summarized into an 11-Step process which is outlined in Annex C (note that the time referred to in table above relates to steps 3-6 inclusive). There are two elements of the 11-step process that incur the most significant administrative burden³⁸ and thus are of interest to this review. These are now examined in more detail below.

Step Six – Contract Negotiations

Prior to the signing of contracts, DAFM engages in further bilateral correspondence in a contract negotiation process with the co-ordinator which can include:

- Seeking additional information it considers necessary
- Seeking and agreeing adjustments or modifications to proposals as recommended during evaluation.
- Negotiating adjustment to proposal details to achieve consistency in approach across and develop coherent measures of impact.

Based on informal enquiries, the extent and depth to which DAFM engages in this contract negotiations process appears to be more extensive than most other research funders in Ireland, and adds a significant delay and administrative burden to the Call process (it delays funding of projects by 2 – 3 months typically). The rationale for this process has been that despite a robust evaluation

³⁸ No direct estimate of staffing costs associated with these two steps was available for the purposes of this spending review. Total Staff costs for administering FIRM, RSF and CoFoRD in 2017, using 2013 Public Spending Code guidance and applying median staff costs at each grade of employee, were estimated at €920,559. This represents 8.3% of expenditure including awards, which totalled €11,040,020, in 2017. If the €920,559 cost figure was replicated across the eight years 2010-2017, the average staff costs percentage relative to total expenditure on the three programmes would average 5.68%, where annual total expenditure including staff costs and awards averaged €16,212,500 over the eight years examined in this spending review.

For comparison, Keogh and Hickey (2019) *Analysis of Science Foundation Ireland Research Grants*, p.8, found SFI “current expenditure, in the form of administration, pay, and general expenses, accounted for between 4.6 percent and 5.7 percent of total SFI expenditure each year” over 2007-17, with a target of 5% for administrative costs as a proportion of annual commitments to 2020. The CRFPs, then, have relatively high administrative costs – possibly reflecting the level of expertise required to monitor projects and the intensive nature of the calls project applications evaluation process.

process (step 4, Annex C), specific details of projects may still require further amendments and this process is aimed at ironing out these anomalies. However, it is unclear to the extent to which other funders conduct this process and this may warrant further examination.

For example, one of the administrative burdens in the process is to agree salary scales for contract research staff of the same grade hired on a project (Post-Doc, technicians etc) that are customised to individual HEI's participating in a project rather than using a uniform standardised scale for all. These details are also verified and checked to ensure that they are correct and in line with contemporary Government pay-agreements periods prior to grant approval.

Step Nine – Financial and Scientific Monitoring of Projects

DAFM monitors delivery of the outputs of each individual project throughout its lifetime through a combination of desk based evaluations of annual progress reports and periodic on-site inspections. It also proactively interacts with the research teams to address problems if and when they arise.

Following the initial grant of award and payment of advances, project co-ordinators are obliged to provide DAFM with an initial progress report six months into the project and on an annual basis thereafter. These progress reports form the basis of claims for payment, as well as capturing key interim outputs from the projects. Each progress report received is subject to both administrative and scientific checks, which include that the tasks and milestones/deliverables set out in the project proposal are being met and that the agreed budget profiles for each expenditure category are being observed. Any outstanding issues which need to be addressed with the project co-ordinator are flagged during this process.

The monitoring system employed by DAFM carries a significant administrative burden, in particular the annual reporting on project progress reports, with work allocated in accordance with staff competencies. At any point in time there can be up to c.200 projects ongoing (national and transnational) across the three programmes, and an increasing challenge in the administration of the programmes is the inevitable major backlogs of project progress reports pending review (as staff are involved in other activities also), which in turn negatively impacts the timely payment of interim stage payments.

Other pending issues that have added to the challenge of administering the programme and may require further examination to address include:

- The fact that, up to now, DAFM has relied totally on a paper based system for monitoring the progress of projects and processing resulting grant payment claims.
- Increased staff mobility (in line with overall DAFM HR policy) with vacancies in some cases proving challenging to fill in a timely manner.
- The increasingly diverse number of co-funding initiatives that DAFM is involved in at both a national but particularly at a transnational level, although strategically justified and encouraged through inter alia, NRPE and EU European Research Areas– participation in such initiatives brings significant resource demands to service them effectively.
- The extent and depth to which DAFM directly manages and engages with the award management of projects is perhaps more extensive than some other Irish research funding agencies who out-source much of this work, and is a major factor in necessitating the current staffing complement in Research and Codex division.

On the first point above, this has been recognised as a major inefficiency in the operation of programmes and a barrier to the effective capture and aggregation of key outputs. DAFM is in the process of transitioning to a grant management software system similar to what is used by most other research funders. The adoption of a customised IT-based grant management system will be a key opportunity to improve the efficiency of the Competitive Research Programmes to manage all files during the application, evaluation, and post-award project monitoring phases. Currently three disparate Access databases and an Excel spread sheet hold key financial information and data on the projects.

Further analysis and consideration would be required to resolve the other three issues outlined above. There may be scope for further efficiencies if a department or division within government, other than DAFM's research division staff, were to review the awards process. There is a dedicated division within DAFM (Management Services Division) who provide analysis, support and recommendations on organisational development, including resource allocation, efficiency and effectiveness and business process improvements. This division could conduct a review on the awards process.

The current process ensures that DAFM follows established best practices in competitive research funding. A relevant World Bank³⁹ paper draws on evidence of international best practice and outlines steps necessary to administer successful competitive research funds with these findings in mind, which DAFM CRFs meet, including:

- Specifying strategic needs
- Setting funding limits at the outset
- Clarifying who can apply for a grant

The ongoing need to 'Monitor progress, set indicators and review outputs' is the key focus of the recognised need for reform and modernisation – a process which is currently underway to improve measurement and data collection to generate consistent, measurable and traceable indicators of inputs and outputs. As evidence and context change, programme designers will continue to follow developments on how best to structure, administer and track the progress of research funding. It should also be noted, more broadly beyond the CRFPs alone, that the GBARD for agriculture was relatively stable over the 2011-17 period – with a moderate overall nominal increase of 5.5% during the period – and the performance of the research should be considered within this context.

Summary

The main input to DAFM competitive research programmes is the grant aid provided to the approved RPOs. Over the 2010-2017 period 247 projects were funded at a value of almost €152.6 million, 225 projects under the national calls (c. €142.6m) and 22 projects under transnational calls (c. €8m). National calls for the three Research programmes are made at c.16 month intervals and successful projects are awarded under a range of funding instruments that vary on size of award, number of RPOs participating and the duration of the project. The Call process is an 11-Step process and two of these steps (steps six & nine) were identified as incurring a more significant administrative burden to DAFM staff. An improvement in the efficiency of DAFM's procedures is expected when the IT grant management system is adopted.

³⁹ The World Bank Agriculture and Rural Development Department (2010) *Designing and Implementing Agricultural Innovation Funds: Lessons from Competitive Research and Matching Grant Projects*.

There may be opportunities for efficiency gains in how funded projects are monitored and evaluated (step nine of the Call process). A review of the process could be undertaken to secure administrative cost efficiencies. A further issue that was highlighted within the current DAFM Research Programmes is a level of inflexibility to facilitate the need to address urgent policy requirements as they arise. This could be addressed by operating a frequently open, rapid response short desk studies Call⁴⁰.

⁴⁰ Such a system would be intended as supplementary and would be financed from existing resources. It would involve a Strategic Studies Programme to meet research needs not currently deliverable under the CRFPs.

5. Outputs and Impacts

The outputs and impacts of DAFM's Competitive Research Programmes are outlined in this section. Due to data availability, there is less information on the outputs of project funded in years 2012 to 2017 because many of these projects are not completed yet and therefore the outputs of these projects have not been reported to DAFM in their entirety yet. Therefore this section focuses on the projects which have been completed and were funded under the three programmes in the National Calls of 2010 and 2011 as stated in the methodology section. Of the 93 projects funded in these years— 51 were funded under FIRM (55%), 31 RSF (33%) and 11 CoFoRD (12%). Thus the relative representation of programme level data is broadly in line with the total project funding in the 2010-2017 period - 225 projects in total of which 125 FIRM (56%), 74 RSF (33%) and 27 CoFoRD (12%). The overall value of the 2010-11 sub-set of projects was €49.52m, of which €24.6m, €18.9 and €6m were funded under FIRM, RSF and CoFoRD, respectively.

The outputs from these 93 completed projects provide a good indication of the likely outputs and impacts in any given call period. The information reported here should be approached with some caution in that this is based on a direct copy of the information submitted by project coordinators at the end of the reporting period for the funded projects and so, it must be interpreted with caution. Notwithstanding these caveats, the data is a useful indicator on project level outputs and general trends in the data.

5.1 Outputs

Building Capacity and Capability

Table 5.1 on the following page summarises the main academic outputs such as the number of peer reviewed publications and staff trained (as early stage researchers) on the DAFM funded projects which are key elements of capacity and capability building.

The peer review process in examining these publications ensures that independent experts have reviewed the work and approve the results as valid and relevant. Accordingly, the number of peer reviewed publications for each programme is a key measure of impact. As Table 5.1 illustrates a total 742 peer-reviewed publications have been produced across the three programmes over the period under review. This represents a significant contribution to the international literature and knowledge economy which are key objectives as set out by DAFM.

Figure 5.1 outlines the mean average publications per project and total number of publications by funding programme. It illustrates that RSF and FIRM programmes had an average of approx. eight and nine peer-reviewed publications per project, respectively – whilst CoFoRD had an average of 2.9 in the period measured – producing an overall mean of 7.98 PRPs per project across the three programmes (represented by the red line in the graph to mark the average). One of the main reasons for the lower figure attributable to the CoFoRD programme is the proportion of smaller and shorter studies (small/desk projects) funded under that programme is much higher than the other two programmes (44% compared to 16% for RSF and 22% FIRM).

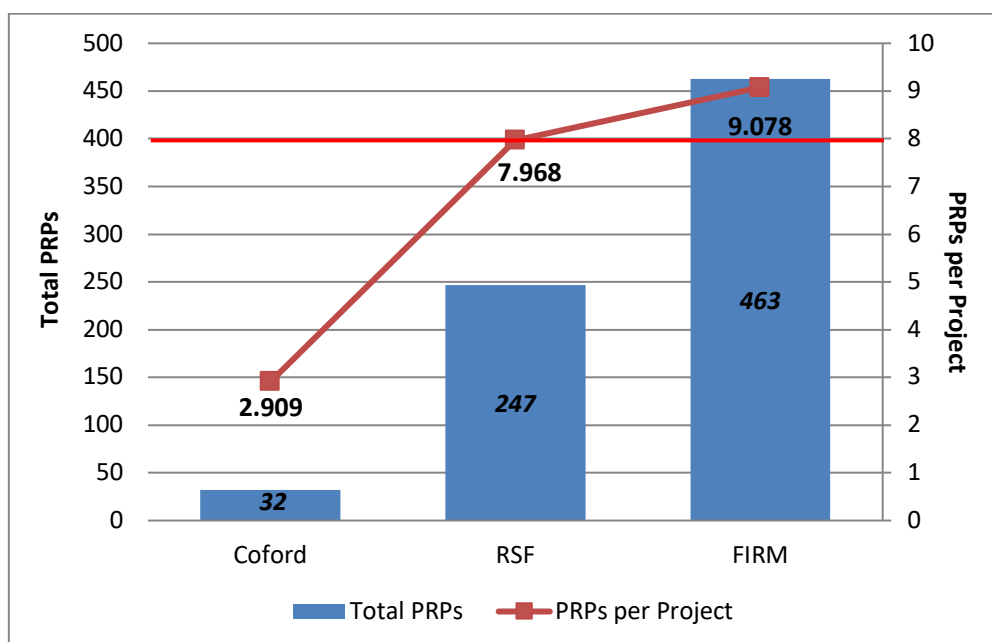
Table 5.1: Academic Outputs for Projects Funded in DAFM's National Research Calls 2010-2011⁴¹

Output↓Programme→	Coford	RSF	FIRM	Total 2010-11
<i>Number of Projects</i>	11	31	51	93
	12%	33%	55%	
<i>No. of Peer-Reviewed Publications (PRPs)</i>	32	247	463	742
	5%	33%	62%	
<i>No. of new products</i>	4	1	18	23
	17%	4%	79%	
<i>No. of new technologies/processes</i>	6	10	69	85
	7%	12%	81%	
<i>No. of new policies⁴²</i>	3	9	7	19
	16%	47%	37%	
<i>No. of links with industry</i>	2	3	88	93
	2%	3%	95%	
Intellectual Property				
<i>No. of Invention Disclosures</i>	1	1	22	24
	4%	4%	92%	
<i>No. of Patents</i>	0	1	7	8
	0%	13%	87%	
<i>No. of Licences</i>	1	0	1	2
	50%	0%	50%	
Funding Leveraged				
<i>National</i>	€ 516,000	€ 5,990,000	€ 23,981,000	€ 30,487,000
	2%	20%	78%	
<i>International</i>	€ 561,000	€ 5,000	€ 3,981,000	€ 4,547,000
	12%	0%	88%	
Staff				
<i>No. of PhD+ (Post-doctorates)</i>	15	60	65	140
	11%	43%	46%	
<i>No. of post grads (PhD & MSc)</i>	23	73	112	208
	11%	35%	54%	
<i>No. of Research Assistants/ Technicians</i>	12	13	22	47
	26%	28%	47%	
<i>No. of research fellows or contract staff</i>	19	56	44	119
	16%	47%	37%	
<i>Total Staff (Inclusive of the above)</i>	69	202	243	514
	14%	39%	47%	

⁴¹ Percentages rounded to nearest whole. Euro values rounded to nearest thousand. Totals are horizontal.

⁴² The lower-than-anticipated figures across programmes for this metric is most likely linked to the closed interpretation of the question by project co-ordinators on the post-project questionnaire.

Figure 5.1: Mean Number of Peer Reviewed publications (PRPs) per Project [RHS] and Total Number of PRPs [LHS] by Programme under DAFM's National Research Calls 2010-2011⁴³



DAFM's Research Programmes place a key emphasis on building capacity into the Irish research system with a total of 514 new staff training positions funded under the 93 projects arising from the 2010 and 2011 Research Calls. Funded staff trained varied across all three programmes with CoFoRD giving rise to significantly less recruitment, which is unsurprising given the lower number of projects and lower funding available.

The number of post-doctoral training positions created from the programmes can also be described as an output in line with the Revised Estimates for Public Services 2018.⁴⁴ Accordingly, the number of post doctoral positions serviced in these two research Calls (Calls 2010 & 2011) was 15 for CoFoRD, 60 for RSF and 65 for FIRM. The number of students trained to Master or PhD level was 23, 73 and 112 for CoFoRD, RSF and FIRM, respectively. At the post-doctoral level, the positions were similarly spread to projects, with 46% of staff funded through FIRM, whilst 43% and 11% were funded under the RSF and CoFoRD programmes, respectively. At post-graduate (student) level, FIRM had significant coverage at 54% of all post-grad positions. The comparable figures were 35% and 11% on the RSF and CoFoRD programmes, respectively.

The mean number of students per project overall was 3.74. The individual breakdown presented in Figure 5.2 below. There is evidence of economies of scale linked to the higher level of funding received by FIRM in particular. The low level of funding received by CoFoRD appears to reduce its output efficacy relative to the other two programmes and reflects the context in which it operates being significantly different. Staff are distributed relatively evenly relative to the size of the programmes, as evidenced by the per-project measures. FIRM, possibly accruing to economies of scale, has a lower level of staff per project generally.

⁴³ The red line, at approx. eight PRPs per project, represents the overall total mean PRPs per project. The actual figure is 7.98, as discussed in the text previously.

⁴⁴ DPER (2017) *Revised Estimates for Public Services 2018* available at: <https://www.per.gov.ie/en/rev/>

Table 5.2: Total Staff and Staff per Output by Programme 2010-11

Programme	CoFoRD	RSF	FIRM	Total
2010-11 Funding and Staff				
Total Awards	€ 6,087,807.70	€ 18,910,777.69	€ 24,602,304.00	€ 49,600,889.39
% Awards	12.3%	38.1%	49.6%	100.0%
Total Staff	69.00	202.00	243.00	514.00
% Staff	13.42%	39.3%	47.28%	100%
2010-11 Mean Funding to Staff Ratios				
Total Funding : Total Staff	€ 88,229.10	€ 93,617.71	€101,244.05	€ 96,499.78
Total Funding : No. Post-grads	€ 264,687.29	€ 259,051.75	€ €219,663.43	€ 238,465.80
Total Funding : No. Post-docs	€ 405,853.85	€ 315,179.63	€378,496.98	€ 354,292.10
2010-11 Staff per Output				
Mean Staff per Project	6.3	6.6	4.8	5.5
Mean Staff per PRP	2.2	0.82	0.52	0.80

Figure 5.2: Students (Postdoctorate and Postgraduate Researchers) and Total Staff by Programme 2010-11; Total (Left-Hand Side) and Mean (Right-Hand Side)

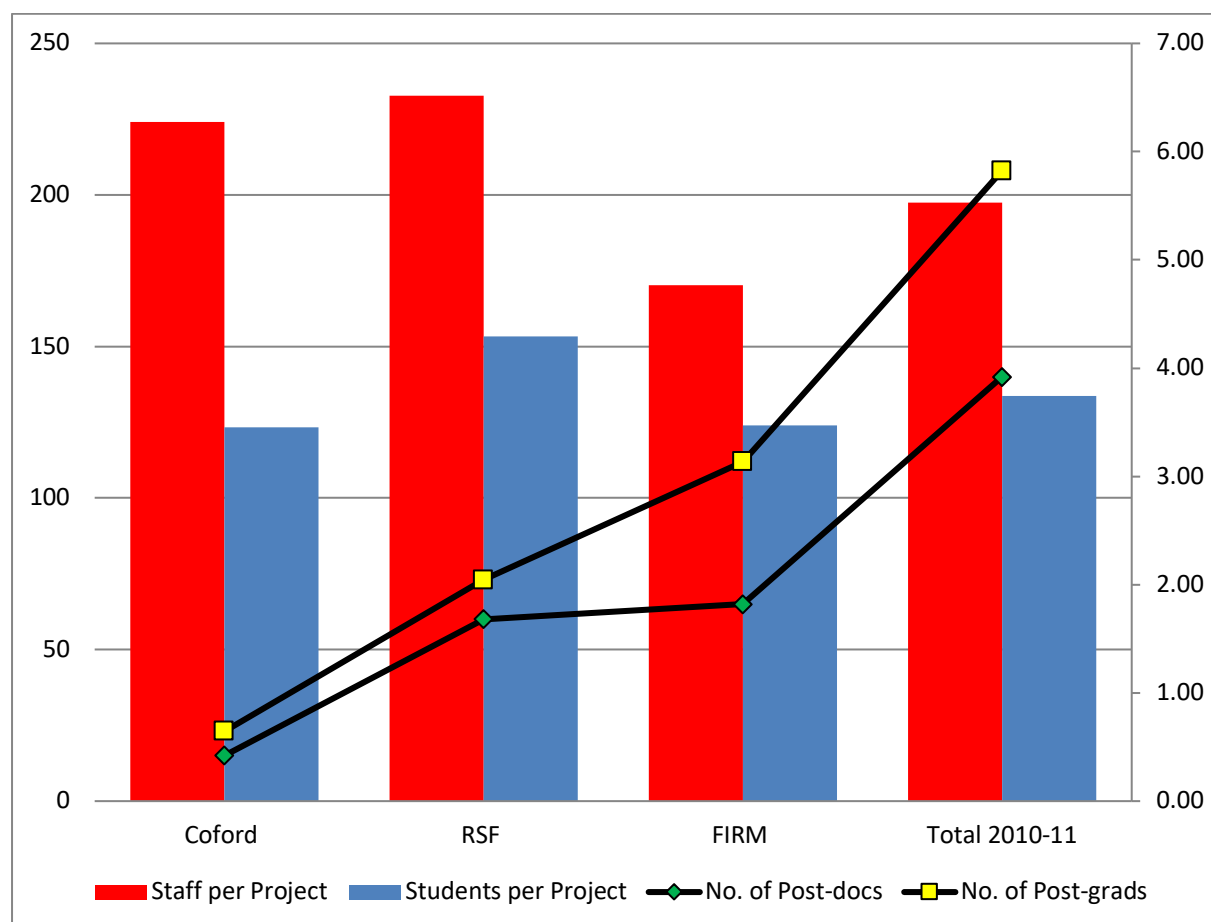
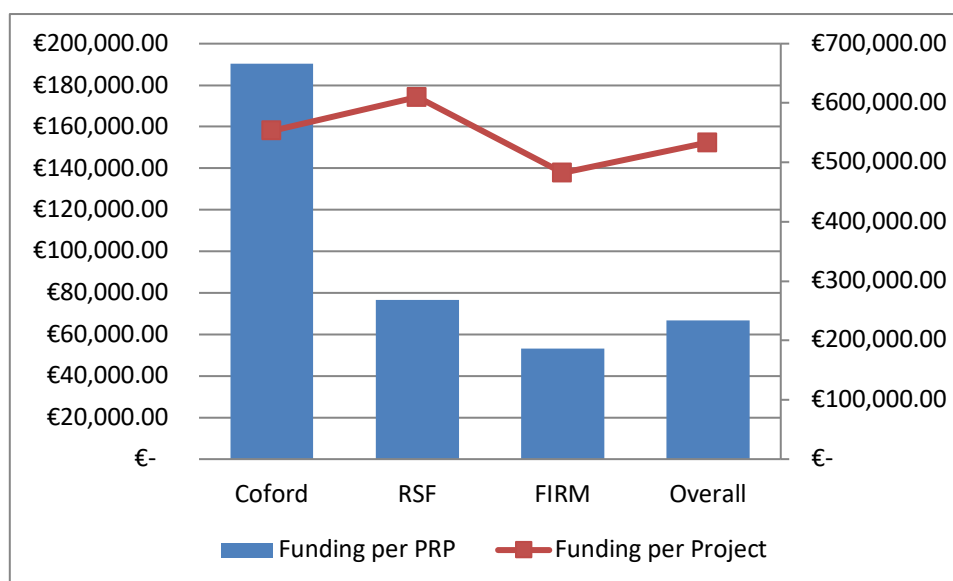


Figure 5.3: Mean Funding per Publication (Left-Hand Side) and Mean Funding per Project (Right-Hand Side) 2010-2011 by Programme



Supports for the Agri-Food Sector

The three programmes have all provided important outputs that have contributed to the development of the agri-food sector. They have led to outcomes in terms of new products, practices, inventions and technological processes. The type of project will determine the degree to which patents, licenses and inventions are achieved. For example, CoFoRD projects aim to improve our understanding of the factors that influence forestry operations as opposed to developing new products. In contrast, the FIRM projects which have a focus on developing new processes and technologies represent the bulk of the outputs achieved under the enterprise heading, with 18 new products and 69 new technology processes reported by coordinators for the 51 projects funded in the 2010 and 2011 Calls (Table 5.1). FIRM appears to be broadly delivering on its mandate – with natural variation in success between projects – by developing over four in five of all new technology processes arising across the three programmes for this period, or 1.35 per project on average. The increased links with industry is a key outcome as these collaborations developed during the DAFM funded projects can accelerate the further development of the agri-food sector.

In addition to the above, the RSF and CoFoRD programmes also provide evidence to guide policy formation and knowledge to help to improve the sustainability and competitiveness of farming and forestry practices. This is very difficult to quantify but it is actively disseminated to farmer/forester end users through, for example, project workshops, the advisory arm of Teagasc, and indeed private agricultural and forestry consultants, where it has a positive impact. For example, efficiencies found in farm practices are disseminated to farmers through the various knowledge transfer programmes. There have also been workshops provided to inform policy makers on the Marginal Abatement Cost Curve (MACC) for potential GHG mitigation measures, and the relative private costs associated with each of these measures. There have since been updates to the MACC⁴⁵, and it continues to be crucial in disseminating the latest implementable and practical research findings to ensure best sustainable

⁴⁵ Lanigan et al (Teagasc 2019) *An Analysis of Abatement Potential of Greenhouse Gas Emissions in Irish Agriculture 2021-30*.

practices are adopted in a cost-efficient manner in the industry. This also evidences the cumulative nature of building a knowledge base over time and the iterative development of knowledge tools.

International Leveraging of funds

International funds were leveraged as a result of the collaborations that took place and the outputs from these 93 projects. International leveraging of funds refers to funds which were sourced as a result of work conducted on the DAFM research projects. This is not to be confused with leveraging resulting from transnational initiatives which are sometimes co-funded by the EU commission. International leveraging refers to further funding leveraged to support additional work that arose as a result of the DAFM funded project, whereas transnational funding is funds provided by DAFM to Irish partners participating in transnational projects. Table 5.3 illustrates that Funded researchers leveraged over €4.5m in international funding through projects funded under DAFM's three programmes in the 2010 and 2011 Calls – again caution is advised in interpreting these figures as it only shows leveraging that was reported while the respective projects were still ongoing, whereas in reality most of the international funding leveraging will have occurred when a project is completed.

The FIRM programme leveraged most of the funding (87.56%), while reported leveraging for CoFoRD projects was much higher (12.33% of the total) compared to the RSF funded projects (<1%). The smaller percentage in RSF is likely due to the fact that the nature or focus of the research in this programme is geared towards improving Irish on-farm agri practices and therefore does not lend itself to leveraging as much as the other programmes.

Table 5.3: Summary data reported for International Leveraging Outputs for Projects Funded in DAFM's National Research Calls 2010 and 2011 (percentage in brackets)

Parameter	CoFoRD	RSF	FIRM	Total
Total Projects	11 (11.83%)	31 (33.33%)	51 (54.84%)	93 (100%)
International funding leveraged	€560,528 (12.33%)	€5,000 (0.11%)	€3,981,108 (87.56%)	€4,546,636 (100%)

DAFM's Research programme long-term investments in agri-food and forest research have contributed to building and broadening Irish researchers' capacity and capability to collaborate at EU level to leverage additional data/expertise/infrastructure/resources with the intention of addressing societal and policy challenges in an integrated and cost-effective manner. This has contributed to enabling Irish-based researchers to gain access to consortia that are better placed to compete for larger funding under the non-Exchequer EU Framework Programmes. For example, in the 7th EU Framework Programme (FP7) period 2007-2013 Ireland performed well in the 'Food, Agriculture and Biotechnology' area where €41m of funding was awarded across 105 projects. This award level was 108% of Ireland's target in FP7 (total national FP7 funding awarded €625m or 104% of target).

In the current Horizon 2020 period (2014-2020) figures available in September 2020 show that in the area most relevant to DAFM Funding Programmes, *Societal Challenge Two: Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bioeconomy*, awards of €91.5 million have been granted to Irish partners in 144 projects. As of May 2018, a success rate of 29% prevailed in terms of the amount of funding awarded (from the total funding requested in all eligible proposals submitted), which compared favourably with Ireland's

overall success rate of 13% in Horizon 2020 with €513m awarded to Irish participants across all programmes.

Table 4.2 in Section 4 set out details of the over €8.1m in funding awards for 22 transnational projects co-funded by DAFM's Competitive Programmes with over €4m of this funding awarded in the 2016 and 2017 period. Thus it is still early in the cycle to come to useful judgments on aggregate output and impacts of these transnationally funded awards. However this review has highlighted the need to measure these outputs and impacts on an ongoing basis.

Due to the multi-jurisdictional nature of international collaborations many key outputs and impacts are not routinely reported on or, in many cases; do not occur until after the project is completed. For instance following bilateral contact with an Irish coordinator for a transnational funded project ('RumenPredict' funded in 2017 as part of the ERA-GAS ERA-NET) the project has already led to PhD students gaining valuable experience working in a world leading institution (Wageningen University) as well as the further leveraging of financial supports (€2m through Teagasc Alimentary Pharmabiotic Centre, Cork and involvement in a €10m H2020 proposal). It would be advisable to develop better data capture systems to record these types of key outputs and wider impacts.

In addition, currently DAFM understands that all of the funding voted for the programmes must be used to fund research and innovation projects. However, given the accepted need for multi-actor approaches, greater amounts of dialogues before, during and after research activities and the importance of trans-national collaboration, it would be beneficial for DAFM to have flexibility to use some funding for coordination, communication and networking activities similar to what is made available in some EU Framework programmes.

5.2 Impact

Promoting Critical Mass and Consolidation

National Bibliometric Data⁴⁶

The National Bibliometric Report 2017⁴⁷ provides a contemporary proxy of the wider impact of DAFM funding in its respective areas. This report was commissioned as part of a wider Department of Business, Enterprise and Innovation-coordinated Audit of Progress report as part of the Refresh of Research Prioritisation exercise that informed the 2018-2023 update of National Research Priority Areas. In the Audit report the data was summarised over two time periods 2005-2009 and 2011-2015, the latter of which is relevant to the time period of the current spending review. As part of the consultation paper for the Refresh of Research Prioritisation, the fields of science were mapped to the 14 NRP priority areas to distinguish the priority areas and facilitate a comparison between those which are closely related. From an agri-food point of view, Tables 5.4 and 5.5 illustrate the results for the two priority areas *Sustainable Food Production & Processing* and *Food for Health* achieved higher

⁴⁶ This section draws on The Health Research Board *National Bibliometric Report 2017*, available at: https://www.hrb.ie/fileadmin/2_Plugin_related_files/Publications/2017_and_earlier_Pubs/Grant_Evaluation_Reports/Bibliometric_analysis_of_research_publication_output_supported_by_the_Health_Research_Board_2013-2016.pdf

⁴⁷ Ibid p.8. This report establishes the link between research and impacts which can be illustrated by bibliometric data: "[...]bibliometric data have a currency across subjects, time and location that is found in few other sources of research-relevant data. [...] Research publications accumulate citation counts when they are referred to by more recent publications. Citations to prior work are a normal part of publication, and **reflect the value placed on a work by later researchers.**" This reflects the iterative nature of knowledge building generated by research.

indexes than the average figures across all research summarised above. Most notably is the CNCI index⁴⁸ which is higher for both time periods.

Table 5.4 – Bibliometric Performance of the Sustainable Food Production and Processing Priority Area in 2005-2009 and 2011-2015 periods⁴⁹

NRPE Research Area	Time Period	Category Normalized Citation Impact (CNCI)	% Documents in Top 10%	% Documents in Top 1%	% International Collaborations	Web of Science Documents
I - Sustainable Food Production	2005 - 2009	1.21	13.68	1.08	52.38	2719
I - Sustainable Food Production	2011 - 2015	1.39	15.11	2.23	58.41	3841

Table 5.5 – Bibliometric Performance of the Food for Health Priority Area in 2005-2009 and 2011-2015 periods⁵⁰

NRPE Research Area	Time Period	Category Normalized Citation Impact (CNCI)	% Documents in Top 10%	% Documents in Top 1%	% International Collaborations	Web of Science Documents
H - Food for Health	2005 - 2009	1.13	12.23	0.62	50.22	1710
H - Food for Health	2011 - 2015	1.33	14.61	2.10	53.12	2690

The CNCI for *Sustainable Food Production and Processing* priority in the 2011-2015⁵¹ period was 1.39 (up from 1.21 for 2005-2009 period) compared to Ireland's overall average figure of 1.37. Similarly the shares in the world's top 10% of research papers in the 2011-2015 period at 15.11% and 14.61%

⁴⁸ CNCI is an unbiased indicator of impact irrespective of age or subject focus of the document type and a CNCI value of 1 represent performance at par with world average.

⁴⁹ Reproduction of Table 27: I – Sustainable Food Production & Processing in *Audit of Progress Report An input into the refresh of the priority areas under research prioritisation*, November 2017

⁵⁰ Reproduction of Table 25: H – Food for Health' in *Audit of Progress Report An input into the refresh of the priority areas under research prioritisation*, November 2017

⁵¹ It is important to note that these figures should be treated as indicative of the expected performance of projects within the scope of this spending review. The metrics quoted from the HRB report contain components from projects outside the timeframe and remit of this spending review, however the report remains the most recent and comprehensive data source for bibliometrics for Irish research.

Projects awarded pre-2010 contributed to the metrics quoted; similarly, projects within the 2010-17 period would not have produced PRPs or received citations at the time of the compiling of the HRB report due to time lags in producing measurable academic outputs. It is, however, the best available approximation of bibliometric performance available and DAFM were the predominant source of funding under the referenced research priorities during the timeframe for projects examined in the report. The 2005-09 period should be treated as a comparable reference point for the 2011-15 period, also.

for the *Sustainable Food Production and Processing* and *Food for Health* areas respectively, demonstrating the level of international collaboration that is taking place among agri-food researchers. In addition, the improvement in performance between the two time periods is noteworthy. For example, the percentage of documents in the top 1% had more than doubled (1.08 to 2.23%) for the *Sustainable Food Production and Processing* priority area for the 2011-2015 period compared to the 2005-2009 period and in the case of the *Food for Health* it had more than tripled (0.62 to 2.1%). Moreover, both priority areas outperformed the overall average result for all Irish research under this parameter by a factor of four (an increase of 0.44 to 0.55% recorded).

The national bibliometric data is a relevant indicator of the performance of publications arising from the DAFM funded projects. Given that DAFM is the main funder of research in the two priority areas *Sustainable Food Production and Processing* and *Food for Health*, it is reasonable to conclude that DAFM funding under the RSF and FIRM programmes has contributed to these results.

Relative global ranking of scientific research

Thomson Reuters InCites Data has shown that Ireland is ranked 12th in the global scientific ranking for the overall quality of scientific research⁵², illustrating the level of excellence Ireland is now achieving in the field. In relation to both *agricultural science*⁵³ and *animal and dairy science*⁵⁴, Ireland ranks second in the world, which is a noteworthy achievement. This is highly relevant in the context of this spending review – particularly for the RSF programme which funded the vast majority of related research performed in this country in these areas during the timeframe of this spending review.

Practical Examples of Impact

Given the broad areas of strategic importance that DAFM funding is directed at, this Spending Review focuses on three specific case studies in areas of high strategic importance to demonstrate the impact being achieved. These areas were chosen as representative and generalisable of the impacts and outcomes of DAFM funding, illustrating the clear links between funding and outcomes which meet the objectives highlighted previously in the paper. The three areas selected are:

1. Animal Breeding
2. Climate Change: Addressing GHG and Ammonia Emissions Challenges
3. Infant Milk Formula

The areas selected represent funding across the three research programmes of interest, with the Animal Breeding thematic area informed mainly by RSF funded projects; Climate Change informed by a combination of RSF and CoFoRD funded projects; and the Infant Milk Formula area by FIRM funded projects.

These case studies, which can be viewed in full in Appendix D, offer a more detailed illustration at the project level of:

- The strong reputational effects Ireland has garnered in science, accruing to research funding,
- The importance of technologies in improving efficiency, sustainability and productivity across the sector, and

⁵² SFI Annual Report 2019

⁵³ Ibid.

⁵⁴ SFI Annual Report 2016

- The contribution of funding to wider policy objectives such as carbon mitigation and export expansion.

The case studies detail the reputational and strategic impacts seen more generally across research funding outputs. It can be difficult to isolate the impacts of a given project, or its relative contribution to meeting wider objectives; however, these snapshots evidence the importance of DAFM competitive research funding in delivering informative, generative and impactful research. This is reflected in the strong relative ranking of Irish (particularly agricultural and food) science, as noted earlier in rankings.

Key returns on funding investment highlighted in the case studies include:

A) Animal Breeding:

€6m awarded via DAFM Competitive Research funds across eight projects 2010-17 contributed to more sustainable, efficient and productive unit efficiency in dairy and beef cattle. This contributed to national strategic objectives and secured high levels of national coverage. For example, 78%⁵⁵ of all bull semen sold in Ireland in 2017 was from genomic bulls, which stems from the Economic Breeding Index developed using RSF funds to improve profitability and genetics in the national dairy herd. A caveat to unit efficiency improvements is that they must be considered in the context of aggregate agricultural Greenhouse Gas Emissions increases.

B) Addressing Climate Change:

€10m was distributed via RSF and CoFoRD to projects aimed at emissions mitigation and reduction. Outputs of this funding will cumulatively contribute to emissions reduction Impacts include:

- Expanded potential carbon sequestration opportunities via grassland management and afforestation strategies explored by the projects.
- The development of databases which contribute to emissions flexibilities for Land Use and Land Use Change (LULUCF), effectively reducing net carbon emissions targets under the ESR and other legally-binding targets.
- The successful leveraging of €2.5m in EU grant aid across 8 projects.
- An RSF project identified important national policy implications for GHG emissions from fertiliser use in switching fertiliser Nitrogen sources from Calcium Ammonium Nitrate (CAN) to protected urea (protected with a urease inhibitor). Its use would sustain yield and efficiency, while reducing national GHG emissions without increasing national ammonia emissions substantially. Its use was subsequently the basis of one of the principal actions recommended in the 2019 latest edition of the Teagasc MACC⁵⁶.

⁵⁵ Cawley, A. And Cronin, A. 2019. *Beef Data Genomics Programme, Spending Review 2019*. This has greenhouse gas emissions mitigation potential through improved emissions efficiency.

⁵⁶ This was part of the Lanigan et al (2019) Teagasc Agriculture MACC model. A commitment to expanded use of urea-based fertiliser was included under the National Climate Action Plan for Agriculture in 2018 and 2019.

C) Infant Milk Formula (IMF)

Irish IMF accounted for 18% of global IMF trade in 2017 and contributes €1.5bn to the economy annually. Five IMF research projects were awarded €2.2m through FIRM over 2010-17 to develop new processing technologies and secure new dairy ingredients to incorporate into formula. Human capital, infrastructure and scientific progress have been developed from these projects. A majority of these projects have long time horizons and are still currently at early-to-mid Technology Readiness Levels (TRLs).

Outputs from the projects have, however:

- Created spillover effects for nutritional formulations
- Contributed a significant proportion of industry research investment
- Developed new processes with medical, nutritional and therapeutic applications, and
- Produced findings which generated further partnerships with IMF manufacturers. This has led to international recognition for domestic researchers in this field. Moorepark Technology Ltd. (research carried out in the pilot plant) has received €4m total income over 2010-17.

Further to the above, several projects have had direct causal impacts on domestic policy development, illustrating the capacity to respond to policy needs and contribute to policy, including:

A) Bio-economy Policy

BioÉire (2014), an RSF project, investigated and evaluated the development opportunities in the bio-economy in Ireland. It also explored the support frameworks – such as policies and initiatives – required for their implementation and success to transition to a sustainable low carbon bio-economy. Outputs and knowledge dissemination from this project have directly helped to guide the initial policy development steps for the Irish bio-economy. Similarly, it has led to the establishment of the Cross-Governmental Bio-Economy Implementation Group comprised of the DAFM and the Department of Communications, Climate Action and Environment (DCCAE).

B) Greenhouse Gas Accounting

Research contributions from several projects resulted in the alteration of how Nitrogen Oxide (N₂O) emissions are incorporated into the national Greenhouse Gas (GHG) inventories, reducing agricultural emissions by 750,000 CO₂-equivalent tonnes, or an 8% reduction in the evaluation of the carbon footprint of milk and beef output.

Summary

This section has demonstrated that there are substantial outputs from the funding programmes in terms of:

- Building capability and capacity in the research community in Ireland;
- Supporting the growth and development of the agri-food sector (eg new products/processes, policies and inventions/licenses) and;
- The international leveraging of significant funding, reflecting the strong reputation of domestic researchers in their respective research fields.

6 Further Considerations

6.1 Concerns around a Lack of Effective Co-Ordination

When first published, the intention was that SHARP would guide the content of Calls for Proposals launched by all the various funders (including DAFM's FIRM and Stimulus programmes) over a number of years. A new feature of SHARP, relative to its predecessors, is that it contains an Implementation Framework.⁵⁷ This Framework contained a set of principles and a structured approach for all the various funding bodies in the agri-food space with the intention of ensuring a logical, joined-up, complementary approach to the funding of research and innovation in the sector. However there are a number of issues that could be further improved. For example, it is unclear the extent to which external funders have been guided by SHARP. SHARP has been used since its launch as the one of the main guides for the DAFM CRFs, as well as the targets of the wider agri-sector strategy – initially Food Harvest 2020 and subsequently Food Wise 2025 – that renew and update the overarching innovation focus. Due to the predominance of DAFM as the main funder of agri-food RDI in Ireland during 2010-2017, however, the wider impact of the strategy has been limited.

The absence of a lead agency to ensure the coordination of all funder's activities is a limitation of the current format and could be an area worth further evaluation, particularly in the context of the policy set for 2018-2023. Further efficiencies may be found if a more robust overarching framework is embedded in the process, as envisaged by SHARP, to maximise coherence of funding and to ensure strategic alignment between all stakeholders. It is also noted that in light of the existence of a rolling series of higher level strategies (currently FoodWise 2025) for the development of the sector including RDI and similar documents being produced at EU level that DAFM is engaged in, there may be a need to review the continuing need for strategic research agendas (such as SHARP and FORI). Current internal proposals are addressing these concerns, with enhanced strategic alignment across programmes.

6.2 The Need for Modernisation in the context of Increasing Overlap across Programmes

It has also been noted that to date the DAFM programmes have funded 'early stage' contract researchers⁵⁸ with more experienced researchers only funded on an exceptional basis where well justified by the nature and sophistication of some elements of the research being undertaken. However, it may now be appropriate to consider extending such exceptions to include permanent non-remunerated staff in certain RPOs where the funding model renders them fully dependent on winning grant awards from competitively operated programmes. As was discussed in section 4.1, funding of such staff would bring DAFM into line with the practice of other funders of competitive research (such as SFI or EPA). It would, moreover, be restricted to the minimum point of the equivalent of a 'research fellow' on the IUA (Irish University Association) scale and limited to a specific time period during the lifetime of the project.

A proposal for a strategic studies programme has been raised within DAFM to address this⁵⁹. This would still be open science research, providing a fast stream of research to urgent or developing policy questions (e.g. feasibility studies, reviews, evidence synthesis etc). This is similar to the existing/proposed developments with other funding agencies such as recent rapid research calls

⁵⁷ P.59, Section 3 of [Sustainable Healthy Agri-Food Research Plan \(SHARP\)](#)

⁵⁸ Post graduate Master or PhD students and post doctorate researchers who have generally less than six years' experience.

⁵⁹ This proposal also reflects the recognised importance of extending funding to senior long-term contract researchers in PROs with ties to DAFM CRFPs – such as, for example, the Tyndall Research Institute.

conducted by SFI/HRB in respect of covid-19, rather than a tendering call that would need procurement of a service for scientific consultants. The intention ultimately is not to retrofit the existing competitive calls for this rapid response purpose but to design a more streamlined approach that takes account of the differing research requirements.

Increasing the numbers of eligible organisations or type of staff would not necessarily require additional funding but would ensure greater competitiveness in attracting DAFM funding and would be line with the increasing emphasis particularly at EU level (e.g. European Innovation Partnerships) of the need for a multi-actor approach to research, and a need for research to address policy challenges at national level.

There has been a trend toward government frameworks which cover areas such as climate change mitigation on a cross-departmental basis. Increasingly, issues such as these are incorporated across projects under the three CRF programmes analysed in this review, creating significant thematic overlap. This reflects the market failure in providing timely, applicable and socially beneficial research findings on issues, such as circularity and the bio-economy, which reinforces the need for public research funds to supply such outputs.

There may be merit in a greater degree of distinction between, or greater oversight across, the three programmes to minimise such overlap. This could be achieved through centralisation of the three programmes under one umbrella. This review has identified the need for greater co-operation in funding allocation to prevent such overlap. This may extend to a broader issue across departments' research interests, creating scope for an oversight mechanism such as a co-ordinating agency. This has since been partially addressed in new proposals for the CRFPs going forward, which would create greater alignment of projects across the three programmes. The historical boundaries between the three programmes and their respective interests are considerably less significant in recent awards calls and there is a general shift underway from distinct focuses to greater alignment.

7 Conclusions and Recommendations

7.1 Conclusions

Research and Innovation plays an important role in developing the agri-food sector in Ireland and is key to realising policy objectives in terms of protecting our environment, improving our food production and processing systems, increasing consumer health and well-being and strengthening the economic competitiveness of the country.

The objective of this Spending Review was to evaluate the three DAFM research funding programmes in the period 2010 to 2017 inclusive. The spending review demonstrated that each Research programme has contributed to its respective policy objectives to date, and the ongoing development of the agri-food sector is dependent on impactful research to develop new technologies and policies to improve the sector further. The type and level of output delivered by the CRFPs is proportionate to their respective funding level and the contexts and objectives of the programmes.

At the outset, four core objectives were outlined for the research programmes: Capacity, Critical Mass, Capability and Consolidation. The specific outputs and impacts (KPIs) detailed in section five link directly to these four core objectives. This illustrates the relationship between the aims of the programmes and their resulting impacts. A formalized direct link should be, and is in the process of being, developed to aid future evaluations by specifying targets and reviewing the degree of success at both the project and overall programme levels. This would aid comparisons with other public and private research funding performance and enable a direct link between funding and exchequer value for money.

The over-arching policy environment and the relevant RDI and agri-food development strategies have changed and evolved during the period covered by this spending review. DAFM's three competitive research funding programmes have attempted to take account of these changes, and the impact of these is the focus of this evaluation. Consideration has also been given to the possibility of crowding out, however there is little evidence of this in the literature on agricultural R&D funding. There appears to be support for the additionality principle, albeit with variation in returns on investment depending on distinctions between maintenance and productivity research funding. Finally, the degree to which funding is distributed across maintenance and productivity research categories should be monitored to balance economic and broader societal returns

The review also highlighted specific issues that may warrant further examination to continually align with contemporary strategic aspirations at both a national and international level. Specifically, objectives need to reflect the bioeconomy, the need for circularity and resource efficiency of food systems and to help meet environmental objectives, reflecting the whole-of-government approach adopted toward climate action. Objectives should be Specific, Measurable, Accurate, Relevant and Timely (SMART). In doing so, it may be beneficial to bring the three programmes under one umbrella⁶⁰ as there are already many areas of overlap between the three programmes and, moreover, the potential for impact and innovation often occurs where agriculture, forestry, and food converge.

⁶⁰ This is currently in the process of being implemented by programme administrators as of September 2020. Similarly, efforts to improve the specificity of objectives to aid future evaluation and review of the CRFPs are being enacted for future projects, with an enhanced emphasis on measurable time-bound indicators.

In light of the number of high level strategies, there may not be a need to develop specific research agendas in order to serve the needs of the agri-food and forestry sectors going forward. This could be reviewed, as it affects the administration of the CRFs. A clear strategy to guide design and implementation, leading on from SHARP, could be developed to serve this purpose in the context of increased funding activity in the areas targeted by the programmes evaluated in this Spending Review.

The review has identified some of the outputs from the Research Programmes that have been achieved but also identified a number of areas where there may be scope for improvement, in particular in the management of the programmes. Given the relatively administratively burdensome steps outlined in section 4.2 it may be beneficial to analyse a process by which these can be streamlined/simplified. The recent procurement of a customised IT-based grant management system will, when fully commissioned, make a contribution to improving the efficiency in the management of all files during the application, evaluation, and post-award project monitoring phases but there may be further efficiencies that DAFM should seek to find.

The evidence presented in this report indicates that the programmes have generated significant outputs with considerable cross-and intra-programme variation in the type, size and timescale of returns. The variation across programmes largely stems from the different contexts in which each operate, for example CoFoRD is geared toward ‘maintenance research’, while FIRM is targeted at ‘productivity-improving’ research to a larger extent. The larger quantities of funding granted to FIRM projects may also enable scale economies for such projects.

The wider impacts such as accelerating the rate of progress in animal breeding; Ireland’s ability to monitor and mitigate the challenge of GHG and ammonia emissions; and maintaining Ireland’s position in the supply of specialised infant formula reflect the importance of these funding programmes to the agri-food sector. However, these findings are of a high-level and reflect the overall impacts of the Research programmes, but more specific detailed indicators at project level could enrich the analysis further. These indicators must be robust and multi-faceted to incorporate the complexities of the research process and the time lags involved in achieving outputs and impact. The new IT system will support this.

A microanalysis on a case-level basis could be undertaken in future using these new indicators to provide a clearer link between inputs and outputs, something which was outside the capacity of this review due to lack of data specificity and granularity.

In addition, the impacts identified in this analysis may be communicated and disseminated more effectively to stakeholders to highlight the value of this use of public funding. It was noted while completing the analysis on the output of the research programmes that there is limited published information on the impacts of the programmes. The publishing of Research Division dashboards (or other forms of communication) highlighting the impacts the research funded could be considered.

7.2 Recommendations

The evidence examined in this Review support a predominately positive finding that DAFM’s Research Programmes have met their objectives, however the analysis also informed a set of recommendations that could enhance the Programmes further. Some of these recommendations

have begun to be addressed by administrators already, reflecting the recognition of the need for modernisation. These are discussed afterwards, below.

Seven core recommendations have emerged from this Spending Review. These include:

1. The objectives of the three programmes should be formally linked to specific, measurable and time-bound metrics to aid future evaluations of the CRFs. This would require the development of an improved set of Key Performance Indicators to be integrated into programme design, which would improve measurement of project outputs and wider impacts.
2. To bring the three Research Programmes under a single consolidated umbrella. This would involve:
 - a. Updating the programme objectives to reflect contemporary policy context; reviewing the sectoral scope of the new programme (agriculture, food, marine, forest, bio-economy) in light of the focus of other funders now operating in space (SFI's Investigators Programme, EPA, SEAI, MI, HRB). Similarly, implementing a lead agency to co-ordinate public agri-food RDI funding to ensure complementarity of timing, positioning and scope between the proliferation of RPOs now active in this space.;
 - b. Reviewing the continuing need for strategic research agendas (SHARP & FORI) in the light of
 - (i) The existence of rolling series of higher level strategies (currently Food Wise 2025) for the development of the sector that also includes RDI
 - (ii) Similarity with agendas and guidance/foresight documents produced by EU-wide bodies and initiatives that DAFM is engaged in (e.g. JPI's, SCAR, etc.).
3. To increase the flexibility to respond to DAFM requests – exclude desk studies from the normal national Calls, and run them separately in a simplified, frequently open, rapid response short desk-based research Call – possibly open to a broader range of Research Performing Organisations. These could be projects of short duration and relatively small grant awards that would cater for DAFM policy/regulatory evidence needs.
4. To invite a party external to the Research Division in DAFM to review the existing contract negotiation and award process, progress monitoring and grant payments to determine if there is scope for further efficiency savings.
5. To improve communication of funded research, (for example the publication of Research Division newsletters/dashboards and organisation of seminars) and use a portion of the programmes' funding for coordination and networking type activities.
6. To examine broadening the list of organisations eligible for Grant Aid to increase the competitive nature and value for money of the DAFM funding. For instance, permanent non-remunerated researchers in certain RPOs where the funding model renders them fully dependent on winning grant awards from competitively operated programmes.
7. The degree to which funding is distributed across maintenance and productivity research categories should be monitored to balance economic and broader societal returns.

Some of these measures have begun to be implemented within DAFM since the initial analysis for this Spending Review commenced:

- A new dashboard has been created to track Key Performance Indicators (KPIs) across project life-cycles is being constructed. This will aid future evaluation exercises.
- A broader project is underway which would include standardised impact statements. These are being developed to better organise, monitor and communicate the outputs and impacts of the research programmes. This would also encourage project co-ordinators to consider how their project aligns with macro-strategic aims and contributes to policy development more broadly.
- A more holistic (life-cycle / whole-of-supply-chain) approach has been applied across the three research programmes to reflect the common nature of sectoral challenges in agri-food and the erosion of historical boundaries between the three research programmes⁶¹.
- A new rapid-response research facility is being developed/proposed to service urgent needs outside of the national calls process. This could aid subsequent calls projects in providing contemporary context and would reflect similar recent initiatives in other public research funding bodies, as discussed in subsection 6.2.

⁶¹ The proposals drafted by DAFM would see the establishment of an umbrella programme that has a suite of (sub)-programmes that have myriad aims and objectives to addresses in different ways the varied research requirements and needs for key challenges facing the agri-food and bio-based sectors. It is also to apply food-systems and life cycle approaches, that move away from the sectoral boundaries between the research areas of the three DAFM research programmes – which exist for historical/legacy reasons – and are no longer appropriate given the increasing complexity and inter-connectivity of challenges and opportunities to be addressed through research and innovation.

Appendix

Annex A: Funding Instruments in which DAFM Awards are made

Funding Instruments	Type of Project	Duration	Max. Grant Request ⁶²
I. Desk Study	Single RPO or Collaborative project involving at least two RPOs.	≤1 years or ≤2 years	≤ €100,000 or ≤ €200,000
II. Small Project	Flexibility for involvement of one or more RPO's.	≤2 years	≤€200,000
III. Standard Project	Collaborative project with at least two RPOs.	≤4 years	≤€600,000
IV. Large Project	Collaborative project with at least three RPOs each accounting for at least 10% of the overall grant requested from DAFM.	≤4 years	≤€1,250,000
V. Programme	Large strategic initiative involving a collaboration of at least four RPOs each accounting for at least 10% of the overall grant requested from DAFM.	≤5 years	≤€3 million
V1. Thematic Coordination Network	Must involve at least 3 on-going or recently completed research projects undertaken across 4 RPOs. The involvement of a no. of agri-food companies, in particular SMEs and/or umbrella representative organisations, is also encouraged where appropriate and adds value.	≤ 3 years	≤ €75,000/year
VII. Research Plus	Small institutional project to bring completed or near completed DAFM funded project to point where it is eligible for EI commercialisation supports	≤1 years	≤€100,000
VIII Innovation Platform	Large, pre-competitive, industry-oriented, initiative involving collaboration between: (a) at least 4 RPOs each accounting for at least 10% of the overall grant requested from DAFM and (b) at least 4 industry / enterprise parties which must contribute 30% of the overall costs of which at least 10% must be in cash.	≤5 years	>€3m & < €7.5 m

VI and VII are not itemized out separately in the report under section 4.1 due to the small number of projects funded under these instruments. These are categorized under small/desk studies.

⁶² Where proposals include NI partners the maximum grant request set out in this Table applies to the combined grant request from both DAFM and DAERA

Annex B: Funded Projects under Transnational Calls

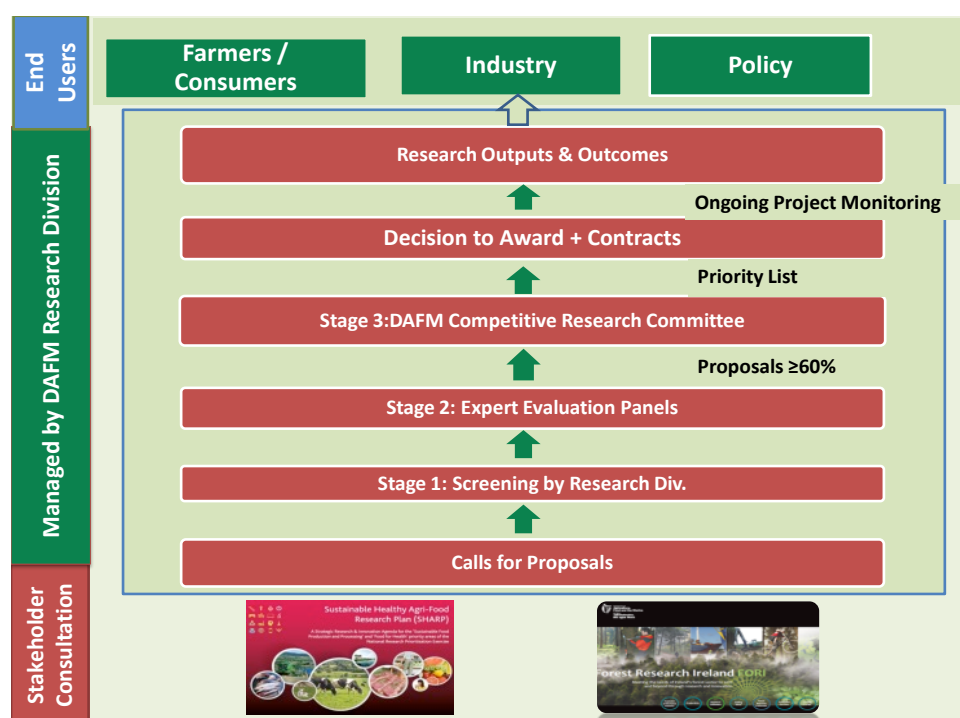
EU Transnational Calls			
Transnational Call	Project title	Award €	Lead(collaborating Institutions)
Emida	Development of novel diagnostic strategies for the anti-mortem immunodiagnosis of bovine tuberculosis and Johne's disease	281,906	UCD
	Coping with Anthelmintic resistance in Ruminants	149,996	Teagasc
Aniwha	Prevalence and optimised detection of resistance to antibiotics vital for animal and human health	246,937	NUIM
ICT AGRI	Smart Integrated Livestock Farming	222,772	UCD
	Development of ground based and remote sensing, automated 'real time' grass quality measurement techniques to enhance grassland management information platforms	242,683	Teagasc (NUIM, CIT)
	Mainstreaming controlled traffic techniques and optimization of movements	259,196	Teagasc (UCD, NUIG)
RURAGRI	Towards Rural Synergies and Trade-offs between Economic development and ecosystem services	99,758	UCD
HDHL Joint Action	European Nutritional Phenotype Database sharing initiative within the JPI	592,957	Teagasc
	Joint Programming Initiative JPI Food Processing for Health Joint Action	332,443	
	Malnutrition in the Elderly Knowledge Hub	249,864	UL, UCD
	Food fermentation for Purpose: Health promotion and biopreservation	667,000	Teagasc, UCC
SusAn	Sustainable Sheep Production	244,999	UL (Teagasc, ICBF)
	Sustain Beef	136,250	Teagasc (UCD)
ERA Gas	Refining direct fed microbials (DFM) and silage inoculants for reduction of methane emissions from ruminants	218,920	Teagasc (UCD, ICBF)
	Managing and reporting of Greenhouse Gas Emissions and Carbon Sequestration in difference landscape mosaics	236,134	Teagasc (UCC)
	Mitigating Ag Greenhouse Gas emissions by improved pH management of soils	245,000	Teagasc (NUIG)
	Predicting appropriate GHG mitigation strategies based on modelling variables that contribute to ruminant environmental impact	244,418	UCD (Teagasc)
WaterWorks	Eutrophication hotspots resulting from biogeochemical transformations and bioavailability of phosphorus in the fluvial suspended sediment of geologically contrasting agricultural catchments (lead by EPA)	115,806	TCD
SUSFood	BIOCARB-4-FOOD	306,794	Teagasc (UCC, UCD)
	ImPrOVE –Innovative (pre) Pomace valorization process	258,800	UCD
	MEFPROC – Improving Sustainability in Food Processing using Moderate Electric Fields (MEC) for Process Intensification and Smart Processing	350,000	UCD
	PLATFORMS - Sustainable Food platforms: Enabling sustainable food practices through socio-technical innovation.	194,493	UCC
SUMFOREST	Benchmarking the sustainability performances of value chains	241,466	UL, NUIG
WoodWisdom+	Impacts of faster growing forests on raw material properties with consideration of the potential effects of a changing climate species choice	350,442	UCD, NUIG
WOODWISDOM	Improvement in collaboration along the wood value chain through knowledge-based methods and mobile applications	199,606	Teagasc

	Maximizing Timber and Energy Wood Production by Innovative Agroforestry Systems with Short Rotation Coppice as Intercrop	103,800	Teagasc
US-IRL R&D Partnership			
US Ireland	Application of next generation sequencing for the identification of DNA based biomarkers in regulatory regions of the genome for susceptibility to bovine respiratory disease complex	345,591	Teagasc and ICBF
	Improved Animal Husbandry through Inhibition of Microbial Bile Salt Hydrolase	301,874	UCC
	Tri-Partite Collaborative: Targeted Genome Editing To Understand And Enhance Genetic Resistance To Bovine Tuberculosis In Cattle	325,115	UCD
	Development and validation of an on-farm, electronic disease diagnosis platform for cattle	345,998	UCC

Annex C: Summary of the 11-Step Call Process

The 11-Step Call Process

1. Conception of Call topics through mapping existing funded agri-food research, reference to SHARP/FORI, consulting relevant internal and external stakeholders, seeking DAFM Management Board approval to proceed and preparation of Call documents.
2. Call Notification published on the DAFM website, in a national newspaper and issued to Research Performing Organisations and other awareness activities are undertaken. Application form and guidance documents made available on the DAFM website.
3. Following the Call submission deadline submitted application forms are printed, categorized and filed.
4. Three-stage Evaluation process (see Figure below).



5. Inform successful and unsuccessful applicants.
6. Contract negotiations usually resulting in re-submission of amended application requiring financial & scientific checks.
7. Award of grant following receipt of signed contract.
8. Payment of initial advance, typically 30%.
9. Desk-based Financial and scientific monitoring of project progress reports submitted annually triggering further tranche payments plus ongoing queries – extensions and budget changes. Evaluation of Final Report for scientific impact and financial compliance triggering payment of final 20% of grant award.
10. On-the-spot scientific inspection and financial verification checking at least once in a project's lifetime.
11. Publishing of Final Report on the DAFM website.

Annex D: Drawdown Summaries

Figures 4.12 - 4.14: Drawdown to Award Proportions 2011 to September 2020

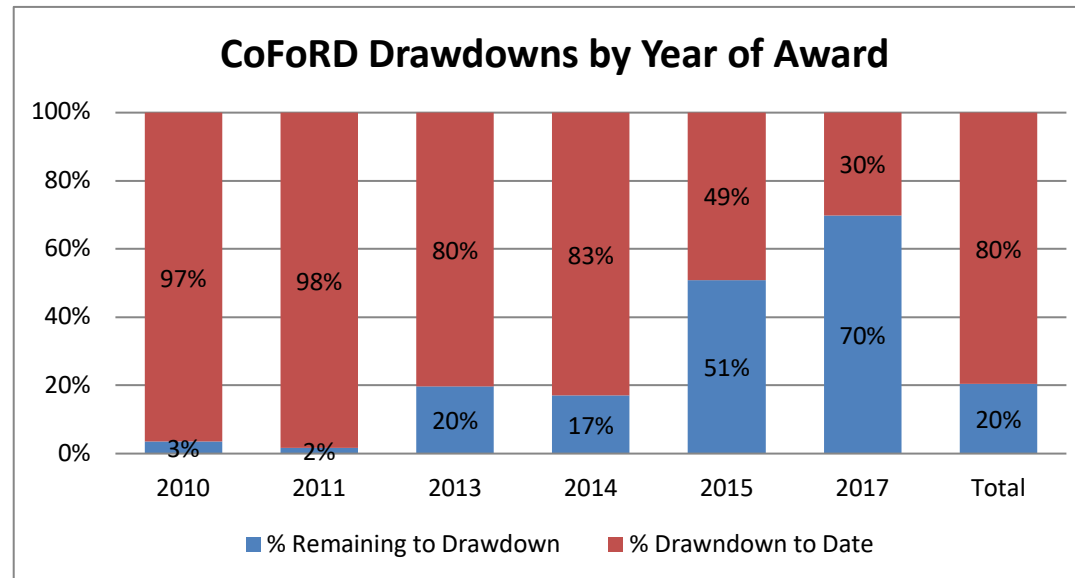
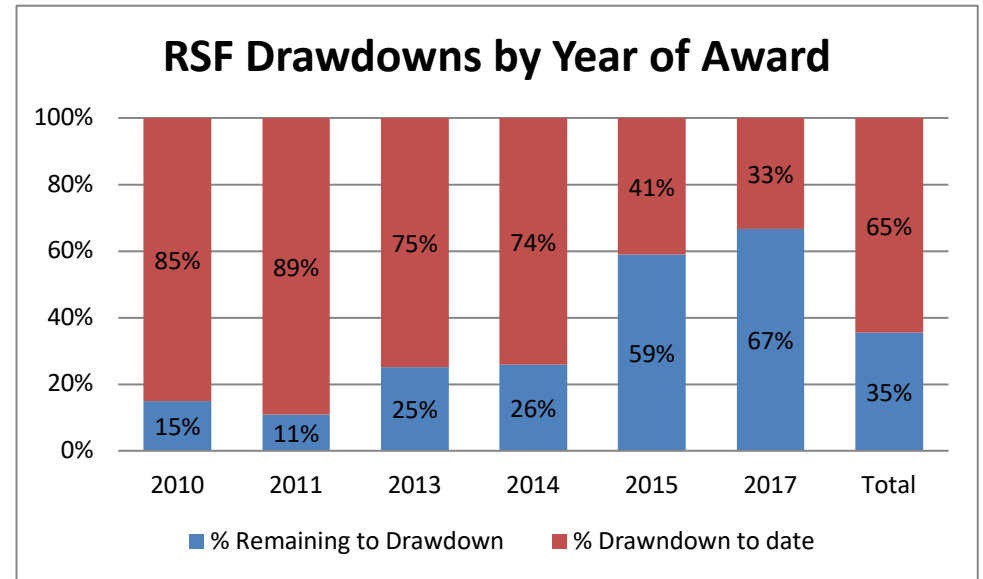
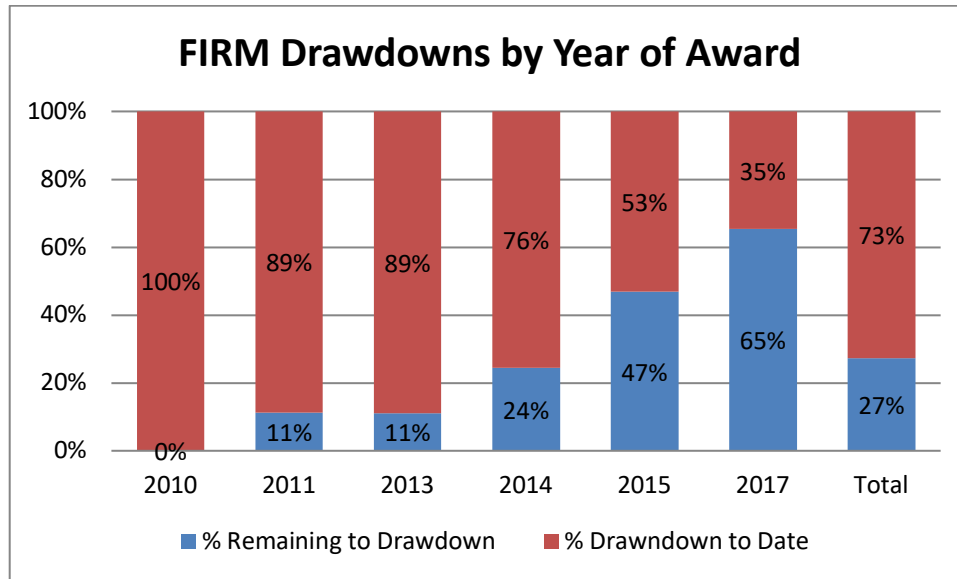


Table 4.22: Drawdowns 2011-2020 for RSF Awards 2010-2017 to September 2020

Year -> Spent ↓ Awarded	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Remaining to Drawdown	Total	Total Drawn Down to Date
2010	€620,604	€0	€0	€473,290	€346,398	€418,229	€68,698	€234,186	€0	€0	€380,185	€2,541,590	€2,161,405
2011	€0	€4,510,240	€67,374	€208,030	€2,950,105	€623,803	€712,235	€587,668	€742,450	€233,012	€1,307,394	€11,942,312	€10,634,917
2013	€0	€0	€5,205,504	€9,256	€199,567	€976,690	€1,460,639	€843,919	€141,631	€692,349	€3,205,404	€12,734,959	€9,529,555
2014	€0	€0	€0	€3,446,223	€0	€542,765	€539,777	€803,742	€818,404	€313,892	€2,250,512	€8,715,315	€6,464,803
2015	€0	€0	€0	€0	€0	€3,408,813	€287,812	€150,084	€527,211	€689,017	€7,288,151	€12,351,088	€5,062,937
2017	€0	€0	€0	€0	€0	€0	€0	€2,470,220	€0	€414,021	€5,754,516	€8,638,757	€2,884,241
Total	€620,604	€4,510,240	€5,272,878	€4,136,799	€3,496,070	€5,970,300	€3,069,162	€5,089,819	€2,229,696	€2,342,291	€20,186,162	€56,924,020	€36,737,858

Table 4.23: Drawdowns 2011-2020 for FIRM Awards 2010-2017 to September 2020

Year -> Spent ↓ Awarded	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Remaining to Drawdown	Total	Total Drawn Down to Date
2010	€1,474,893	€0	€21,634	€1,050,124	€820,745	€150,023	€112,071	€588,135	€124,077	€0	€0	€4,341,702	€4,341,702
2011	€0	€6,386,427	€60,938	€82,090	€3,048,886	€1,169,034	€1,363,306	€1,168,131	€667,515	€233,662	€1,790,494	€15,970,483	€14,179,989
2013	€0	€0	€6,976,242	€265,201	€760,270	€1,914,725	€2,709,216	€1,637,251	€955,520	€578,003	€1,982,258	€17,778,686	€15,796,428
2014	€0	€0	€0	€4,319,898	€0	€190,617	€863,548	€1,178,012	€1,000,224	€491,511	€2,595,997	€10,639,807	€8,043,810
2015	€0	€0	€0	€0	€0	€4,524,969	€0	€555,658	€2,004,240	€823,138	€7,002,639	€14,910,644	€7,908,005
2017	€0	€0	€0	€0	€0	€0	€0	€3,145,374	-€24,163	€546,512	€6,914,037	€10,581,760	€3,667,723
Total	€1,474,893	€6,386,427	€7,058,814	€5,717,313	€4,629,901	€7,949,368	€5,048,141	€8,272,561	€4,727,413	€2,672,826	€20,285,425	€74,223,082	€53,937,657

Table 4.24: Drawdowns 2011-2020 for CoFoRD Awards 2010-2017 to September 2020

Year -> Spent ↓ Awarded	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Remaining to Drawdown	Total	Total Drawn Down to Date
2010	€751,302	€216,956	€29,088	€320,119	€902,920	€63,493	€433,509	€10,021	€0	€0	€98,279	€2,825,686	€2,727,407
2011	€0	€1,074,335	€76,422	€168,679	€505,356	€333,127	€461,203	€172,565	€10,883	€0	€49,099	€2,851,669	€2,802,570
2013	€0	€0	€656,180	€0	€174,067	€107,035	€292,158	€0	€29,203	€0	€309,394	€1,568,037	€1,258,643
2014	€0	€0	€0	€246,895	€0	€330,858	€235,173	€283,680	€5,373	€784	€228,129	€1,330,892	€1,102,763
2015	€0	€0	€0	€0	€0	€579,512	€0	€192,822	€93,338	€79,934	€982,580	€1,928,186	€945,606
2017	€0	€0	€0	€0	€0	€0	€0	€289,577	€0	€0	€670,254	€959,831	€289,577
Total	€751,302	€1,291,291	€761,690	€735,693	€1,582,342	€1,414,025	€1,422,043	€948,665	€138,797	€80,718	€2,337,736	€11,464,302	€9,126,566

Table 4.25: Cumulative and Percentage Year-on-Year (% YoY) Changes in Drawdowns by Year 2011-20 for all Programme Awards 2010-2017 to September 2020

Year -> Spent	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Remaining to Drawdown	Total
Total	€2,846,799	€12,187,958	€13,093,382	€10,589,805	€9,708,313	€15,333,693	€9,539,346	€14,311,045	€7,095,906	€5,095,835	€42,809,323	€142,611,404
Cumulative Drawdowns	€2,846,799	€15,034,757	€28,128,139	€38,717,943	€48,426,257	€63,759,950	€73,299,296	€87,610,340	€94,706,246	€99,802,081	€ -	€99,802,081
% YoY Change in Drawdowns	-	328%	7%	-19%	-8%	58%	-38%	50%	-50%	-28%	-	Average = 33%

Annex E: Case Studies

Case Study 1: Animal Breeding

Through funding under the RSF programme DAFM has a long standing focus on aiming to ensure that the best available breeding technologies are identified and proven at a research level with the intention of ensuring that the value of national livestock output is maximised in the most environmentally sustainable manner. Various strategic research priorities cite research to advance animal breeding objectives as a priority, as alluded to in section 3 of this paper and in particular Food Harvest 2020,⁶³ FoodWise 2025,⁶⁴ the SSAPRI document,⁶⁵ and SHARP.⁶⁶ On foot of €6.15m awarded for eight different animal breeding related projects in DAFM's competitive research programmes over the 2010-2017 period, there have been positive impacts in accelerating the rate of progress in animal breeding, in the Irish livestock sector and elevating Ireland's international standing in this field.

The statistical methodology and bespoke genotyping tools of the national beef herd in Ireland was undertaken within DAFM-funded projects which laid the foundations for the world's first large multi-breed DNA-based evaluation in 2014,⁶⁷ through the National Beef Genomic Scheme. The approach uses technology that aims to produce better, more environmentally friendly and sustainable beef cattle. The national approach to genotyping involves the establishment of a centralised database which allows for intensive monitoring of the key trends in genetics, which can be measured accurately to target further efficiencies and improvements which is a valuable resource for further research. This also aims to further enhance the reputation of Irish beef internationally by providing evidence of genetic improvements through a centralised national dataset. The establishment of the database strives to enhance Ireland's reputation as a world leader in genetics, with metrics and data to back up our message of sustainable livestock systems. Ireland is viewed as a leader in providing reliable data through this system by the international coordinating body ICAR.⁶⁸

In the dairy sector, industry is using breeding tools developed within several different DAFM funded projects to accelerate genetic gain for the national profit index, the Economic Breeding Index (EBI). The use of the dairy genetic evaluations informed almost exclusively by DAFM-funded research has cumulatively increased genetic gain in the dairy industry through the introduction of the genomic programme. In total, 78% of dairy semen sold in Ireland during 2017 was from genomic bulls⁶⁹ - genomic bulls which have proven to be economically far more advantageous compared to conventionally selected bulls.⁷⁰ DAFM's research funding therefore helped in facilitating these high economic impact results at a national level because without the funded research into the development of the genetic evaluations the genomic programme may not exist today.

⁶³ Food Harvest 2020 published in 2010 identified animal breeding as an area where research should be prioritised.

⁶⁴ FoodWise 2020 published in 2015 stated in one of the actions under competitiveness an aim to '*improve the use of genomic technologies and better breeding to improve the sustainability of the National herd*'

⁶⁵ In 2011 SSAPRI identified '*animal genetics/genomic selection technology and other technologies in cattle breeding programmes*' as a high priority for research investment.

⁶⁶ In 2015 SHARP identified '*animal breeding and reproduction*' as a key investment area and included a number of high level objectives around developing optimal breeding programmes.

⁶⁷ Personal communication with Prof Donagh Berry, the lead researcher involved in the development of the evaluations.

⁶⁸ ICAR (2018) available: <https://www.icar.org/index.php/certifications/certificate-of-quality/list-of-organisations-granted-with-the-certificate-of-quality/>

⁶⁹ Extracted from Article on [ICBF website](#) on 17 July 2017

⁷⁰ <https://www.icbf.com/wp/?p=8116>

Significant funds have been leveraged from both national and international sources on foot of DAFM funded research. Arising from the inclusion of the Innovation Platform funding instrument (Annex A) in DAFM's National Call 2015, a €43m new SFI Research Centre VistaMilk⁷¹ which is co-funded by DAFM – and included in the €43m is a €13.6m funding contribution from industry. The future work planned in the animal breeding component of the VistaMilk Centre is based on the results from DAFM funded projects with the ongoing objective to develop precision genomics using state-of-the-art technologies and is an example of the impact achieved from the DAFM programmes (primarily RSF in this case).

At European and international levels, results and capacity derived from the DAFM funded projects contributed to enabling Irish partners (mainly Teagasc) sharing awards of €2.3m as part of a total of €26.4m awarded across nine separate EU funded projects (primarily Horizon 2020 and Framework Programme 7) in the period from 2010 to 2017. Irish researchers are leaders in many of these international projects and are contributing greatly to develop Irish scientific capability on the global stage.

Case Study 2: Climate Change – Addressing GHG and Ammonia Emissions Challenges

In light of a national policy focus on the beef and dairy sectors, it is important for Ireland to address ammonia and Green House Gas emissions, by amongst other things, maximising the carbon sequestration potential of its land sector namely forests, croplands and grasslands to help achieve targeted reductions in emissions. Climate Change objectives and related research priorities have been consistently highlighted in the various strategic research agendas and reports including Food Harvest 2020,⁷² FoodWise 2025,⁷³ SSAPRI,⁷⁴ SHARP,⁷⁵ and Forest Research Ireland (FORI).⁷⁶ On foot of these reports DAFM's Competitive Research Calls prioritized this area of work and 10 projects worth over €10 million were funded under the RSF and CoFoRD programmes in the 2010-2017 period (Annex F). The projects have helped Ireland more accurately monitor and mitigate the challenge of GHG and ammonia emissions which is considered a positive impact of the DAFM funding.

A deep body of research work has been funded by DAFM in quantifying accurate emission levels for the GHGs nitrous oxide (N₂O) and ammonia (NH₃) for a range of activities in the national emissions inventories. The alteration and incorporation of N₂O emissions into the national GHG inventories has resulted in a 750,000 tonne CO₂-equivalent reduction in agricultural emissions or an 8%

⁷¹ Overall the VistaMilk Centre aims to customise, integrate, test and validate products and services that can help drive systematic change and better underpin the sustainability and competitiveness of the entire dairy sector from grass to human nutrition

⁷² Food Harvest 2020 stated that *DAFM and the relevant State agencies should continue to research the ability of forestry to sequester carbon and the extent to which it can help to reduce Ireland's greenhouse gas emissions from agriculture.*

⁷³ In 2015 FoodWise noted that *'reducing the extent of future climate change by limiting the amount of greenhouse gases being emitted, and by increasing the rate of removal of CO₂ from the atmosphere is a significant global challenge'*

⁷⁴ In 2011 SSAPRI identified *'climate change & transboundary gases as a high priority for research investment'* and included a number of specific mitigation related actions for farm level action.

⁷⁵ In 2015 SHARP identified *'land use, climate change and trans-boundary gases'* as a key investment area and included a high level objective – *'to develop and support actions that reduce or offset greenhouse gas emissions'*.

⁷⁶ FORI 2015, was the first strategic agenda for forest research and it dedicated a full thematic area of actions under the heading *'Climate Change: Impact, Adaptation and Mitigation'*.

reduction in the carbon footprint of milk and beef. Through DAFM funding, datasets have been made available to EPA for the qualification of emission factors for various activities in the cattle systems in Ireland. For example, the ammonia yard emission factor was measured at 22.5% compared to the default factor of 75%. This update⁷⁷ has therefore reduced the attributed estimate emissions by 70% from this source and is now incorporated into national ammonia emissions.

In addition, a number of mitigation and technology adoption options have been developed through DAFM funding primarily under the RSF programme. For example it was demonstrated that farmers can maintain yields and reduce GHG emissions (70% reduction in N₂O emissions) by switching fertilizer type from CAN (a type of fertiliser in common use) to urea based fertilisers. In addition it was shown that inclusion of a urease inhibitor with urea fertiliser (protected urea) reduced ammonia emissions by 78% compared to regular urea. Achieving a 50% change in national use from CAN to protected urea could potentially save approximately €130 million (up to as much as €187.5m if full uptake is achieved) worth of abated emissions over the period 2021-2030⁷⁸. DAFM funded research also found that the addition of amendments/additives to cattle slurry has been shown to reduce ammonia emissions from storage of slurry by 90%. The use of such amendments in the pig and bovine sectors could reduce ammonia by 1300 tonnes NH₃ yr⁻¹ and over 50,000 tonnes CO₂-e.⁷⁹ These mitigation measures can be inputted directly into national inventories. Research into improved grassland management is beneficial for GHG mitigation, as permanent grassland can store 608 million tonnes of carbon in contrast to approximately 37 million tonnes in arable land,⁸⁰ and therefore represents a significant opportunity in terms of GHG mitigation given the large proportion of agricultural land is permanent grassland in Ireland.

Carbon sequestration is an attractive mitigation option as management of grassland systems (fertilisation, grazing etc) generally enhances sequestration. Inventory of soil carbon stocks and fractions for grassland soils based on management system have been developed through DAFM's research programmes which now provide critical baseline data to enable a national approach to carbon sequestration. Data has shown that underneath every hectare of grassland, there is, on average 360 - 700 tonnes CO₂ stored. Funding on a number of DAFM projects has also led to the development of forest ecosystem productivity models which have been applied to remote sensing data to create models for producing carbon stocks and measuring changes at regional and national levels.

A software system called Carbware has been used by Ireland for reporting and development of GHG projection scenarios for forest lands to the United Nations Convention on Climate Change and the adopted Kyoto protocol since 2010.⁸¹ DAFM research funding has contributed to the support of this software in being continually updated to provide more accurate reporting of emissions. Under its current iteration Ireland has been allocated the largest degree of flexibility available (2.7 million tonnes carbon dioxide credits per year) under the IPCC reporting framework. Of most importance it has allowed Ireland to move from a Tier 1 to Tier 2 and 3 reporting systems (Tier 1 refers to default methods, higher tiers use country specific and more complex modelling approaches). The use of Tier

⁷⁷ Representing a 4,300 tonne NH₃ reduction in national ammonia emissions

⁷⁸ Based on a C floor price of €25 per tonne (proposed EU floor price) - a 50% change from CAN to protected urea will reduce emissions by, on average, 521,000 tonnes CO₂-e per annum from 2021-2030.

⁷⁹ From ammonia MACC, Lanigan et al. 2018 – An Analysis of the Cost of the Abatement of Ammonia Emissions in Irish Agriculture to 2030. Teagasc, Oak Park, Carlow

⁸⁰ National Mitigation Plan (2017) available: <https://www.dccae.gov.ie/en-ie/climate-action/publications/Documents/7/National%20Mitigation%20Plan%202017.pdf>

⁸¹ For example the Carbware system calculated sequestration 13 Mt CO₂ or 20% of the required reduction in Ireland's national emissions for the 2008–2012 target

2 and 3 systems help substantiate modelled scenarios and verifiable country specific data, thereby contributing to flexibility to access new and additional credits from the Land Use and Land Use-Change for Forestry (LULUCF) sector in the EU Effort Sharing regulation (ESR) under the 2030 Climate and Energy Framework.

Researchers participating in relevant DAFM funded projects since 2010 have gone on to leverage a further €2.5m of EU grant-aid awarded to Irish research institutes (at both partner and coordinator level) across 8 separate projects⁸² in this thematic area under EU Framework Programmes (Horizon 2020 and FP7) and Interreg IV programme. One of these projects NitroEurope has led to the development of new European ammonia targets, while another, 'AnimalCHANGE', which assessed global agricultural climate mitigation and adaptation potential, has resulted in the global 4 per mille initiative⁸³ to increase soil carbon.

Case Study 3: Infant Milk Formula

Irish based Infant Milk Formula (IMF) companies account for approximately 18% of the volume of milk formula traded internationally in 2017, with exports estimated to be worth over €1.5 billion to the Irish economy annually⁸⁴. DAFM's FIRM programme has contributed to this sector by supporting research and innovation into formulations and technologies which contribute to maintaining Ireland's leading position in the supply of specialised infant formula and related products and ingredients.

€2.2m has been awarded to 5 different IMF related projects in DAFM's FIRM programme over the 2010-2017 period specifically targeted at processing technologies, and these have contributed to the sector's growth through the generation of human capital, infrastructure and both fundamental and applied science. A particular theme of past research calls has been to develop new dairy ingredients for incorporation into infant formula and to enhance and protect the bioavailability of ingredients through new processing technologies. While many FIRM projects are at the early to mid-stages of Technology Readiness Levels (TRLs), their outputs have informed scientific advancement and contributed to the establishment of the IMF pilot plant capability within Moorepark Technology Ltd at the Teagasc campus in Fermoy. Teagasc have signed multiple agreements with IMF companies (national and international), also with companies that supply ingredient to the IMF sector. The cumulative industry spend on research activities amounts to more than €2.5 million while the income to Moorepark Technology Ltd. (research carried out in the pilot plant) amounts to some €4 million for the 2010-2017 period. Furthermore, many project outputs have been incorporated into Enterprise Ireland's (EI's) Dairy Processing Technology Centre (DPTC) work programmes. These advancements in processing technologies are often applicable to other companies involved in

⁸² AnimalCHANGE, LANDMARK, SoilCare, NitroEurope, BATFarm, DairyMAN, 'Nutri2Cycle' and ERA-Gas Co-Fund ERA-Net

⁸³ The international initiative "4 per 1000", launched by France on 1 December 2015 at the COP 21, consists of federating all voluntary stakeholders of the public and private sectors (national governments, local and regional governments, companies, trade organisations, NGOs, research facilities, etc.) under the framework of the Lima-Paris Action Plan (LPAP). The aim of the initiative is to demonstrate that agriculture, and in particular agricultural soils can play a crucial role where food security and climate change are concerned.

⁸⁴ <https://comtrade.un.org/data/>

nutritional formulations and a number of joint industry-RPO projects funded under EI's Innovation Partnership Programme (IPP) have emerged as a result.

Some examples of research collaborations and industry applications arising from infant formula projects funded under FIRM include the following:

- A project investigating “the use of novel technologies for improving quality and process efficiency in high protein beverage production”. This project advanced an energy efficient process for the manufacture of infant formula, (which had been developed as part of a previous FIRM funded project), and the technology transferred to a multinational IMF company who subsequently performed pre-commercial trials in collaboration with Teagasc researchers. A pilot plant processing unit was developed to advance the technology, which was utilised by industry for proof of concept trials.
- As part of a project investigating “Concept Protein ingredients for next generation infant formulation” a new process for the manufacture of IMF was developed. The process is based on membrane separation and an enhanced understanding of nutrient partitioning, which has nutritional, medical and therapeutic applications.
- Another project investigated the control of surface-activity of protein aggregates for their incorporation into nutritional formulation for optimised processability. The project discovered that the pre-heating of whey proteins improves the heat stability in whey protein products such as nutritional beverages and infant formula.
- A project investigating “Decoupling pH & Ionic Effect in Protein Super-Concentrates” advanced the understanding of the thermal stability of whey concentrates and found that improvements could be made by controlling pre-heat/solids parameters. The resulting methodologies that were developed to determine the functionality of dairy ingredients were provided to dairy processors and this resulted in an EI Innovation partnership with an IMF manufacturer.

The outputs from these collaborative research projects have resulted in tangible applications for industry. National researchers have attracted worldwide recognition as experts in the field with many being invited to join international consortium projects and as guest lecturers and key note speakers at conferences worldwide.

Annex F: DAFM Funded Projects Relevant to Thematic Area 1 Animal Breeding

Programme	Acronym	Title	Award	Lead (Collaborating) Institution
RSF	MultiGS	Multi-breed genomic selection in dairy and beef cattle	€376,735	Teagasc (ICBF)
RSF	Ovigen	Multi-breed sheep genetic and genomic evaluations	€1,106,382	Teagasc (UCD, ICBF)
RSF	HealthyGenes	Long-term sustainable breeding strategies for consistently superior health in cattle	€1,120,108	Teagasc (UCD, ICBF)
RSF	GenCost	Genetics of costs production traits	€290,142	Teagasc (ICBF, UCD, DCU)
RSF	Genotrace	Genomic strategies for animal and meat provenance, authenticity and traceability	€99,500	Teagasc (ICBF)
RSF	BreedQuality	Genetic selection for improved milk and meat product quality in dairy, beef and sheep	€1,160,654	Teagasc (UCD, ICBF, UCC)
FIRM	BullBeef	Genetic selection for improved meat quality in beef cattle	€1,328,701	Teagasc
RSF	Bull-Max	Maximising the genetic potential of young elite bulls by optimising the onset of puberty without compromising animal health	€672,598	UL (Teagasc, UCD, ICBF)
Total			€6,154,820	

Annex G: DAFM Funded Projects Relevant to Thematic Area 2 Climate Change - Addressing GHG and Ammonia Emissions Challenges

Programme	Acronym	Title	Award	Lead(Collaborating)Institution
RSF	Agri I	Agricultural Greenhouse Gas Research Initiative for Ireland	€1,698,136	Teagasc (TCD, UCD, AFBI, UL)
RSF	Sudan	Sustainable nitrogen fertiliser use and Disaggregated Emissions of Nitrogen	€640,177	Teagasc (UCD, AFBI)
RSF	Low ammo	Measurement and abatement of ammonia emissions from Agriculture	€1,246,290	Teagasc (UCD, AFBI)
RSF	Square	Soil Quality Assessment and Research	€1,017,315	Teagasc (UCD, UL, IT Sligo)
RSF	07RSF527	Assessing GHG impacts of establishing biomass and biofuel crops	€476,539	Teagasc (TCD, UCD)
CoFoRD	CforRep	Additions and refinements to the Irish forest carbon accounting and reporting tool	€1,485,708	UCD (UCC, UL, Teagasc)
CoFoRD	FORSITE	Monitoring and Assessment of critical biomass removal in Irish forests	€818,001	UCD (TCD, UL, Teagasc)
CoFoRD	CarbiFor II	Carbon sequestration in Irish forest ecosystems	€2,213,502.95	UCD
RSF	GHG-Manage	Managing and Reporting of Greenhouse Gas Emissions and Carbon Sequestration in different landscape mosaics	€236,134	UCD (Teagasc)
RSF	MAGGE-pH	Mitigating Agricultural Greenhouse Gas Emissions by improved pH management of soils	€244,999	Teagasc (NUIG)
Total			€10,076,802	

Annex H: DAFM Funded Projects Relevant to Thematic Area 3 Infant Milk Formula

Programme	Acronym	Title	Award	Lead(Collaborating)Institution
FIRM	NovTech	The use of novel technologies for improving quality and process efficiency in high protein beverage production	€356,104	Teagasc (UCD, UCC)
FIRM	Next Gen IMF	Concept Protein ingredient for next generation infant formulation	€296,164	Teagasc (UCC)
FIRM	Protein aggregates	Controlling surface-activity of protein aggregates for their incorporation into nutritional formulation for optimised processability	€333,840	Teagasc (UCC)
FIRM	Protein Super-concentrates	Decoupling pH & Ionic Effect in Protein Super-Concentrates	€401,700	Teagasc (NUIM, TCD)
FIRM	Smart Ingredients	Dehydration/Rehydration dynamics for development of 'SMART' dairy ingredients.	€797,084	Teagasc (UCC, UL)
Total			€2,184,892	

Quality Assurance process

To ensure accuracy and methodological rigour, the author engaged in the following quality assurance process.

- ✓ Internal/Departmental
 - ✓ Line management
 - ✓ Spending Review Steering group
 - ✓ Other divisions/sections
 - ✓ Peer review (IGEES network, seminars, conferences etc.)
- ✓ External
 - ✓ Other Government Department
 - ✓ Other Steering group
 - ✓ Quality Assurance Group (QAG)
 - ✓ Peer review (IGEES network, seminars, conferences etc.)
 - ☐ External expert(s)





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