AN ROINN FIONTAR, TURASÓIREACHTA AGUS FOSTAÍOCHTA

DEPARTMENT OF ENTERPRISE, TOURISM AND EMPLOYMENT (DETE)

An Evaluation of Deadweight in the DETE Economic Appraisal Model (EAM)

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EXECUTIVE SUMMARY

PURPOSE AND POLICY CONTEXT

This study was commissioned by the Department of Enterprise, Tourism and Employment (DETE) to review and evaluate the estimation of deadweight used within the Economic Appraisal Model (EAM) applied by the enterprise agencies Enterprise Ireland (EI) and IDA Ireland (IDA). Deadweight occurs when public expenditure is incurred to achieve benefits which would have been achieved in the absence of the project being so funded[1]. It is the proportion of supported activity that would have occurred in the absence of grant aid. Deadweight reduces net additionality and value for money and therefore affects the credibility of appraisal outputs and the calibration of EAM parameters.

The primary aim of the study was to provide a robust evidence base that would support a better understanding and assessment of deadweight in the EAM. The findings from the research will be used to guide future changes in deadweight in the EAM and inform the development of a cost-benefit analysis (CBA) model for environmental aid.

APPROACH AND EVIDENCE BASE

Three complementary evidence streams were tested:

- **Rapid Evidence Assessment (REA):** structured synthesis of Irish and international literature on deadweight concepts, measurement methods and mitigation strategies.
- **Enhanced Propensity Score Matching:** Applied to Annual Survey of Business Economic Impact (ABSEI) firm-level panel data linked to EI and IDA grant records to estimate deadweight for enterprise supports.
- **Counterfactual Survey for Environmental Aid:** Captured timing and scale effects through structured recipient responses, mapped to grant values.

METHODOLOGY AND OUTPUTS

The study examined general enterprise supports and environmental aid provided by the enterprise agencies aiming to apply robust, internationally recognised methodologies. However, several practical constraints limited the ability to produce definitive deadweight estimates.

In respect of general grant aid the analysis used firm-level panel data from the ABSEI spanning 2010-2022, integrated with detailed grant aid timelines. A series of methodological challenges were encountered.

Firstly, sample size limitations proved a critical barrier. When data was segmented by region, grant type, and outcome category, the number of observations fell below thresholds needed for reliable statistical inference. This was particularly acute in smaller regions and niche grant schemes, where even advanced matching techniques could not overcome the lack of comparable firms.

[1] Public Spending Code A Guide to Economic Appraisal: Carrying Out a Cost Benefit Analysis, Available at: a-guide-to-economic-appraisal-carrying-out-a-cost-benefit-analysis.pdf –

Secondly, data completeness and quality issues undermined the feasibility of certain approaches. Missing baseline information, such as pre-grant employment, turnover, and R&D expenditure—restricted the ability to construct credible counterfactuals. Without these foundations, even sophisticated econometric models risked producing unstable or misleading estimates.

Thirdly, outcome volatility and timing misalignment complicated metric-based inference. Many firm-level indicators fluctuate significantly due to market cycles, external shocks, and firm-specific dynamics. When these variations are large relative to plausible grant effects, it becomes impossible to disentangle programme impact from natural variability. Attempts to infer additionality from within-firm changes were therefore abandoned because they lacked the structure needed for credible attribution.

Finally, limited overlap between treatment and control groups constrained the strength of propensity score matching. In some strata, firms receiving grants were systematically different from those without support, leaving insufficient common ground for valid comparisons.

Firms receiving grant aid are referred to as the supported (treatment) group.

- Matched non-supported firms are referred to as the comparison (control) group.

Two design constraints shape interpretation of the reported results:

1. Baseline completeness and outcome reporting gaps reduced effective sample sizes, particularly after disaggregation by region and grant type.
2. Some candidate approaches (including within-firm performance inference without an explicit counterfactual) were not taken forward because outcome volatility and inconsistent reporting prevented credible attribution.

These constraints imply that the results are not appropriate for application in the current economic appraisal model as deadweight estimates.

In respect of environmental aid, the approach was to elicit structured counterfactual responses from grant recipients and map these to administrative grant values to estimate project level and grant weighted deadweight. Once again sample sizes were notably limited as these are a newer type of support compared to general grant aid. This restricted the extent to which results could be disaggregated by region, project category, or scheme type without generating high variance estimates.

Therefore similarly, evaluation guidance indicates that where sample sizes are small, results should be treated as indicative and reporting should focus on feasibility, transparency of assumptions, and identification of the conditions required for more robust future estimation, including improved response rates and pooling across periods where appropriate

LESSONS LEARNED

The evaluation highlighted several important lessons for future work. Firstly, metric-only approaches are not viable under current conditions. While attractive for their simplicity, they fail when baseline data is incomplete and outcome volatility is high. Robust counterfactuals, whether through matched comparators or structured surveys, are essential for credible estimation of deadweight.

Secondly, granular annual estimates are unrealistic in a small economy like Ireland. Ireland's enterprise and environmental grant programmes operate within relatively small cohorts, meaning that disaggregated estimates by region and grant type often fall below minimum sample thresholds. Pooling cohorts across multiple years and pre-specifying aggregation rules is therefore necessary to achieve stability.

Thirdly, environmental aid requires distinct outcome concepts. Traditional economic metrics such as employment or turnover do not capture the primary objectives of environmental schemes, which often deliver benefits through emissions reductions, energy savings, or technology adoption. Evaluation frameworks must therefore incorporate these dimensions and align monitoring with expected impact windows.

Fourthly, counterfactual surveys are feasible but require careful design. They can capture timing and scale effects that matter for additionality, but they must mitigate bias through structured question wording, confidentiality assurances, and planned follow-up to improve response rates. Linking survey responses to administrative data will further strengthen validity. Furthermore, sample size may continue to be a challenge in the medium term given the relatively novel nature of these supports.

RECOMMENDATIONS

To build a more robust evidence base, several practical steps are recommended. The first step is adopting a minimum evidence standard for publishable deadweight estimates. This should include clear thresholds for sample size, mandatory reporting of matching diagnostics, and transparent uncertainty statements. Estimates that do not meet these standards should be suppressed or aggregated to avoid over-precision.

The second recommendation is to improve data readiness at the source, while remaining mindful of the administrative overhead required. This means capturing baseline information at the point of grant application, harmonising grant taxonomies across agencies, and implementing unique identifiers to enable linkage between administrative and performance datasets. Without these foundations, even advanced methods will remain constrained.

The third recommendation is to standardize environmental outcome monitoring where possible. Programmes should seek to collect consistent data on expected and realised energy savings, emissions reductions, and technology specifications, with follow-up measurement points aligned to impact lags. These measures will allow deadweight estimation to reflect the true channels of additionality in environmental schemes.

The final recommendation is to consider the role of sensitivity testing in economic appraisal model outputs that reflect evidence-weighted ranges. Deadweight is inherently uncertain and context-dependent. Sensitivity testing empowers decision makers to consider elements of the proposal that are uncertain.

STRATEGIC DIRECTION

In light of the findings of this review, this report sets out recommendations and a proposed roadmap for building a more robust evidence base on deadweight in Ireland. Implementing the recommendations provided in this report will enable DETE and its agencies to:

- Move toward decision-grade parameters for deadweight that reflect real additionality.
- Improve appraisal credibility and transparency of initiatives and schemes.
- Support better resource allocation and policy targeting of enterprise supports.

Deadweight estimation is not a static exercise. It requires continuous improvement in data systems, methodological design, and evaluation capacity. Implementing the standards and plan set out in this report will improve the credibility of the Economic Appraisal Model (EAM) and support evidence-based resource allocation across the enterprise and environmental policy portfolios. This report provides the foundation for that continued journey.

CONTENTS

Glossary of terminology

Additionality: The extent to which public support leads to outcomes that would not have occurred without the intervention.

Behavioural additionality: Changes in firm behaviour or capabilities induced by public support, beyond simple input or output additionality.

Bootstrapped DEA: An advanced version of DEA (see *Data Envelopment Analysis (DEA)* definition) that applies statistical bootstrapping techniques to generate confidence intervals and correct for sampling bias. This method provides more robust efficiency estimates by accounting for statistical uncertainty in the efficiency scores.

CDTI (Centro para el Desarrollo Tecnológico Industrial): Spain's Centre for the Development of Industrial Technology, a public organisation that provides financial support and assistance to Spanish companies to promote their technological development and innovation.

Counterfactual: The hypothetical scenario of what would have happened in the absence of public support.

Data Envelopment Analysis (DEA): A non-parametric method used to empirically measure the relative productive efficiency of multiple decision-making units (such as organisations, policies, or programmes). DEA creates an efficiency frontier based on observed best performance and measures how far an organisation's observed performance is from that frontier.

Deadweight: The extent to which specific activities, projects, or investments would have been carried out without public support. In enterprise and environmental support evaluation, deadweight indicates situations where public funds are used to support actions that would have occurred anyway, representing inefficient allocation of public resources.

Deadweight loss: The quantifiable economic impact or reduction in net economic benefits resulting from supporting activities that would have occurred without public intervention. In enterprise support evaluation, this typically represents the monetary value or percentage of funding that did not generate additional economic activity.

Displacement effect: When public support to one firm or sector negatively affects other firms or sectors not receiving support.

Deadweight spending: Public expenditure on activities, projects, or investments that would have proceeded without support, specifically referring the financial resources expended without generating additional economic or social benefits beyond what would have occurred naturally.

Development projects: Initiatives aimed at promoting economic growth, improving social conditions, or enhancing environmental sustainability. In the context of enterprise and environmental funding, these may include research and innovation activities, capacity building programmes, or initiatives to promote sustainable practices.

Dynamic modelling techniques: Mathematical or computational methods used to study systems that change over time, often employed to capture the evolving impacts of policy interventions.

Econometric analysis: Statistical methods used to estimate economic relationships and test economic theories.

Investment projects: Specific initiatives or ventures where capital is allocated with the expectation of generating future returns. In the context of enterprise funding, these often involve expenditures on physical assets, technology, or infrastructure to enhance a firm's productive capacity or efficiency.

Malmquist Index: A measure used to calculate productivity change over time, decomposing it into two components: efficiency change (catching-up) and technical change (frontier shift). In the context of policy evaluation, it helps identify whether improvements come from better use of existing resources (efficiency change) or from technological/methodological innovations (technical change).

Malmquist Index decomposition: The process of breaking down the Malmquist Index into its constituent components to understand the sources of productivity change. This decomposition helps identify whether changes in performance are due to improvements in efficiency, technological progress, or both.

Matthew Effects: Describe cumulative advantage, whereby firms or individuals that already hold recognition or resources tend to attract further opportunities and rewards over time, reinforcing initial differences.

Multi-level modelling: A statistical approach that analyses hierarchical data structures, accounting for variations at different levels (e.g., individual, firm, and policy levels) simultaneously.

Network models: Analytical approaches that examine the structure and dynamics of relationship between entities (e.g., firms, individuals, or institutions) in a system, often used to study knowledge diffusion or collaborative patterns).

Propensity score matching: A statistical matching technique that attempts to estimate the effect of a treatment by accounting for the covariates that predict receiving the treatment.

Partial deadweight: Cases where some aspects of the supported activity (such as scale, timing, or quality) would have differed without public support, even if the core activity would have proceeded.

Pure deadweight: Situation where 100% of the supported activity would have occurred in exactly the same form and timeframe without public support.

R&D: Research and Development, referring to innovative activities undertaken by corporations or governments in developing new services or products, or improving existing ones.

Randomised controlled trials (RCTs): An experimental research design where participants are randomly assigned to either a treatment group (receiving an intervention) or a control group, allowing for the estimation of causal effects of the intervention.

Regression discontinuity: A quasi-experimental design in policy evaluation that examines the causal effects of interventions by comparing observations lying closely on either side of a fixed threshold.

Spillover effects: Positive or negative 'externalities', events that occur when the actions of one economic agent affect others not directly involved in the action. Examples of positive externalities could include knowledge spillovers; whilst negative externalities could include displacement effects or pollution.

SMEs (Small and medium-sized enterprises): Businesses that meet specific size criteria as defined by the European Union recommendation 2003/361. Small-sized enterprises have fewer than 50 employees, while medium-sized enterprises have between 50 and 249 employees. Large enterprises are those with 250 or more employees.

Synthetic control method: A statistical method used to evaluate the effect of an intervention in comparative case studies.

Abbreviations

ABSEI: Annual Business Survey of Economic Impact

ATT: Average Treatment Effect on the Treated

CAP: Common Agricultural Policy

CDTI: Centro para el Desarrollo Technológico Industrial

DEA: Data Envelopment Analysis

DETE: An Roinn Fiontar, Turasóireachta agus Fostaíochta (Department of Enterprise, Tourism and Employment)

EAM: Economic Appraisal Model

ECP: EU Cohesion Policy

EFF: European Fisheries Fund

EI: Enterprise Ireland

EU: European Union

FDI: Foreign Direct Investment

GDP: Gross Domestic Product

GEM: Global Entrepreneurship Monitor

GNP: Gross National Product

IDA: IDA Ireland

NGO: Non-Governmental Organisation

OECD: Organisation for Economic Co-operation and Development

OLS: Ordinary Least Squares

R&D: Research and Development

REA: Rapid Evidence Assessment

RCT: Randomised Controlled Trial

SME: Small and Medium-sized Enterprise

SPOQ: Scoring Principles of Quality

2SLS: Two-Stage Least Squares

1 INTRODUCTION

1.1 BACKGROUND AND CONTEXT

The Department of Enterprise, Tourism and Employment commissioned ADAS to undertake this study which aimed to independently evaluate the current estimation of deadweight in the Economic Appraisal Model (EAM) utilised by DETE and its partner agencies, Enterprise Ireland and IDA Ireland. DETE mission includes working to create the conditions for sustainable enterprise growth and investment, high-quality jobs and workplaces across all regions of Ireland. Enterprise Ireland is the government agency responsible for the development and growth of Irish enterprises in world markets, by working in partnership with Irish enterprises to help them start, grow, innovate and win export sales on global markets. IDA Ireland is the principal agency responsible for attracting and growing foreign direct investment in Ireland. As such, the activities of both agencies support sustainable economic growth, regional development and secure employment.

Deadweight is central to policy appraisal because it directly affects value for money and the credibility of expected net benefits. The Public Spending Code (Public Spending Code 2019) expressly requires that deadweight should be considered as part of appraisal[2]. Internationally, the Green Book (HM Treasury, 2022) emphasises that appraisal should compare options on the basis of additional costs and benefits relative to a clearly specified reference case, and that evaluation should be designed to test whether observed outcomes are attributable to the intervention rather than to wider trends. In this context, deadweight represents the share of outputs or outcomes that would have occurred in the absence of the intervention, meaning that expenditure has not generated additional change relative to the reference case.

Established additionality guidance treats deadweight as one component of a structured framework for moving from gross outputs to net impact, alongside leakage, displacement, substitution, and multiplier effects, and it recognises that additionality can arise through changes in scale, timing, quality, and persistence of outcomes. Improving the evidence base on deadweight therefore supports more transparent parameter setting within appraisal tools and strengthens confidence that public resources are directed to interventions where support is most likely to change behaviour and outcomes (HM Treasury, 2022; Homes and Communities Agency, 2014).

1.2 PURPOSE OF THE EVALUATION

This review of deadweight within the EAM was commissioned to improve the accuracy and effectiveness of how deadweight is applied within the model. In addition, gaining a greater understanding of how deadweight could be applied in the context of grants for environmental initiatives was another key factor behind this research. As identified by Enright *et al.* (2024), although emissions have experienced a notable decrease, if Ireland is to meet the various environmental targets that have been established with regards the green transition, matching funding opportunities for environmental support with firms is a crucial in facilitating the development of climate action plans by Irish enterprises. Enright *et al.* (2024) identify that availability of funding represents a significant challenge for firms in developing a climate response, and, as such, this work will provide further insight to inform more efficient allocation of resources within the greening of the Irish economy.

The original aim of this study was to produce robust deadweight estimates for enterprise and environmental grant schemes. However, significant data and design constraints meant that decision-grade parameters could not be generated under current conditions. Rather than presenting numeric

[2] public-spending-code-a-guide-to-evaluating-planning-and-managing-public-investment-dcf.pdf

estimates that risk overstating precision, this report provides recommendations for enabling credible deadweight estimation in future reviews. This approach ensures that findings remain policy-relevant and actionable, while acknowledging the limitations of the current evidence base.

1.3 CONTRIBUTION TO THE LITERATURE

This evaluation contributes to the Irish and international literature on deadweight estimation in three important ways:

Firstly, it documents the practical challenges of applying widely recommended counterfactual methods, such as propensity score matching and structured surveys, within the constraints of a small economy and fragmented administrative data systems. While these methods are standard in impact evaluation, evidence on their feasibility under real-world conditions remains limited. By highlighting where and why these approaches failed to deliver decision-grade estimates, the report provides policy-relevant insights that go beyond the theory.

Secondly, the study operationalises timing and scale effects as recognised channels of additionality, extending the conceptualisation of deadweight beyond binary "would have happened / would not have happened" classifications. This is particularly relevant for environmental aid, where grants often accelerate delivery or enable higher-specification technologies rather than determining whether investment occurs at all. Incorporating these dimensions aligns with international guidance (Homes and Communities Agency, 2014; HM Treasury, 2022; European Commission, 2021) and advances the discussion on partial deadweight estimation.

Thirdly, the report reframes deadweight estimation as a staged, evidence-building process rather than a one-off exercise. It sets out minimum evidence standards, data harmonisation priorities, and evaluation-ready design principles that can be embedded in programme planning. This roadmap approach responds to persistent gaps identified in the literature, such as incomplete baselines, lack of unique identifiers, and short-term monitoring, and provides a practical template for moving from indicative signals to robust, publishable parameters over successive review cycles.

In doing so, the report bridges the gap between methodological ambition and implementation reality, offering lessons that are transferable to other small economies and to emerging domains such as environmental grant evaluation. It complements existing studies that focus on econometric techniques by emphasising the enabling conditions (data architecture, monitoring frameworks, and comparator strategies) required for credible deadweight estimation in practice.

1.4 ANALYTICAL APPROACH

The evaluation applied a mixed-method design combining:

- Rapid Evidence Assessment (REA) of Irish and international literature to identify best practice and contextual challenges.
- Enhanced propensity score matching (PSM) using ABSEI firm-level panel data linked to EI and IDA grant records for enterprise supports.
- Structured counterfactual survey for environmental grant aid to capture timing and scale effects.

These approaches were selected to align with international evaluation guidance and to move beyond reliance on self-reported impacts toward more objective, data-driven methods. However, as documented later, constraints in baseline completeness, sample sizes, and monitoring arrangements limited the feasibility of producing robust estimates using these approaches.

1.5 STRUCTURE OF THE REPORT

This report has been restructured to emphasise what was attempted, why certain approaches fell short, and how lessons learned can inform future work. The focus is on providing a strategic roadmap for improving deadweight estimation rather than presenting results that cannot be generalised. The chapters are organised as follows:

- **Chapter 2**: Literature Review- Summarises existing evidence and methodologies for deadweight estimation and positions this report within that context.
- **Chapter 3**: General Grant Aid- Describes the approach attempted for enterprise grants, challenges encountered, and lessons learned.
- **Chapter 4:** Environmental Aid- Outlines the intended approach, issues experienced, and implications for future work.
- **Chapter 5:** Conclusions and Recommendations- Synthesises key challenges, identifies what does not work, and sets out practical steps and a roadmap for enabling robust deadweight estimation in future reviews.

2 LITERATURE REVIEW

To evaluate the existing evidence on deadweight levels in enterprise funding and environmental aid, a rapid evidence assessment (REA) was conducted. The review synthesised insights and key findings from a broad range of academic studies, policy papers, and evaluations, highlighting the most relevant and impactful research in the field. The review examined key factors relevant to assessing deadweight in the Economic Appraisal Model (EAM). These factors guided the subsequent analysis of the ABSEI database, survey results and EI and IDA grant data, focusing on deadweight within both general grant aid and environmental grant aid. It should be noted that this literature review is a high level, rapid assessment of the evidence base on the estimation of deadweight levels, rather than a detailed systematic review and discussion of deadweight policy

2.1 INTRODUCTION

Deadweight, in the context of enterprise funding, is a critical concept that fundamentally challenges the efficacy of public support programmes. For instance, when grants are given to businesses that would have undertaken projects anyway, or when environmental subsidies support actions that companies were already planning to implement, this represents inefficient allocation of resources, as there is no additional generation of positive outcomes from the provision of funds.

Lenihan (2004) defined deadweight as the extent to which projects or investments would have proceeded without public funding. In general, economic terms, deadweight represents "a reduction in net economic benefits resulting from an inefficient allocation of resources" (Conlon *et al*., 2012: 9). This definition underpins much of the literature in this field and serves as a cornerstone for evaluating the additionality of public support.

The conceptualisation of deadweight has evolved to recognise its multi-faceted nature[3]. Early work by Lenihan (1999) and Hart and Lenihan (2006) introduced a nuanced understanding by distinguishing between "pure" and "partial" deadweight. Pure deadweight occurs when 100% of the activity would have taken place without funding, while partial deadweight acknowledges that some aspects of the project might have changed in the absence of support. This distinction is crucial as it allows for a more granular analysis of programme impacts.

More recent studies, such as Dvouletý *et al.* (2021), have further refined these concepts and their application, seeking to enhance the conceptualisation of deadweight estimates by accounting for some of the indirect benefits associated with grant assistance, such as financial leverage, whereby grants help firms secure additional funding from other sources, and the networking opportunities provided by the grant-supplying agency.

Hart and Lenihan (2006) suggested a need to "re-calibrate" current estimates of the impact of funding on businesses, due to the extent of positive externalities associated with such funding, which contribute to a significant uplift in additionality measurements. These positive externalities result from enhanced opportunities to access additional alternative financing and indicate the important and dynamic relationship between private and public sector financing.

[3] The OECD (2006) report on government funding and firm behaviour identifies seven core types of additionalities, essentially the inverse of deadweight. These include (1) input additionality, i.e., whether government funding leads to additional private R&D spending, (2) output additionality in the more typical sense, as to whether outputs and/or results are achieved due to the presence of government funding, (3) behavioural additionality insomuch that firm behaviour and strategies change as a result of receiving government funding, (4) project additionality in the sense of whether projects would have been carried out without funding (a more specific conceptualisation of deadweight), (5) effects on the speed or acceleration of projects, (6) scope additionality in that the scale and scope of projects is altered, and (7) network additionality, whereby the receiving of government funding effects collaboration and partnerships.

Clarysse *et al.* (2009) and Roper and Hewitt-Dundas (2016) expanded the concept of deadweight by incorporating "behavioural additionality", which considers changes in firm behaviour due to public support, *even if* the specific funded project would have occurred anyway[4]. Brandsma *et al.* (2013) showed how behavioural additionality affects the investment behaviour of firms in competitive markets within the context of the EU Cohesion Policy (ECP). Specifically, Brandsma *et al.* (2013) found that market structure plays a crucial role. Enforcing additionality in imperfectly competitive markets can lead to distortions and welfare losses. In contrast, providing support can increase investment and welfare in such markets, even when additionality is not enforced. As such, targeting sectors with market imperfections is more effective, as firms will tend to increase investment even without enforced additionality.

In perfectly competitive sectors, however, the support mainly acts as an income transfer, unless additionality is enforced[5]. Bia and Mattei (2012) proposed a more dynamic view of deadweight, which considered how the amount of financial assistance affected the survival and growth trajectories of firms over time. Falk (2007) also highlighted the various degrees of additionality, moving beyond a simple binary classification, while Wren (2007) further identified additionality as a "multi-dimensional" concept.

More recently, alongside the contribution of Dvouletý *et al.* (2021), Lenihan *et al.* (2024) note that while there exists evidence that Research and Development (R&D) grants and tax credits do drive additional R&D investment and performance improvements in foreign-owned subsidiaries located in Ireland, such firms may transfer knowledge produced by government-funded R&D to other locations, with commercialisation occurring outside of the host country. While the authors show that this effect does not sufficiently materialise in the Irish context, it does raise an important consideration when assessing the relative deadweight and additionality of public funding to foreign-owned subsidiaries in increasingly globalised economies.

Mulligan *et al.* (2022) also identified this international element to deadweight considerations as a phenomenon that requires policy mandates to ensure benefits of funding are experienced in the host country. The authors found a positive impact on firm performance within the host country of subsidiary firms, indicating, at least, some additionality rather than full (or pure) deadweight. Perez-Alaniz *et al*. (2023) found similar results amongst public R&D funding to foreign-owned subsidiaries, identifying positive links between public support-induced R&D and firm performance measures, again providing evidence of additionality. Perhaps most notably, Lenihan *et al.* (2025) found positive impacts from policy instrument sequences over time. This finding suggests that there is also a temporal element to the considerations and assumptions regarding the promotion and facilitation of additionality.

Further to this, Lenihan *et al.* (2025) note earlier studies, such as Guellec and van Pottelsberghe (2003), which found evidence of substitution effects between different policy instruments, suggesting the existence of deadweight. Later studies, including Bérubé and Mohnen (2009),

[4] The conceptualisation of behavioural additionality is not theoretically new and the reader is referred to the early foundational literature concerning deadweight, studies by Davenport *et al.* (1998) and Buisseret *et al.* (1995) in particular, which identify behavioural effects associated with public funding. More recently that an agreed consensus is emerging with regards its true nature and implications.

[5] It is important to note that the authors refer to a theoretical, idealised scenario in which policy-makers can somehow ensure that firms increase their investment exactly by the quantity of the support, but acknowledge, that perfect enforcement is extremely difficult or impossible to fully achieve in reality, "because usually there are no available counterfactual data to check the firm investment level with and without the support. Policy makers can observe only capital use with the support. At the same time, firms do not have incentive to reveal their true counterfactual investment intentions. This makes the monitoring of the application of investment additionality costly and thus hard to enforce" (Brandsma *et al.*, 2013: 853).

identified complementary effects between instruments, while Antonelli and Crespi (2013) observed 'Matthew effects.'[6] These occur when the same firms repeatedly receive multiple policy supports over time, often at the expense of other, potentially more deserving firms. Such an effect can be "vicious", when firms simply build significant capacity in the logistical and procedural aspects required to access funding, as opposed to any inherent need for support or clear strategy of how it will generate additionality.

Conversely, a "virtuous" Matthew effect can result from firms cultivating the best collection of novel ideas, which would not be exploited without public support. As such firms receive progressively more policy instruments, capacity increases, they subsequently become more proficient in realising success and therefore require additional policy support. As can be seen from the collection of these more nuanced analyses of the efficiency and efficacy of public funding and value-adding additionally, the conceptual understanding of the dynamics of limiting deadweight and cultivating additionality is continually expanding.

Measurement approaches to deadweight vary considerably across studies, reflecting the complexity of capturing this phenomenon. Tokila and Haapanen (2009) employed a sophisticated methodology that combined self-assessment with econometric analysis. Their approach involved asking beneficiaries about counterfactual scenarios and then using this information within a broader econometric framework. This method aimed to mitigate the potential biases inherent in pure self-reporting while leveraging the insights that only beneficiaries can provide.

Bondonio and Greenbaum (2014) advocated for the use of counterfactual analysis, emphasising the importance of comparing funded entities to similar non-funded entities. This approach is particularly helpful in disentangling programme effects from other factors affecting outcomes. Bondonio and Greenbaum (2014) highlighted the challenges in constructing appropriate comparison groups and the potential for selection bias to skew results. To address these issues, the authors employed propensity score matching techniques, alongside difference-in-difference estimations, which have proved to be stable techniques in the literature concerning impact evaluation.

The measurement of deadweight is not without its challenges. As noted by Doucouliagos and Paldam (2005) in their meta-analysis of studies assessing the effectiveness of aid in a development context, the choice of measurement technique can significantly influence results. The authors argued for a more standardised approach to measurement to enable comparison across studies and contexts.

Huergo and Moreno (2017) compared different types of support and their impact on deadweight effects, suggesting that the form of support can also influence the degree of deadweight. Specifically, the authors noted that for low-interest loans, national R&D subsidies, and European R&D subsidies, in the context of their study in Spain, all three types of support increased the probability of firms conducting R&D activities, but the impact varied by instrument. European subsidies had the largest effect, which was three times larger than the effect of loans. Moreover, Huergo and Moreno (2017) identified different impacts for SMEs and large firms, with complementarity between both subsidies and loans for SMEs. The study found that receiving both led to higher investment, compared to receiving just one type, whereas, for large firms, the authors could not dismiss crowding-out effects between subsidies and loans, which suggests potential deadweight effects for large firms receiving multiple types of support.

[6] Matthew effects describe cumulative advantage, whereby firms or individuals that already hold recognition or resources tend to attract further opportunities and rewards over time, reinforcing initial differences. For example, a firm that has previously secured public support may build stronger application capability and closer programme familiarity, making it more likely to win subsequent rounds of funding than an otherwise similar firm with no prior award history.

2.2 LITERATURE REVIEW METHODOLOGY

The REA synthesised existing research, empirical studies, and academic literature on economic appraisal models in the context of government support programmes, deadweight assessment methodologies, best practices in project evaluation, and assessment and evaluation of public environmental programmes. The review process followed a structured approach to ensure comprehensive coverage and rigorous analysis of the relevant literature.

Search Strategy

Peer reviewed published journal article databases were searched by a means of targeted queries, using a combination of traditional literature searching techniques and AI tools. Beyond traditional literature searching techniques, Elicit, an AI research assistant tool that leverages large language models to enhance the literature review process, was used to improve searches. Elicit searches across 126 million academic papers, covering all academic disciplines. This was particularly useful for this project, especially in helping gather insights from various fields and thematic areas. The use of Elicit itself has been validated by recent research with regards to evaluating its methodology, usefulness and ultimate success in conducting literature reviews. Elicit has been shown to perform better than GPT4-Turbo and can outperform trained human experts in terms of detail and information retrieval (Spillias *et al.*, 2024). Elicit is also noted for its novel interface approach, which allows users to synthesise literature and probe additional questions within articles (Kung, 2023). Within the context of this review, Elicit was particularly valuable for assisting with the following processes:

- **Comprehensive Paper Discovery**
    - Identifying relevant papers across multiple databases that might have been missed through traditional keyword searches,
    - Surfacing papers that use different but related terminology for deadweight concepts, and
    - Finding cross-disciplinary applications and insights from adjacent fields.
- **Efficient Paper Analysis**
    - Cross-checking the identified methodological approaches and measurement techniques across multiple papers, to ensure the connections and contradictions between different studies were accurate.
    - Quality Assessment Support
    - Cross-checking the evaluation of papers against the SPOQ framework criteria, in order to identify outliers or paper assessments that could require further evaluation.

The use of Elicit complemented traditional research methods by providing an additional check to the review process and helping to ensure comprehensive coverage of the literature. However, all AI-generated insights were carefully verified through human review and cross-referencing with original sources. This hybrid approach of combining AI-assisted research tools with traditional academic review methods helped ensure both breadth and depth in the literature review while maintaining academic rigor and accuracy.

The search strategy employed a set of predefined keywords and their combinations, including, but not limited to, “deadweight”, “deadweight loss”, “deadweight spending”, “enterprise funding”, “environmental aid”, “economic appraisal model”, “environmental aid”, “additionality”, etc. Specifically, searches were conducted in the context of the seven key objectives which were outlined in the project specification:

1. Definitions and measurements of deadweight loss,
2. Empirical evidence of deadweight loss in enterprise funding programs,
3. Empirical evidence of deadweight loss in environmental aid initiatives,
4. Comparative studies between different countries or regions,
5. Methodologies used to assess deadweight loss in these areas,
6. Factors influencing the extent of deadweight loss, and
7. Proposed strategies to minimise deadweight loss in these funding contexts.

While still relevant in the Irish context, direct comparisons across some of the literature were approached with caution due to several potential issues:

- Differences in economic contexts.
- Variations in scale and complexity.
- Divergent objectives.
- Measurement challenges.
- Political and institutional factors.

Accordingly, the use of such papers was limited to extracting relevant lessons that provided insight into the specific context of this study, including:

- **Methodological approaches.** Techniques such as propensity score matching and counterfactual analysis where applicable in both contexts.
- **Conceptual frameworks**. The core concepts of deadweight and the importance of additionality are relevant across international aid and domestic state support.
- **Factors influencing deadweight**. Variables such as firm size or sector may have similar effects in both settings.
- **Policy design considerations**. Lessons on targeting, selection processes, and rigorous evaluation are valuable in both contexts.
- **Measurement challenges**. Both contexts face difficulties in establishing true counterfactuals and addressing selection bias.

To enable the review of literature to be more directly applied to the Irish context and the appraisal of enterprise funding, the following review strategies were adhered to throughout the REA process:

- Prioritisation of studies from developed countries, especially EU member states with similar economic structures to Ireland,
- Focus on enterprise support programmes rather broad development aid initiatives,
- Consideration of the specific economic and institutional context of Ireland when interpreting results from other countries,
- Supplementing international literature with any available studies or evaluations of Irish enterprise support programmes, and
- Explicitly stating specific limitations of drawing comparisons between international aid and internal state support when presenting findings.

This approach allowed important lessons to be identified across the literature, whilst ensuring relevance and contextual understanding. Transferability of lessons between contexts is common

when studying programme and policy evaluation methodologies. Both Pawson and Tilley (1997), a seminal piece of work in programme evaluation, and Warwick and Nolan (2014) provide insightful direction on how to draw lessons across different settings and provide guidance on the comparability of different contexts in this regard.

This REA adopted an approach similar to that of Lenihan (2011), which adeptly addressed issues of transferability between contexts when examining enterprise policy evaluations. Lenihan (2011) provided a comprehensive framework that considered specific contextual factors in the comparative analysis of evaluation methodologies across different countries, including challenges in developing nations, cultural influences, industry dynamics, and the emergence of social entrepreneurship. This approach promotes a systematic analysis of transferability while acknowledging the need for context-specific adaptations in enterprise policy evaluation.

2.3 LITERATURE REVIEW FINDINGS

2.3.1 Empirical evidence of deadweight in enterprise funding

The empirical literature consistently reports significant levels of deadweight in enterprise funding programmes, though the magnitude varies considerably across studies. Tokila and Haapanen (2009) find deadweight loss estimates ranging from 20% to over 70% in their comprehensive study of Finnish enterprise support programmes. This wide range highlights the context-dependent nature of deadweight and the importance of programme-specific evaluations. Programme design, target beneficiaries, economic conditions, and sector-specific characteristics may all influence the extent of deadweight. Furthermore, the wide range could also reflect differences in measurement techniques and methodologies used to estimate deadweight, alongside varying complexity with regards the challenges in accurately measuring and interpreting deadweight. Ultimately, the wider range and variation suggests scope for targeted evaluations of public spending mechanisms, and/or identifies potential for improving the efficiency of some programmes.

Lenihan (1999), focused on the Irish context, reported deadweight loss levels of around 78% in enterprise support schemes at the time of that study. This high proportion of deadweight raised significant concerns about the efficacy of public support programmes in Ireland and indeed, sparked a broader debate about the design of such initiatives. The study by Lenihan (1999) was a seminal piece of research, leading to further academic research in Ireland and internationally on the effectiveness of enterprise support policies.

Bondonio and Greenbaum (2014) provided a more nuanced picture in their analysis of Italian enterprise support programmes. The authors found that deadweight varies significantly across different types of support and firm characteristics. Notably, Bondonio and Greenbaum (2014) observe lower levels of deadweight for smaller firms and for certain types of support, such as innovation-focused grants.

More recently, Blomquist and Waldo (2022), examining the Swedish aquaculture and fish processing sectors, found deadweight loss of around 35% in aquaculture, but a much higher 77% in fish processing. This sectoral variation highlights the importance of considering industry-specific factors in programme design and evaluation. The Blomquist and Waldo (2022) study illustrates the potential difference between environmental support/sectors and more traditional enterprise support. This difference could suggest that environmental support programmes might experience different levels of deadweight compared to conventional enterprise support, possibly due to unique market failures or externalities in environmental sectors (Kemp, 2000; Jaffe *et al.*, 2005). With regard to market failures in particular, smaller firms are more likely to be credit-constrained due to failures surrounding limited knowledge of financiers. As such, public support has the potential to stimulate investments and growth (Brandsma *et al.*, 2013).

These empirical findings collectively suggest that while deadweight is a pervasive issue in enterprise funding programmes, its extent can vary dramatically based on a variety of programme-specific characteristic, alongside broader economic contexts. For instance, Tokila *et al.* (2008) found that deadweight varied significantly across regions and firm sizes in Finland, Lenihan *et al.* (2007) demonstrated how different programme designs in Ireland led to varying levels of deadweight, and Czarnitzki and Fier (2002), studying German innovation subsidies, showed how broader economic contexts influence the extent of deadweight. The persistence of high deadweight estimates across various studies and contexts highlights the need for continued evaluation and refinement of support programmes (Dimos and Pugh, 2016; Zúñiga-Vicente *et al.*, 2014).

2.3.2 Empirical evidence of deadweight in environmental aid funding

The literature on deadweight in environmental aid initiatives was less developed compared to general enterprise funding, reflecting a gap in the research that warranted further attention. Some studies have begun to explore this area, providing initial insights. These studies, while not directly quantifying deadweight estimates, have made effort to assess the efficiency of environmental policies and support. In this respect, these studies can help inform a better understanding of deadweight within the environmental context.

Czyzewski *et al.* (2020) examined the efficiency of environmental protection funds from Poland. Specifically, using the boot-strapped Data Envelopment Analysis (DEA) method and Malmquist Index decomposition, the authors assessed the extent to which public expenditures have been wasted. This was achieved by environmental policy inefficiency, i.e., deadweight, being represented when a benchmark country achieves similar environmental output levels but with a lower quantity of public resources. The Czyzewski *et al.* (2020) analysis suggests that there is significant room for improvement in the allocation and use of these funds, implying the potential presence of deadweight. The authors highlight the importance of considering the specific challenges of environmental projects, such as longer time horizons and more complex impact assessments, in evaluating effectiveness.

Afonso *et al.* (2005), although not explicitly quantifying deadweight, measure public sector performance and efficiency across 23 industrialised countries, constructing composite indicators that include environmental factors. They suggest that public spending in many countries could be much smaller and more efficient, implying deadweight. In a similar technique to that of Czyzewski *et al.* (2020), Vlontzos *et al.* (2014) apply DEA to energy and environmental efficiency of primary sectors in EU member states, analysing efficiency over time, including before and after implementation of new CAP policy[7], and suggest that variations in efficiency scoring could be related to the duration of EU membership and associated policy implementations.

In a similar vein, and using a comparable methodology again, Meleddu and Pulina (2018) evaluate the efficiency of public resources allocation aimed at complying with European environmental directives. Focusing on two specific sectors, namely, air and water, and biodiversity, respectively, they analyse regional productivity changes over time. The findings imply potential inefficiencies in public spending, with significant differences in efficiency scores across regions, suggesting deadweight levels vary substantially geographically. Much like Vlontzos *et al.* (2014) Meleddu and Pulina (2018) observe that newer EU member states generally achieve lower efficiency scores and

[7] Vlontzos *et al.* (2014) focuses on a specific change in the Common Agricultural Policy (CAP), by analysing two distinct periods, namely, 2001 to 2006 and 2007 to 2008. The former period was characterized by a fully coupled subsidy scheme, where subsidies were linked to specific cultivations. The latter period marks the beginning of the implementation of a new decoupled scheme, under which farmers receive payments that are not tied to the production of specific crops or livestock. This change was part of broader CAP reforms aimed at reducing the distortion of agricultural markets and encourage more market-orientated farming.

suggest that countries which have been in the EU longer have had more time to implement policies oriented towards environmental protection and energy efficiency. The authors also note that the monitoring and fulfilment over time of environmental policy is effective in achieving the technological progress necessary to improve levels of efficiency. This variance in efficiency across geographic regions towards environmental policy is also observed by Wang (2018), who studied fiscal spending on environmental protection across several provinces in Central China between 2007 to 2015. Specifically, Wang (2018) concluded that GDP per capita for regions has a significant positive effect on the efficiency of public expenditure on the environment, whereas levels of urbanisation and industrialisation have significant negative effects on efficiency.

Rausch and Karplus (2014) assessed cost-effectiveness of different policy approaches in achieving emissions reductions using a computable general equilibrium model to compare efficiency of market-based and regulatory climate policies in the United States. Findings from the study highlight inefficiencies in regulatory approaches compared to market-based policies, implying greater deadweight. Rausch and Karplus (2014) highlight that this effect is due to the inflexibility in regulatory approaches, which lead to higher costs for given environmental outcomes.

Furthermore, Sanz-Días *et al.* (2017) assessed Spain's efficiency with regard environmental performance and compared the country's performance against other EU countries over time. Interestingly, the authors distinguish between "natural efficiency" (reducing inputs) and "marginal efficiency" (improving technology), indirectly addressing potential sources of deadweight. Their findings suggest that countries on the efficiency frontier have some level of inefficiency in their environmental policies and that economic crises affect efficiency scores, potentially indicating changing levels of policy deadweight during economic fluctuations.

Finally, on a more micro level, Mikulić *et al.* (2016) evaluated the economic impact of energy saving retrofits of residential and public buildings in Croatia. Using a cost-benefit analysis approach to assess the impact of such programmes, the authors found that energy efficient renovation investments were not financially viable from the owner's perspective without government subsidies, suggesting potential deadweight in unsubsidised spending.

As environmental concerns become increasingly central to policy-making, understanding the effectiveness of targeted environmental support programmes is crucial for ensuring the efficient allocation of resources in addressing pressing environmental challenges. This research aims to further add to the evidence base on deadweight in environmental aid initiatives.

2.3.3 Comparative studies between countries or regions

Comparative analyses provide valuable insights into how deadweight varies across different geographical and institutional contexts. Tokila and Haapanen (2009) offer a comprehensive comparison of deadweight across different regions in Finland, highlighting significant regional variations. The authors found that more economically disadvantaged regions tend to exhibit lower levels of deadweight, suggesting that enterprise support programmes may be more effective in regions with less developed private capital markets.

Furthermore, Di Cataldo (2017) provides a broader European perspective, comparing the effectiveness of EU Structural Funds across different regions. This study emphasises the importance of institutional quality in determining the extent of deadweight, with regions exhibiting stronger institutional quality generally showing lower levels of deadweight. Interestingly, while Di Cataldo (2017) found positive effects on unemployment and economic growth, the study indicates that this influence is not sustained once funding ends.

In addition, Becker *et al.* (2013), through evaluating the heterogeneous effects of EU Objective 1 regional transfers, found that only regions with sufficient human capital and institutional quality

effectively utilise regional transfers. This suggests that regional characteristics play a crucial role in determining the effectiveness of environmental aid and potential deadweight.

The concept of important regional characteristics is also noted by Bondonio and Greenbaum (2014), who, in their study of Italian regions, found notable differences between Northern and Southern Italy. The authors attributed these differences not only to varying levels of economic development, but also to differences in the institutional capacity to administer support programmes effectively.

The comparative studies discussed above collectively emphasise the need for context-specific programme design and evaluation, suggesting that a one-size-fits-all approach to enterprise support is likely to be ineffective, given the significant variations in deadweight across different geographical and institutional settings.

2.3.4 Methodologies to assess deadweight

The literature employs a diverse range of methodologies to assess deadweight, reflecting the complexity of the phenomenon and the challenges in its measurement. These methodologies have evolved over time, becoming increasingly sophisticated in their attempts to isolate the true impact of enterprise funding and environmental aid initiatives.

Counterfactual analysis[8] forms the backbone of many studies in this field. Bondonio and Greenbaum (2014) provide a rigorous application of this approach, comparing funded firms to similar non-funded firms in an attempt to isolate the impact of funding. The methodology adopted by Bondonio and Greenbaum (2014) involved a two-stage process: first, they used propensity score matching to create comparable groups of funded and non-funded firms; then, they applied a difference-in-differences analysis to estimate quantifiable deadweight over time. This approach helped to control for both observable and unobservable differences between firms, enhancing the reliability of deadweight estimates.

Propensity score matching, as mentioned already, has become increasingly prevalent in the literature. This technique aims to create valid comparison groups by matching funded and non-funded entities based on observable characteristics. Notably, Biagi *et al.* (2015) demonstrated the importance of careful matching to ensure that comparisons are made between truly similar firms, thereby reducing potential bias in deadweight estimates.

Surveys and interviews, while potentially subject to bias, remain a valuable tool in assessing deadweight. Lenihan (1999) and Hart and Lenihan (2006) showcase the value of direct engagement with funding recipients. The novel approach taken in Lenihan (1999) involved asking detailed questions about what would have happened in the absence of funding, allowing for a nuanced understanding of both pure and partial deadweight. While acknowledging the potential for response bias, both studies argued that the insights gained from direct engagement with beneficiaries are crucial for understanding the mechanisms through which deadweight occurs.

Econometric models, particularly those employing panel data techniques, have become increasingly sophisticated. Blomquist and Waldo (2022) utilised a fixed-effects panel data approach to estimate

[8] Counterfactual analysis in this context refers to the evaluation of what would have happened in the absence of public support. It involves comparing the observed outcomes *with* public support to the hypothetical outcomes that would have occurred *without* it. This approach is crucial for accurately estimating deadweight, as it helps isolate the true additionality of public support by considering what actions or investments recipients would have undertaken even without the support. Counterfactual scenarios are typically constructed using various econometric techniques, such as difference-in-differences, regression discontinuity designs, or propensity score matching, which aim to create a valid comparison groups or baseline. For a comprehensive review of counterfactual analysis methods in programme evaluation, the reader is referred to Imbens and Wooldridge (2009). For an application specific to deadweight in public support programmes, the reader is referred to Lenihan (2004).

the effect of investment support on firm investments. The methodology adopted allowed for the control of time-invariant firm characteristics, providing a more robust estimate of the additionality of support. Specifically, Blomquist and Waldo (2022) applied a fixed-effects panel data implementation of the difference-in-difference estimator to analyse the effect of European Fisheries Fund (EFF) support on investments in Swedish aquaculture and fish processing firms from 2007 to 2015. This approach removes biases that could arise from permanent differences between firms, such as management quality or location advantages. By comparing changes in investment activity over time, between treatment and non-treatment firms, the method effectively creates a counterfactual scenario, addressing the challenge of non-random assignment of support.

In addition, the Blomquist and Waldo (2022) model included time-specific effects to control for general trends affecting all firms, such as business cycle fluctuations. This methodology allowed them to isolate the impact of the EFF support from other confounding factors, leading to a more accurate estimation of deadweight. For instance, the authors found that in aquaculture, EFF support increased investments by a factor of 0.65, implying a deadweight loss of 35%, which would be difficult to ascertain without controlling for firm-specific and time-specific effects.

Each of the methodologies discussed have their own strengths and limitations. Counterfactual analyses and propensity score matching offer strong potential for causal inference but rely heavily on the quality of available data and the appropriateness of matching criteria. Survey-based methods provide rich, context-specific information but may suffer from response biases. Econometric models offer powerful tools for controlling various factors but can be sensitive to model specification and data quality.

The trend in the literature is towards multi-method approaches that combine these various techniques (Lenihan *et al.*, 2007; Dvouletý *et al.*, 2021). Such approaches aim to leverage the strengths of different methodologies while mitigating their individual weaknesses. For instance, combining econometric analysis with qualitative insights from surveys can provide a more comprehensive and nuanced understanding of the complexities of deadweight (Lenihan, 2004; Venetoklis, 2001). Venetoklis (2001) combined various methods to provide a multi-faceted analysis of business subsides and bureaucratic behaviour in Finland. The approach used several econometric analyses techniques including OLS (ordinary least squares), 2SLS (two-stage least squares), and logistic regressions to analyse relationships and examine factors that influence which firms receive subsidies repeatedly.

These techniques were complemented with descriptive statistical analysis, synthesis of findings from previous studies, and qualitative analyses drawing on institutional knowledge of the subsidy allocation process. The authors then interpreted results through a theoretical lens, applying Nishanen's theory of budget-maximising bureaucrats, and considered alternative theoretical explanations, such as constraints theory. The Venetoklis (2001) study highlighted the potential value in conducting complementary analyses, particularly with regards combining both quantitative and qualitative techniques. Such thorough methodological explorations, however, are often not within the scope of most studies.

2.3.5 Factors Influencing the Extent of Deadweight

The literature identifies several key factors that influence the extent of deadweight in enterprise funding and environmental aid initiatives. Understanding these factors is crucial for designing more effective support programmes and targeting interventions where they are likely to have the greatest additionality. It also allows more relevant and appropriate evaluation of support-dispensing processes.

Firm size emerged as a significant factor across multiple studies. Blomquist and Waldo (2022) found that larger firms tend to exhibit higher levels of deadweight. The authors attributed this to larger

firms' having greater access to alternative sources and the ability to undertake projects without public support. This finding was supported by research undertaken by Bondonio and Greenbaum (2014), who observed that smaller firms, particularly in less developed regions, showed lower levels of deadweight. These results suggest that targeting support towards smaller firms may be a strategy for reducing overall deadweight.

Cin *et al.* (2017) provided further evidence supporting this conclusion in their study of R&D subsidies in South Korea. The authors found that R&D subsidies have a more significant positive effect on the R&D investment of small and medium-sized enterprises compared to large firms. Specifically, Cin *et al.* (2017) observed that a 1% increase in R&D subsidies led to a 0.062% increase in private R&D investment for SMEs, while the effect was statistically insignificant for large firms. This differential impact suggests that subsidies to SMEs are less likely to crowd out private investment, potentially indicating lower deadweight. Moreover, Srhoj *et al.* (2019) matched grant receiving firms with grant non-receivers and estimated the average treatment effect using a two-way fixed effects regression, with the noted positive effect of the grant schemes particularly evident for firms of smaller size.

It should be noted, that although most studies found that larger firms tend to exhibit higher levels of deadweight, some studies have found more nuanced relationships between firm size and the extent of deadweight. Huergo *et al.* (2016) observed a U-shaped relationship between firm size and deadweight, with medium-sized firms showing the lowest levels of deadweight. This suggests that the relationship between firm size and deadweight may be more complex than initially thought, potentially jointly influenced by the presence of additional factors.

Sectoral differences also play a crucial role in determining the extent of deadweight, as already alluded to. Bondonio and Greenbaum (2014) observed significant variations across different industries, reflecting differences in capital intensity, market structures, and innovation dynamics. For instance, it was found that lower deadweight occurred in knowledge-intensive sectors, suggesting that support for innovation-driven industries may yield higher additionality. This finding was further supported by Castellacci and Lie (2015) in their meta-regression analysis of R&D policy evaluation studies.

The Castellacci and Lie (2015) study found that the additionality effect of R&D support schemes is significantly higher in high-tech sectors compared to low-tech industries. Specifically, the results of the study found that studies focusing on high-tech sectors, report, on average, an additionality effect that is higher than studies covering all sectors. This sectoral heterogeneity in policy effectiveness highlights the importance of tailored support programmes to specific industry characteristics and innovation dynamics. The heterogeneity would seem to be explained by the higher risk and uncertainty associated with R&D activities in specific sectors, making public support more crucial. In particular, the Castellacci and Lie (2015) study found that the additionality effect is, on average, stronger for SMEs, firms in the service sectors, and firms in low-tech sectors in countries applying an incremental tax credit scheme.

Geographic location is another critical factor, again, as has already been discussed. Di Cataldo (2017) and Becker *et al.* (2013) highlighted significant regional variations in the effectiveness of EU Structural Funds, with less developed regions often showing lower levels of deadweight. This may be due to these regions having less developed private capital markets, making public support more crucial for project implementation. Bondonio and Greenbaum (2014) also identified stark regional variations.

The size and type of grant also influence deadweight. Bondonio and Greenbaum (2014) found that larger grants are sometimes associated with higher deadweight, though this relationship is not always clear. The authors found evidence of several reasons why this relationship is complex. In particular, they firstly found diminishing returns to larger subsidy amounts, suggesting that as grant sizes increase, the marginal employment impact per euro of subsidy decreases. They suggested this

could be due to firms using larger grants to fund projects or investments they may have undertaken anyway without subsidies.

In addition, Bondonio and Greenbaum (2014) found that effects can vary significantly across different types of firms, depending on firm size, age, sector, and pre-existing growth trends, all of which interact with grant size to influence employment trends. The authors stated that soft loans have similar employment impacts to capital grants, but at a much lower public cost, suggesting lower deadweight. The mixed use of different policy instruments across grant size categories complicates the overall relationship between grant size and deadweight. The authors also noted that the relationship between grant size and deadweight may be non-linear, and additionally identified limitations in their ability to precisely estimate deadweight due to difficulties in constructing appropriate counterfactuals for firms receiving large, unique grants. This was particularly true for soft loans, where default rates were unknown. However, in spite of the complex nature of their findings, Bondonio and Greenbaum (2014) ultimately provided clear policy suggestions, including that smaller, targeted interventions may be more effective in generating additional economic activity.

Economic context also plays a vital role, as highlighted by Anyadike-Danes *et al.* (2011). The authors observed in their study that the effectiveness of support programmes can vary significantly depending on the broader economic conditions. During economic booms, deadweight may be higher as firms have greater access to alternative funding sources and may be more likely to undertake projects regardless of public support. Similarly, Hud and Hussinger (2015) found particular variation associated with the 2009 economic crisis. In their study of the impact of R&D subsidies on subsequent R&D investment by SMEs in Germany during the 2008-2009 global financial crisis, the authors found an overall positive effect of subsidies for the full period, but with significant crowding-out effects in 2009 (the crisis year), followed by a return to positive, but smaller effects in 2010 (that they denote, 'the recovery year'). They found no evidence that lower effects were due to changes in the subsidy programme or characteristics of recipients[9].

2.3.6 Evidence on Approaches and Challenges of Minimizing Deadwieght

Potential approaches to minimizing deadweight are discussed in the literature. While these strategies aim to enhance the additionality of public support programmes and improve their overall effectiveness, the literature also notes that they can be challenging to implement due to their impact on the administrative overhead they impose, the creation of misaligned incentives and challenges of implementing them so that decisions can be made in a timely manner. Effective programme design necessarily requires that tradeoffs be made.

2.3.7 Targeted approach

Blomquist and Waldo (2022), amongst other sources (e.g., Criscuolo *et al*. (2019); Bondonio and Greenbaum (2014); Castellacci and Lie (2015)), advocated for focusing funding on smaller firms or specific sectors with historically lower observed deadweight. In particular, Blomquist and Waldo (2022) found that large fish processing firms (over 20 employees) showed no statistically significant effect on R&D investment after receiving a subsidy. By contrast, small fish processing firms (less than 20 employees) showed an increase in R&D investment by a factor of 0.64, implying a deadweight loss of only 36%. The authors note a similar figure of 35% for the aquaculture sector, which notably consisted of mainly small firms. The authors suggested this difference arises because small firms are more likely to face credit constraints that limit their R&D activities in the absence of subsidies,

[9] It should be noted that the paper specifically refers to the global financial crisis of 2008-2009, and notes that Germany was severely affected, with GDP declining by 4% in 2009 and private sector R&D spending decreasing by 2.9%.

whereas larger firms have better access to capital markets and are therefore more likely to fund profitable R&D projects even without subsidies.

As such, a targeted approach suggests that more precise selection of specific types of firms and/or sectors can enhance programme effectiveness. This enhanced effectiveness arises from the ability of smaller firms to overcome potential credit constraints (Blomquist and Waldo, 2022), and allows for bias towards firms that are lagging behind the technological frontier, as opposed to pushing the frontier further out (Castellacci and Lie, 2015). This also avoids inefficiencies associated with diminishing returns to larger subsidies (Bondonio and Greenbaum (2014), and allows for navigation away from larger firms that are better able to "game" the system and obtain subsidies without actually changing their investment and employment behaviour (Criscuolo *et al.*, 2019).

While the literature suggests targeting support towards smaller firms or specific sectors to reduce overall deadweight and enhance additionality, it also suggests caution, as such an approach could potentially lead to exclusion of high-potential projects from larger firms or from more traditional sectors. Accurate identification of firms or sectors with the highest potential for additionality can be complex and data-intensive, due to the extent to which firms and sectors vary across a range of characteristics, necessitating detailed firm-level and sector-level data to make accurate assessments (Castellacci and Lie, 2015). Moreover, the dynamic nature of innovation necessitates the continuous data collection and analysis for firms and sectors that are always changing (Bronzini and Iachini, 2014), and the continuous need to identify sectors with the greatest potential for positive spillover effects to other firms or sectors. Measuring such positive externalities is data-intensive and methodologically challenging (Bloom *et al.*, 2013).

On top of such concerns, Criscuolo *et al.* (2019) caution against creating disincentives for firm growth. While the authors acknowledge that targeting subsidies towards smaller firms due to their significant treatment impact can be effective, they suggest instead a more nuanced approach to subsidy design that considers firm size dynamics. In particular, Criscuolo *et al.* (2019) suggest tailoring subsidies to target smaller firms, to ensure that they are more likely to result in actual job creation and economic activity, rather than being absorbed by larger firms without corresponding benefits, but to ensure that larger firms are not perceived to be excluded, thus not generating subsequent mal-incentives that undermine the efficiency gains of targeting smaller firms.

2.3.8 Improved selection processes

Several studies emphasise the importance of rigorous selection criteria in grant allocation (e.g., Takalo *et al.*, (2013), Doucouliagos and Paldam (2005) and Cantner and Kösters (2012)). The suggestion across the literature is that more sophisticated screening processes, which take into account financial constraints and growth potential of firms, for example, could help identify recipients where public support is likely to have the greatest additionality. In essence, this approach is similar to that of targeting, discussed previously in section 2.3.7.

The literature also acknowledges that more rigorous selection criteria may increase administrative burdens and costs for both agencies and applicants. In particular, Cantner and Kösters (2012) discuss the trade-offs between enhanced selection rigor and a largely expanded administrative burden. As such, overly complex selection processes might deter some eligible firms, particularly smaller ones with limited resources, from applying for support.

2.3.9 Alternative forms of support

Bondonio and Greenbaum (2014) and Busom *et al.* (2017) propose the use of alternative financial instruments, such as soft loans or guarantees, and tax credits and subsidies, instead of outright grants. Bondonio and Greenbaum (2014) suggest such instruments may encourage more prudent project selection by recipients and potentially reduce deadweight. They note, however, that different financial instruments may attract different types of firms, potentially leading to selection

bias. Bondonio and Greenbaum (2014) further suggest that some alternative forms of support will be less effective for certain project contexts, particularly those that are of higher risk or which run over longer-term schedules. Moreover, Busom *et al*. (2017) note that highly productive firms within a given industry are more likely to obtain subsidies, whereas the use of tax credits appears unrelated to a firm's productivity. As such, the authors suggest that policy-makers should take heed that these instruments are not substitutes, which should be taken into account in the design of subsidies and incentive programmes.

2.3.10 Rigorous evaluation systems

Lenihan (2011), advocates for the implementation of comprehensive monitoring and evaluation frameworks. Regular, rigorous evaluations can help identify programme features that are associated with lower deadweight and inform continuous programme improvement. Lenihan *et al.*, (2007) caution that the challenge in implementing such comprehensive, long-term evaluation frameworks can be the level of resource-intensity and technical complexity required. As such, the limitation of these more comprehensive systems is that rigorous evaluations will not be available in time to inform short-term policy decisions. Indeed, if evaluation methodologies are too sophisticated and complex, appropriate data may ultimately not exist to allow for their full, timely and beneficial implementation (Lenihan *et al.*, 2007; Barkenov *et al.*, 1990).

2.3.11 Strategic alignment with broader economic strategies

The importance of aligning support programmes with broader economic development strategies is also well acknowledged in the literature (Anyadike-Danes *et al.*, 2011; Mazzucato, 2018; Kattel and Mazzucato, 2018). This alignment can help ensure that public support complements rather than substitutes private investment, potentially reducing deadweight. For example, Kattel and Mazzucato (2018) suggest that strategic public investments can help steer innovation in desired directions.

The literature caveats this goal with potential issues in coordination across different policy domains and levels of government. Overly rigid alignment with strategic goals could reduce flexibility to respond to emerging opportunities, challenges or trends. For example, Kattel and Mazzucato (2018) indicate that this involved a wide range of public institutions, which requires well-defined responsibilities for coordination and monitoring. Moreover, Mazzucato (2018) suggests that the changes required to coordinate a broad range of goals "are not trivial" and requires trust. Indeed, this requires "joined up policy making, whereby the priorities are translated into concrete policy instruments and actions to be carried out by all levels of the public institutions involved" Mazzucato (2018: 807).

These concept of embedding public support within broader economic strategies highlights the importance of evidence-based policy design and ongoing programme evaluation to maximise the additionality of public funding initiatives. However, it is important to note that effectiveness will vary across different contexts, highlighting the need for tailored approaches based on local economic conditions and institutional settings. For instance, Anyadike-Danes *et al*. (2011) discuss the importance of considering regional differences in policy formation, Mazzucato (2018) emphasises the importance of context-specific policy design, based on a particular society's need, and drawing on its own science and technology system, and Kattel and Mazzucato (2018) discuss the concept of "dynamic capabilities" in the public sector, which synthesises "cultures" of capabilities and capacities.

2.3.12 Mix of policy instruments

Huergo and Moreno (2017) compared the effects of different types of direct public support, namely, CDTI loans, national subsidies, and European subsidies. They found that that while all three types of support increase the probability of firms conducting R&D activities, with regards R&D intensity, i.e., the amount of R&D investment, European subsidies have the largest effect, followed by national

subsidies, with CDTI loans having the smallest effect. In addition, the authors found complementarity between subsidies and loans for SMEs, but possible crowding-out effects for large firms. These results imply that a policy mix of different direct support instruments could be beneficial, optimising additionality and minimising deadweight.

The importance of understanding how different policy instruments work together is further emphasised in recent work by Lenihan *et al.* (2025), who specifically examined how the sequencing of different R&D policy instruments over time impacts firm-level R&D. The analysis of Irish firms in the Lenihan *et al.* (2025) study revealed that receiving R&D grants and R&D tax credits as part of a sequence over time results in significantly higher R&D input additionality compared to receiving single instruments alone. Notably, it was found that sequencing support through an R&D grant first, followed by an R&D tax credit, proves most effective at driving firm-level R&D, highlighting how the specific ordering of policy instruments can significantly influence their impact.

Furthermore, Mouqué (2012) recommends focusing on small and medium-sized enterprises (SMEs) and including non-financial support. The Mouqué (2012) study found that financial support to SMEs effectively increases investment and employment, with a return of €1.30 for every euro invested. Mouqué (2012) suggests that including non-financial elements in addition, for example, business advice, could further enhance cost-effectiveness and reduce deadweight. In particular, the authors found that innovation support, networking, and innovation consortia proved effective at increasing long-term growth and productivity for medium-sized enterprises, and, what's more, that basic business advice for small and micro enterprises was potentially the single most cost-effective form of support.

The Mouqué (2012) study cites an example where just 4-12 hours of professional business advice improved long-term survival rates of startups at a very low cost per job created. In addition, the authors note that synergies between financial and non-financial support means that their combination results in an impact greater than the sum of individual effects, and that while financial support alone often increased production without improving productivity, non-financial support showed more promise for helping firms become more efficient. As such, addressing specific needs and constraints beyond just capital, non-financial support may help ensure public funds are used to generate additional activity rather than simply substituting for private investment, and ultimately, reduce deadweight.

2.3.13 Challenges and limitations in deadweight research

While the literature on deadweight in enterprise funding and environmental aid initiatives has made significant strides, several challenges and limitations persist, warranting careful consideration in both research and policy applications.

2.3.14 Data Limitations

A recurring theme across studies is the limited availability and quality of data. While Lenihan (2004) highlighted these challenges, more recent research suggests that data limitations continue to be a significant issue. Dvouletý and Blažková (2021), for instance, noted that despite technological advancements, obtaining comprehensive, high-quality data for long-term impact analysis remains a challenge, particularly for SMEs.

2.3.15 Counterfactual Construction

As emphasised by Bondonio and Greenbaum (2014), constructing appropriate counterfactuals remains a significant challenge. This is particularly crucial in deadweight estimation, as, without a robust counterfactual, it obviously becomes difficult to isolate the true impact of an intervention from what would have occurred naturally. This issue is compounded by the potential for selection bias, where firms or projects that receive support may inherently differ from those that do not.

Advanced techniques such a propensity score matching, and difference-in-differences have been employed to address this, but, as Bia and Mattei (2012) found, each method comes with its own set of assumptions and limitations, necessitating careful consideration in their application and in subsequent interpretation of the results generated.

2.3.16 Self-reporting Bias

Studies relying on self-reported data, such as those by Lenihan (1999), face potential biases in respondent reporting. Beneficiaries may have incentives to overstate or understate the impact of support, depending on their perceptions of how their responses might influence future funding decisions.

2.3.17 Heterogeneity in Programme Design

The wide variety of enterprise support and environmental aid programmes makes direct comparison challenging. Tokila and Haapanen (2009) noted that differences in programme design, eligibility criteria, and implementation can significantly affect deadweight, complicating cross-programme and cross-country comparisons.

2.3.18 Dynamic Effects

The focus on short to medium-term impacts in many studies potentially overlooks crucial longer-term dynamic effects. Anyadike-Danes *et al.* (2011) conducted an analysis of new business formation in Ireland during the period of rapid economic growth initiated in the mid-1990s. Their study revealed that while Ireland experienced significant economic expansion, the patterns of new business formation did not show a dramatic change. The authors found that the growth rate in new business venture creation in Ireland in the late 1980s and early 1990s, i.e., prior the rapid economic growth of the 'Celtic Tiger', was broadly similar to those observed during the most rapid growth phases, 1994-2000 and the period 2001-2004. This finding challenges the assumption that periods of rapid economic growth are necessarily associated with increased rates of new business formation.

The authors suggested that the extraordinary growth of the Irish economy since the mid-1990s may have been driven by factors other than a surge in entrepreneurial activity, with its associated enterprise subsidies, and government support, such as foreign direct investment, EU structural funds, and other policy measures. This observation introduces the possibility that the relationship between new business formation and economic growth is more complex than often assumed, and that rapid economic growth can occur without a corresponding spike in business birth rates.

More specifically, in the context of deadweight evaluations, the findings of Anyadike-Danes *et al.* (2011) highlight an important aspect of dynamic effects. Their observation that new business formation rates in Ireland remained relatively stable before, during, and after the period of rapid economic growth, suggest that the impact of economic policies and support programmes may not manifest in immediately observable changes in entrepreneurial activity. This time lag between policy implementation and observable outcomes complicates the evaluation of deadweight. Traditional evaluations that focus on short-term impacts might miss any delayed effects, potentially overestimating deadweight by failing to capture long-term changes in the business landscape.

The Irish case demonstrates that the full effects of support programmes on business dynamics may only become apparent over an extended period and may be influenced by a complex interplay of factors beyond the direct scope of the programme. This highlights the need for longitudinal studies and more sophisticated evaluation methodologies that can account for these dynamic, long-term effects when assessing the true impact and efficiency of public support programmes. Examples of potential solutions are discussed in the next section.

2.3.19 Spillover Effects

The literature often struggles to account for spillover effects, both positive and negative, which can significantly impact the overall assessment of programme effectiveness. Positive spillovers might lead to underestimation of programme benefits, while negative spillovers might lead to overestimation. As highlighted in the UK government's Additionality Guide (2014), spillover effects can manifest in various forms, including market displacement, supply chain impacts, and knowledge transfers. Positive spillovers, such as knowledge diffusion to non-treatment firms, might lead to underestimation of programme benefits. Conversely, negative spillovers, like market displacement where treatment firms gain at the expense of control firms, could lead to overestimation of net programme impact.

A comprehensive study by the UK Department for Business, Innovation and Skills (Medhurst *et al.*, 2014) on spillovers from technological innovation support programmes found that while such spillovers are widely acknowledged, quantifying them remains challenging. The study identified that spillovers could occur through various channels, including labour mobility, formal and informal networks, and demonstration effects. However, the magnitude and direction of these spillovers can vary significantly across different contexts and sectors.

Moreover, as discussed in a European Commission discussion paper (Pfeiffer *et al.*, 2021), accounting for spillover effects is crucial in assessing the full impact of public investments, particularly in the context of cross-border and inter-regional effects. The paper proposed the use of advanced modelling techniques, such as spatial computable general equilibrium models, to capture these complex dynamics. However, implementing such sophisticated methods requires extensive data and modelling expertise, which may not always be feasible in standard programme evaluations.

2.4 EMERGING TRENDS AND FUTURE RESEARCH DIRECTIONS

The field of deadweight research in enterprise funding and environmental aid is evolving, with several emerging trends and promising avenues for future research.

2.4.1 Machine learning and big data

The application of machine learning and big data analytics in deadweight research represents a potentially significant advancement in the field. Athey (2017) discusses the potential of machine learning methods in econometrics and policy evaluation, highlighting its ability to handle high-dimensional data and complex relationships. In the context of deadweight estimation, such techniques could have clear uses and be particularly valuable for improving the accuracy of counterfactual predictions. Varian (2014), for instance, suggests that machine learning algorithms could be used to identify complex patterns in firm behaviour, which could ultimately indicate the presence or absence of deadweight. This could involve analysing large datasets of firm characteristics, market conditions, and policy interventions to predict which firms are most likely to engage in activities that would have undertaken even without support.

Moreover, as noted by Einav and Levin (2014), big data approaches could allow researchers to incorporate a wider range of variables into their models, potentially capturing previously unobserved factors that influence the effectiveness of support programmes. This could lead to more nuanced understanding of the conditions under which deadweight is more or less likely to occur.

2.4.2 Natural experiments

Increasing use of natural experiments and quasi-experimental designs in deadweight research aligns with broader trends in empirical economics towards more credible identification strategies. As discussed by Angrist and Pischke (2010), these approaches can help overcome endogeneity issues that often plague policy evaluation studies.

In the context of enterprise funding and environmental aid, natural experiments might arise from policy changes, regional variations in programme implementation, or sudden shocks to the economic environment. For example, Criscuolo *et al.* (2019) exploit changes in EU regional aid eligibility rules as a natural experiment to estimate the impact of investment subsidies on firm performance and employment. Similar approaches could be applied to assess deadweight in various other governmental support programmes.

Quasi-experimental methods like regression discontinuity modelling have also shown to be both useful and insightful. Bronzini and Iachini (2014) use a regression discontinuity approach to evaluate the effectiveness of R&D subsidies in Italy, an approach that could be extended to assess deadweight more directly. These methods can provide convincing causal evidence on the true additionality of support programmes, helping to distinguish their effects from underlying trends or selection bias.

2.4.3 Integration of qualitative insights

The integration of qualitative insights into deadweight research represents a move towards a more holistic understanding of policy effectiveness. As argued by Creswell and Plano Clark (2017), mixed methods research can provide a more comprehensive view of complex phenomena than either quantitative or qualitative approaches alone.

In the context of deadweight, qualitative studies can shed light on the decision-making processes of firms and policymakers, helping to explain the patterns observed in quantitative data. As discussed previously, Lenihan (2004) used a combination of econometric analysis and case studies to examine deadweight and displacement in enterprise support programmes in Ireland. This approach allowed for a deeper understanding of why certain firms experienced deadweight while others did not. Indeed, more in-depth qualitative techniques, such as face-to-face interviews, allows for increased accuracy and enhanced understanding of decision-making processes.

Moreover, qualitative research can help identify important variables or mechanisms that might be overlooked in purely quantitative studies. As noted by Yin (2017), case study research can be particularly valuable for exploring the "how" and "why" questions that often elude statistical analysis. In deadweight research, this could involve investigating how firms make decisions about whether to undertake projects with or without public support, or why certain policy designs are more effective at minimising deadweight than others.

2.4.4 Focus on environmental aid

The focus on environmental aid in deadweight research is particularly timely given the growing urgency of climate change and other environmental challenges. As noted by Stern (2015), effective environmental policies are crucial for addressing these issues, and understanding the efficiency and efficacy of environmental aid is a key part of this.

Research in this area could build on existing studies of environmental policy effectiveness, such as the work of Bennear and Stavins (2007) on the design of climate policy instruments. In particular, there is a need for more specific focus on deadweight in environmental aid programmes. This could involve examining the additionality of grants for renewable energy projects, subsidies for energy-efficient technologies, or support for sustainable agricultural practices.

One challenge in this area, as highlighted by Keohane (2009), is the difficulty of establishing appropriate counterfactuals for environmental outcomes. Future research could explore innovative methods for addressing this challenge, perhaps drawing on advances in environmental modelling and scenario analysis.

2.4.5 Long-term impact studies

Long-term impact studies are crucial for understanding the full effects of enterprise funding and environmental aid programmes, including the dynamics of deadweight over time. As highlighted by Lerner (2002) in his study of government support for entrepreneurial activity, the impacts of such programmes often take years to fully materialise.

In the context of deadweight, longitudinal studies could help address the question of whether initial deadweight might be offset by longer-term benefits. For instance, Zhao and Ziedonis (2020) conducted a long-term study of R&D tax credits, finding that while there was some initial deadweight, the policy led to increased innovation over time. Similar approaches could be applied to other types of support programmes.

Moreover, long-term studies could help identify potential "hidden" additionality that might be missed in short-term evaluations. As suggested by Feldman and Kelley (2006) in their study of public R&D funding, government support can have catalytic effects that only become apparent over longer time horizons. Future research could explore whether similar dynamics exist in relation to deadweight in various types of aid programmes.

2.4.6 Policy design optimisation

Policy design optimisation represents a crucial frontier in deadweight research, with the potential to directly inform more effective policymaking. This approach aligns with the growing emphasis on evidence-based policy design, as advocated by authors such as Cartwright and Hardie (2012).

Future research in this area could draw on the methodologies of policy evaluation and experimental economics. For instance, List (2011) discusses the potential of field experiments for testing economic theories and policies. In the context of deadweight, this could involve randomised controlled trials of different policy designs, such as varying the level of support, the targeting criteria, or the conditions attached to funding.

2.4.7 Cross-country comparative analyses

Cross-country comparative analyses offer valuable opportunities to understand how different contexts influence the effectiveness of support programmes and the prevalence of deadweight. This approach aligns with the growing recognition of the importance of context in policy effectiveness, as discussed by Rodrik (2008) in his work on industrial policy. However, there is scope for more cross-country analyses within the context of programme support evaluation, specifically in the context of deadweight and additionality.

Future research in this area could build on existing comparative studies, such as the work of Czarnitzki and Lopes-Bento (2013) comparing R&D policy effectiveness across different European countries. However, there is a need for more comprehensive analyses that systematically account for a wide range of institutional, economic, and cultural factors.

Such research could draw on methodologies from comparative political economy, as outlined by Hall and Soskice (2001) in their varieties of capitalism approach. This could involve developing typologies of support programme designs and examining how their effectiveness varies across different types of economic systems.

The ultimate benefit of cross-country studies would be that they potentially help identify best practices in minimising deadweight. As suggested by Edler *et al.* (2016) in their review of innovation policy, comparative analyses can provide valuable insights into what works, in what contexts, and why. Future research could extend this approach to specifically include the issue of deadweight in enterprise funding and environmental aid.

2.5 IMPLICATIONS FOR POLICY AND PRACTICE

The REA of deadweight in enterprise funding and environmental aid initiatives has highlighted several implications for policy design and implementation. These include:

- **Continuous evaluation**: Given the complex and dynamic nature of deadweight, continuous evaluation and adjustment of support programmes are crucial. This requires building robust monitoring and evaluation frameworks into programme design from the outset. This project represents a significant effort by the DETE to revisit deadweight within the Economic Appraisal Model (EAM), building on previous analysis, and ensuring that protocols and lessons are in place going forward.
- **Balanced approach to risk**: While minimising deadweight is important, policymakers must balance this against the risk of excluding potentially valuable projects. Overly stringent criteria aimed at reducing deadweight might inadvertently exclude high-potential initiatives that genuinely need support.
- **Transparency and accountability**: Clear communication of programme objectives, selection criteria, and evaluation results can help build trust and potentially reduce strategic behaviour by applicants that might otherwise contribute to deadweight.
- **Capacity building**: Enhancing the capacity of both implementing agencies and potential beneficiaries to design, implement, and participate in support programmes effectively could contribute to reducing deadweight.
- **Complementary policy measures**: Enterprise support and environmental aid programmes should be viewed as part of a broader policy mix. Complementary measures, such as improving the overall business environment or addressing market failures, may enhance the effectiveness of direct support programmes.

This final point raises a significant reality regarding efforts to mitigate deadweight and seek improved allocation of resources. The implementation of measures to mitigate deadweight often involve a complex trade-off with broader policy mandates, presenting a significant challenge for policy-makers. For instance, while targeting smaller firms, which may reduce deadweight (Lenihan *et al.*, 2007; Bondonio and Greenbaum, 2014), as identified in **Section 2.5**, it potentially conflicts with policy objectives aimed at job creation, as larger firms typically generate more employment (Neumark *et al.*, 2011). Similarly, focusing on innovative sectors to minimise deadweight (Czarnitzki and Lopes-Bento, 2013) might clash with goals to support traditional industries.

The tension between regional development objectives and deadweight minimisation is also evident; less developed regions often show lower deadweight (Di Cataldo, 2017), but concentrating support in these areas may contradict aims for balanced national growth. Moreover, stringent selection criteria to reduce deadweight could inadvertently exclude high-potential projects that genuinely need support, potentially stifling innovation and growth (Georghiou, 2002a, 2002b). Policymakers must therefore navigate a delicate balance, weighing the benefits of deadweight reduction against other crucial policy objectives. This necessitates a nuanced, context-specific approach to policy design, where deadweight considerations are integrated into a broader framework of economic and social goals, rather than treatment as an isolated objective.

2.6 LITERATURE REVIEW CONCLUSIONS

The review of literature on deadweight in enterprise funding and environmental aid initiatives revealed a complex landscape with significant implications for policy design and evaluation. While substantial progress has been made in understanding and measuring deadweight, challenges remain in accurately quantifying its extent and identifying the most effective strategies for its mitigation.

The persistent finding of significant deadweight across various contexts highlight the importance of careful programme design and ongoing evaluation. However, the variation in findings also highlights the context-dependent nature of deadweight and the need for nuanced, tailored approaches to enterprise support and environmental aid.

As the field continues to evolve, integrating advanced analytical techniques, embracing mixed-methods approaches, and focusing on long-term impacts and broader economic effects will be crucial. Additionally, the growing importance of environmental concerns necessitates increased attention to deadweight in environmental aid initiatives.

Ultimately, the goal is not just to minimise deadweight, but to optimise the overall impact of public support programmes. This requires a holistic approach that considers deadweight alongside other factors such as spillover effects and long-term economic impacts.

This REA has aimed to make several important contributions to the understanding of deadweight in enterprise and environmental funding. First, it synthesises evidence from both traditional enterprise support evaluation and the emerging field of environmental aid assessment, providing a systematic comparisons of deadweight across these two domains. This cross-domain analysis revealed important differences in how deadweight manifests in environmental versus traditional enterprise support, with implications for policy design and evaluation.

Second, the REA developed a nuanced understanding of deadweight by examining various conceptualisations, from pure deadweight to partial deadweight, and from static to dynamic effects. By bringing together insights from multiple theoretical frameworks and empirical studies, it helps clarify how different types of deadweight can be identified, measured, and potentially mitigated.

The REA also makes a methodological contribution by systematically evaluating evidence quality through the SPOQ framework, providing a rigorous assessment of the current evidence base. This approach not only synthesises existing knowledge but also identifies important gaps in current methodologies and measurement approaches.

Finally, the review's examination of factors influencing deadweight and strategies for its mitigation provides practical insights for policymakers. By identifying what works, under what circumstances, and why, it offers evidence-based guidance for the design and implementation of more effective support programs. This is particularly timely given the increasing focus on both enterprise support and environmental aid in both Ireland and internationally.

These contributions collectively highlighted a need for further systematic evidence synthesis in this field, to provide both theoretical clarity and practical guidance for policy development and implementation.

3 GENERAL GRANT AID

3.1 OBJECTIVES AND FRAMING

The original objective for general (enterprise) grant aid was to produce robust deadweight estimates for use in the Economic Appraisal Model (EAM). General (enterprise) grant aid provided across the agencies serves a broad range of functions. While each agency offers distinct supports, their grants can be broadly grouped under common thematic areas. Within the general enterprise grants, businesses are supported in R&D, business development initiatives, scaling, and growth supports, and the creation and development of employment.

In practice, consistent with the constraints set out in Chapter 1, decision-grade parameters could not be produced under current conditions. This chapter therefore documents the approach taken, sets out lessons learned and proposes recommendations to build a roadmap to support future reviews. The emphasis is on the methodological learnings and proportionate interpretation, in line with established appraisal guidance that requires credible counterfactuals and transparent uncertainty reporting.

3.2 DATA SOURCES, INTEGRATION AND COVERAGE

3.2.1 The ABSEI database

DETE conducts the Annual Business Survey of Economic Impact (ABSEI) each year to monitor employment trends and economic contributions of agency-assisted firms. The ABSEI, conducted from April to August, surveys around 4,600 firms to collect detailed information on expenditure, sales, and other economic indicators. These responses form the ABSEI database, a comprehensive dataset used to generate performance metrics, support policy analysis, and inform agencies' engagement with client companies.

Survey planning and execution are overseen by an inter-agency steering group comprising DETE, enterprise agencies, and a research contractor. Data is collected via secure online systems, validated line-by-line, and statistically weighted before being compiled into summary tables and integrated into the ABSEI database. Quality assurance follows the Irish Statistical System Code of Practice and the General Statistical Business Process Model, with oversight by a designated IGSS statistician. Final reports and datasets are published openly on DETE's website, ensuring transparency and accessibility while maintaining strict confidentiality standards. The ABSEI database has been used to help inform deadweight estimates in this study.

3.2.2 Performance Metrics

The analysis used firm-level panel data from the ABSEI spanning 2010-2022, integrated with detailed grant aid timelines. Each firm was identified through a unique identifier, allowing tracking across multiple years and matching of support instances with performance outcomes. The ABSEI data was used to identify potential key performance metrics to enable assessment of firm behaviour and outcomes. These included:

- **Value added per employee**. Calculated as total value added divided by full-time equivalent employment, providing a measure of labour productivity.
- **R&D intensity**. Measured as R&D expenditure relative to total sales, which indicates innovation effort.
- **Export intensity**. Calculated as export value divided by total sales, reflecting international market engagement.
- **Overall productivity**. Calculated as the total value of goods and services per full-time equivalent employment.

- **Export market diversity**. Derived using a Herfindahl-Hirschman Index (HHI) approach across five geographic markets (UK, North America, Rest of Europe, Asia, and Rest of World, respectively), measuring export market concentration. Export market diversity was calculated as: $1 - \sum(market\_share^2)$.

While these performance metrics were initially considered to support inference on additionality, they were not used in the final deadweight estimation results because they did not meet minimum robustness requirements for causal interpretation under the available data conditions. Several candidate variables exhibited substantial data gaps and inconsistent reporting patterns once firms were segmented by grant category, region, and baseline year. In counterfactual analysis, credible estimation depends on adequate overlap in observed characteristics between treatment and comparable unsupported firms, and on sufficient sample size to support balance and reduce sensitivity to individual observations. Where these conditions are weak, estimates can become unstable and can reflect selection effects or data artefacts rather than intervention impact.

To identify the most appropriate metric for each grant type, consultations were undertaken with the enterprise agencies to assess which performance metric best aligned with the intended function of each grant. Given the significant overlap in grant objectives, a common set of performance metrics was aligned to each support type. For the purposes of this review, reactionary measures were excluded from the grants considered, as they were designed to respond to external environmental shocks. Through engagement with the agencies and the consideration of the metrics that could be feasibly attributed, it was determined that each performance metric aligns with a specific support type, as outlined below.

In addition, many firm outcomes fluctuate materially over time due to market conditions, firm life cycle dynamics, and external shocks. When outcome volatility is large relative to plausible grant effects, and when impact windows differ by intervention type, metric-based inference risks conflating noise with policy signal. Under these circumstances, evaluation guidance recommends selecting outcomes that are conceptually close to the intervention logic, measurable within a credible impact window, and reported alongside transparent uncertainty statements where sample sizes are limited.

For these reasons, the quantitative enterprise analysis prioritised approaches that explicitly construct a counterfactual comparison between treatment and control firms on the basis of observable baseline characteristics, consistent with the core logic of propensity score methods (Rosenbaum and Rubin, 1983; Imbens and Rubin, 2015; European Commission, 2021).

3.3 ANALYTICAL APPROACH ATTEMPTED

3.3.1 Exploratory Ratio-to-Variation Framework (Not Taken Forward)

An exploratory framework tested whether post-grant changes in outcomes exceeded each firm's typical pre-grant volatility (coefficients of variation) using the following sequential steps:

1. **Data preparation**: Reshape panel data (wide-to-long), compute metrics, classify by firm size (micro-small, medium, large).
2. **Pre-grant variation analysis**: Calculate CVs for each metric (2010–2018) to establish "normal" variation.
3. **Post-grant assessment**: Measure changes post-grant (2019–2023) versus pre-grant averages.
4. **Additionality classification:** Ratio of change to pre-grant variation:
    - High additionality: ratio > 2
    - Partial additionality: 0.5–2

- Likely deadweight: < 0.5

5. **Multi-dimensional analysis:** Examine patterns across regions, grant types, firm sizes and metrics.
6. **Statistical testing:** Implement t-tests for differences between supported and unsupported firms.

This pathway was not taken forward to final reporting because it did not provide sufficiently robust evidence for deadweight estimation under the available data conditions. The principal constraints were incomplete and inconsistent metric reporting, substantial year to year volatility relative to plausible grant effects, misalignment between reporting windows and expected impact lags, and the absence of a sufficiently credible counterfactual without an explicit control group. These constraints are well documented in evaluation practice, which emphasises the need for a credible counterfactual and adequate overlap between treatment and control units when estimating causal effects from observational data (Rosenbaum and Rubin, 1983; Imbens and Rubin, 2015; European Commission, 2021).

3.3.2 Methodology Adjustment

As noted above, the Exploratory Ratio to Ratio Variation Framework was not progressed due to methodological constraints. To enable further analysis, a revised methodology was required, Enhanced Propensity Score Matching. This methodology was selected as it provided further robust analysis for this review. In particular, this methodology was intended to provide a more accurate 1:1 match based on pre-grant and post-grant results.

3.3.3 Enhanced Propensity Score Matching

Enhanced propensity score matching was used to compare treatment firms with statistically similar comparison firms on observable pre-treatment characteristics. This strengthened counterfactual logic relative to purely descriptive approaches, but it also introduced constraints. Only a subset of grant recipients could be included due to differences in ABSEI coverage and baseline completeness, and effective samples were further reduced after imposing common support restrictions and subgroup segmentation.

The PSM approach involved:

- **Treatment definition:** Receipt of grant payments during 2014-2023 for enterprise supports.
- **Covariates:** Baseline employment, total value, R&D expenditure/flags, export status, firm size categories, sector (NACE), ownership; log transforms and conservative winsorisation applied to reduce the influence of extremes.
- **Propensity score estimation:** Logistic models with adaptive specification, progressively simplifying when convergence issues arose (full covariates → without industry controls → core variables with size/region → core variables only → basic employment and value specification).
- **Matching protocol:** One-to-one nearest-neighbour matching with callipers, restricted to the common-support region, and performed without replacement to create clean pairs.
- **Balance assessment:** t-tests and diagnostics on key covariates to confirm similarity between matched treatment and control groups.
- **Outcome comparisons:** Where feasible, employment, total value, and in-house R&D growth from a common baseline were compared for matched pairs.
- **Inference:** ATT estimated via mean differences with robust standard errors; bootstrapping used to derive confidence intervals; estimates reported with uncertainty statements.

- **Minimum evidence thresholds:** A minimum of 10 total observations and ≥5 matched pairs per reported cell were required to mitigate spurious findings in very small samples.

3.3.4 Structured Framework for Performance Analysis

The core analytical framework involved the following sequential steps:

1. **Data preparation.** Reshape the panel data from wide to long format, calculate performance metrics, and categorise firms by size (micro-small, medium, large).
2. **Pre-grant variation analysis.** Calculate coefficients of variation (CVs) for each metric during the pre-grant period (2010-2018) to establish "normal" levels of variation for each firm. This is a crucial step as it allows us to determine what constitutes typical performance fluctuation for a given firm or industry.
3. **Post-grant performance assessment.** Measure changes in performance metrics (employment, in-house R&D expenditure, total value) post-grant compared to pre-grant averages to quantify improvements after receiving support.
4. **Additionality framework.** Calculate the ratio of performance changes to pre-grant variation, classifying firms into three categories:
    - High additionality: Ratio > 2 (changes substantially exceed normal variation)
    - Partial additionality: Ratio between 0.5 and 2 (modest additionality)
    - Likely deadweight: Ratio < 0.5 (changes within normal variation range)
5. **Multi-dimensional analysis.** Examine deadweight rates across regions, grant types, firm sizes, and performance metrics to identify patterns and optimal targeting strategies.
6. **Statistical testing.** Employ t-tests to assess the statistical significance of differences between grant recipients and non-recipients.

This methodology, although novel, provides a structured framework for assessing the effectiveness of enterprise support while acknowledging the complex nature of firm performance and the challenges in establishing causality.

3.4 WHY ROBUST DEADWEIGHT LEVELS COULD NOT BE DELIVERED

Four interlocking constraints prevented decision-grade estimation:

1. Incomplete and inconsistent baselines limited match quality and reduced eligible cohorts.
2. Small effective samples after segmentation and common-support restrictions yielded unstable, high-variance estimates.
3. Outcome volatility and timing misalignment confounded attribution where natural fluctuations exceeded plausible grant effects and monitoring windows were not aligned to expected impact lags.
4. Limited overlap with controls weakened comparability and increased sensitivity to specification choices.

These constraints are structural and measurement-related rather than programme-specific. Under such conditions, publishing deadweight figures would risk over-precision and misinterpretation.

3.5 METHODOLOGICAL LESSONS

Several important lessons emerged from the evaluation of approaches tested for estimating deadweight. The attempt to use metric-only inference without a comparator proved unviable. Even when adjustments were made for volatility, observed changes in firm performance were largely

driven by macroeconomic cycles, firm life-cycle dynamics, and regression-to-the-mean effects rather than attributable programme impacts. This reinforced the principle that credible attribution requires an explicit counterfactual rather than reliance on descriptive trends.

The effort to produce highly disaggregated estimates also highlighted structural limitations in a small economy. When estimation was attempted at granular levels, such as by region, grant type, and outcome, the resulting samples were often too small to support robust inference. These small cohorts produced fragile outputs that were highly sensitive to specification choices, trimming, and winsorisation. This finding underscores the need for pooled multi-year cohorts and pre-specified aggregation rules to stabilise estimates and reduce volatility.

Finally, the evaluation confirmed that uniform short-run financial outcomes are not always appropriate for certain instruments, particularly those designed to build innovation capacity or enhance firm capabilities. For these programmes, impacts may materialise through timing, scale, specification, or behavioural changes rather than immediate shifts in headline financial metrics. Future methodologies must therefore align outcome selection with programme logic and expected impact windows to avoid misinterpretation.

3.6 STRENGTHS

Despite these limitations, the analysis demonstrated that propensity score matching can provide decision-useful signals under certain conditions. Where adequate overlap existed between treatment and control groups and baseline data were sufficiently complete, PSM offered a defensible counterfactual and produced estimates that were proportionate to evidence quality. These estimates, when accompanied by sample counts, balance checks, and uncertainty statements, added value to the evaluation process.

The application of transparent thresholds and suppression or aggregation rules further strengthened methodological integrity. By enforcing minimum evidence standards and clearly documenting diagnostic results, the analysis reduced the risk of false precision and ensured that findings were interpreted appropriately. Internal peer review and conservative inference protocols also contributed to maintaining proportionality, ensuring that results were presented as indicative rather than definitive. Collectively, these partial strengths provide a foundation for refining future approaches and demonstrate that robust estimation is achievable when enabling conditions are in place.

3.7 ROADMAP FOR FUTURE REVIEWS

The roadmap for improving deadweight estimation in future reviews focuses on four interdependent pillars: evaluation-ready data, cohort design and reporting rules, a tiered counterfactual toolkit, and outcome alignment with timing considerations. Each pillar addresses structural and methodological constraints identified during this evaluation and provides actionable steps to enable robust, decision-grade estimation.

3.7.1 Evaluation-Ready Data at Source

The foundation for credible deadweight estimation lies in the availability of complete and consistent baseline data. Future programme design should mandate the capture of core firm-level characteristics at the point of grant application, including employment, turnover or value added, R&D expenditure, export status, ownership structure, and sector classification. These variables are essential for constructing valid counterfactuals and ensuring comparability between supported and unsupported firms. Harmonisation of grant taxonomies across agencies is equally critical to avoid fragmentation and enable consistent reporting over time. In addition, implementing a Unique

Business Identifier across administrative datasets will allow seamless linkage between grant records, ABSEI data, and monitoring systems, creating an integrated evidence base for longitudinal analysis.

3.7.2 Cohort Design and Reporting Rules

Structural constraints in a small economy mean that granular annual estimates are rarely feasible. To address this, future reviews should pool cohorts across three to five years to increase sample sizes and smooth idiosyncratic shocks. Pre-specified aggregation rules should be applied to combine adjacent categories such as similar grant types or regions when minimum sample thresholds are not met. Transparency in reporting is paramount: all published estimates should include treatment and control counts, balance diagnostics, and uncertainty measures such as confidence intervals and p-values. Where these standards cannot be met, results should be suppressed or aggregated to avoid misleading precision. These measures will ensure that published parameters reflect evidence strength and maintain credibility.

3.7.3 Tiered Counterfactual Toolkit

No single method can address the diversity of programme designs and data conditions encountered in practice. Future evaluations should adopt a tiered approach to counterfactual construction. Matching-based estimators, such as propensity score matching or covariate balancing methods, should remain the default where overlap and sample size are adequate. For small treatment cohorts, synthetic comparison approaches or Bayesian estimators may provide a viable alternative, provided uncertainty is explicitly reported. Programmes with clear eligibility thresholds should be evaluated using quasi-experimental designs such as regression discontinuity, which offer strong causal inference under appropriate conditions. Where comparators are infeasible, pooled descriptive trends should be combined with structured qualitative evidence, clearly labelled as non-parameter-setting, to provide contextual insights without overstating precision.

3.7.4 Outcome Alignment and Timing

Deadweight estimation must reflect the logic of the intervention and the expected trajectory of impacts. For innovation and capability-building supports, short-run financial metrics are often inadequate proxies for programme success. Future methodologies should incorporate intermediate indicators such as R&D persistence, export diversification, or capability development, alongside traditional measures of employment and turnover. Impact windows should be defined in advance and aligned to programme theory, recognising that some outcomes materialise over longer horizons. Consistent rules for handling zero or missing baseline values should also be established to prevent bias and ensure comparability across cohorts.

Together, these actions form a coherent roadmap for strengthening deadweight estimation in Ireland. By embedding evaluation-ready design into programme planning, harmonising data systems, and adopting flexible yet rigorous methodological frameworks, DETE and its agencies can move from indicative signals toward decision-grade parameters that support transparent, evidence-based resource allocation.

3.8 PROPOSED MINIMUM EVIDENCE STANDARD

Before any general-grant deadweight parameter is used in the EAM, the following must be evidenced:

1. **Sample size:** ≥5 matched pairs and ≥10 total observations per reported cell (post common support).
2. **Diagnostics:** Balance tests on pre-treatment covariates; visual/common-support confirmation.

3. **Uncertainty:** Confidence or bootstrap intervals and p-values for underlying outcome differences.
4. **Transparency:** Documented suppression/aggregation rules; treatment of missing/zero baselines; rationale for impact windows.
5. **Replicability:** Versioned data definitions and taxonomy mappings.

Cells failing the standard should be suppressed or aggregated, with a short note explaining the limitation.

4 ENVIRONMENTAL GRANT AID

4.1 INTRODUCTION

This study also sought to assess whether a structured counterfactual survey approach could provide usable evidence on deadweight for environmental grant aided projects, and to identify the conditions under which such an approach could be scaled into a routine evidence source for appraisal. In appraisal terms, the purpose was to test whether recipient reported counterfactuals could be translated into transparent estimates of what would have happened in the absence of support, and whether those estimates could be expressed in a form that would be directly usable within parameter setting for the EAM. This aligns with evaluation guidance that emphasises explicit reference cases and proportionate claims based on evidence strength, particularly where experimental designs are not feasible (European Commission, 2021; HM Treasury, 2022).

Additionality guidance recognises that deadweight can arise not only where projects would have proceeded unchanged without support, but also where support changes timing, scale, quality, or persistence of outcomes. These channels are particularly relevant for environmental investments, where grants may accelerate adoption, expand scope, or enable higher specification technologies, rather than determining whether any investment occurs at all. In this context, a structured survey can be appropriate because it can capture partial additionality that may not be visible in short term firm level indicators, and it can provide a basis for distinguishing between full deadweight, partial deadweight, and no deadweight scenarios in a way that is transparent and replicable (Homes and Communities Agency, 2014; HM Treasury, 2022).

4.2 INTENDED METHODOLOGICAL APPROACH

The intended approach was to elicit structured counterfactual responses from grant recipients and map these to administrative grant values to estimate project level and grant weighted deadweight. The method sought to operationalise the reference case by asking whether the supported project would have been undertaken without the grant and, if so, whether it would have proceeded at the same scale, at a reduced scale, or with delay. The resulting response categories were then converted into transparent rules for allocating deadweight proportions at project level, with grant weighting used to ensure that aggregate estimates reflected the distribution of public expenditure across projects rather than simple averages alone.

This reflects standard practice where experimental evaluation is not feasible and where counterfactual logic is approximated through structured evidence collection while retaining clarity on assumptions (Homes and Communities Agency, 2014; European Commission, 2021). Counterfactual evaluation guidance recommends that where self-reported information is used, the mapping between responses and quantitative estimates should be explicit, and the approach should be framed as part of a broader evidence building pathway that can be strengthened through data linkage and outcome monitoring (European Commission, 2021; HM Treasury, 2022). The intention in this study, therefore, was to produce an initial estimate and establish a replicable approach that could be improved over time as data and monitoring arrangements mature.

4.3 ISSUES EXPERIENCED

Sample sizes were notably limited as these are a newer type of support compared to general grant aid, which restricted the extent to which results could be disaggregated by region, project category, or scheme type without generating high variance estimates. In practical terms, small cohorts reduce statistical precision and increase sensitivity to individual observations, which limits the reliability of subgroup conclusions and increases the risk that apparent patterns reflect sampling variability rather than genuine differences. Evaluation guidance therefore indicates that where sample sizes are small, results should be treated as indicative and reporting should focus on feasibility, transparency of

assumptions, and identification of the conditions required for more robust future estimation, including improved response rates and pooling across periods where appropriate (European Commission, 2021; HM Treasury, 2022).

4.4 LESSONS LEARNED AND IMPLICATIONS FOR FUTURE WORK

The survey-based approach is feasible as an evidence building tool but is not sufficient, at current scale, to provide decision-grade deadweight parameters for all environmental supports. The principal lesson learned is that while structured counterfactual elicitation can capture timing and scale effects that matter for additionality, robust parameter setting requires adequate representativeness, stable response processes, and sufficient sample sizes to support disaggregation where that is required for policy use. Evaluation guidance indicates that where these conditions are not met, the appropriate use of results is to inform learning, identify risk areas, and guide data improvement priorities rather than to fix definitive parameter values for all contexts (European Commission, 2021; HM Treasury, 2022).

Survey derived estimates should be strengthened through triangulation with administrative and outcome data, and through clearer alignment between monitoring arrangements and expected impact windows. In particular, environmental interventions often deliver benefits through changes in timing, scale, and specification, and these channels should be reflected in the monitoring framework so that reported counterfactuals can be tested against realised implementation and outcome measures where feasible. Guidance on additionality and evaluation design stresses the importance of transparent assumptions, appropriate time horizons, and proportionate interpretation of evidence where uncertainty is material (Homes and Communities Agency, 2014; European Commission, 2023; HM Treasury, 2022).

4.5 RECOMMENDATIONS FOR FUTURE WORK

Future work should prioritise evaluation ready programme data and consistent monitoring arrangements to strengthen environmental deadweight estimation. This includes standardised fields collected at application, approval, completion, and follow up that capture expected and realised environmental outcomes, such as energy savings, emissions reductions, technology installed, and commissioning dates, alongside a clear record of project scope and delivery milestones. This data should be linkable to grant administration records using consistent identifiers, enabling triangulation between counterfactual intent, delivery timing, delivery scale, and realised outcomes. This approach aligns with guidance on monitoring arrangements and counterfactual evaluation, which emphasises that credible estimation depends on measurable baselines, consistent outcome definitions, and the ability to connect intervention records to outcome data over time (European Commission, 2021; European Commission, 2023; HM Treasury, 2022).

Future work should also strengthen the counterfactual design by improving representativeness and by embedding practical comparator options where feasible. Survey protocols should include clear assurances on confidentiality and non-attribution, structured question wording that distinguishes timing, scale, and non-delivery counterfactuals, and planned follow up to improve response rates and reduce non response bias. Where appropriate, administrative pipeline comparators should be developed, including near miss applicants or deferred projects, so that survey evidence can be complemented by comparison groups derived from programme operations.

Finally, estimates should be reported using minimum sample thresholds and clear uncertainty statements, with multi-year pooling and pre-specified aggregation where cohort sizes are small. These recommendations are consistent with evaluation guidance on proportionality, counterfactual design, and transparent reporting in contexts where experimental designs are not feasible (European Commission, 2021; Homes and Communities Agency, 2014; HM Treasury, 2022).

5 CONCLUSIONS AND RECOMMENDATIONS

This chapter consolidates cross-cutting insights from the evaluation of deadweight estimation for general (enterprise) grant aid and environmental grant aid. It summarises the constraints that prevented decision-grade parameters, articulates lessons that inform future practice, and presents a proportionate, actionable roadmap to enable credible estimation in subsequent review cycles. The recommendations emphasise evaluation-ready design, data harmonisation, transparent diagnostics, and methods aligned to programme logic.

5.1 SYNTHESIS OF FINDINGS ACROSS GRANT TYPES

The evaluation confirmed that deadweight estimation is highly sensitive to data readiness, cohort scale, and comparator quality. For general enterprise grant aid, enhanced propensity score matching strengthened counterfactual logic compared with descriptive approaches; however, incomplete baselines, small effective samples after segmentation and common-support restrictions, and limited overlap between treated and comparison firms constrained feasibility. For environmental aid, a structured counterfactual survey produced indicative signals on timing, scale, and specification effects, but low achieved samples, variability in monitoring data, and reliance on self-reported counterfactuals limited the precision and generalisability of estimates. Across both domains, numeric results were best treated as indicative rather than parameter-setting, and estimates required explicit uncertainty statements and supporting diagnostics.

5.2 WHAT DOES NOT WORK

Two families of approaches proved unsuitable for parameter setting under current conditions. The first was metric-only inference without an explicit comparator. Firm outcomes such as employment, turnover, value added, and R&D expenditure fluctuate with market conditions and firm life-cycles. When natural volatility is large relative to plausible programme effects and impact windows are misaligned, descriptive changes risk conflating noise with policy signals and cannot sustain causal claims. The second was highly disaggregated estimation in thin strata. In a small economy, segmentation by region, grant type, and outcome rapidly reduces effective sample sizes, yielding fragile estimates that are sensitive to specification, trimming, and winsorisation choices. In both cases, the underlying limitation is structural rather than programme-specific: insufficient baseline coverage, small cohorts, and limited overlap weaken counterfactual comparisons and increase uncertainty beyond acceptable bounds for parameterisation.

5.3 LESSONS LEARNED

Lesson 1. The primary constraint is evaluation ready data

Across both environmental and enterprise grant schemes, the principal limitations arose from missing baselines, inconsistent classifications, and restricted ability to identify comparable unsupported firms. Where these foundations are weak, greater modelling sophistication can increase instability rather than resolve uncertainty. A priority for future work should be to make data consistently suitable for evaluation through stable identifiers, harmonised grant classifications, baseline measures captured at application, and longitudinal follow up.

Lesson 2. Cohort scale constraints limit granular estimation

Even with appropriate methods, some grant schemes and regions yield small analytic cohorts after applying eligibility, timing, and completeness criteria. This is a structural feature in smaller economies and implies that highly granular annual deadweight estimates may not be feasible. Evaluation guidance should therefore support pooling across multiple years, prespecified aggregation rules, and transparent minimum sample thresholds for subgroup reporting (European Commission, 2021; HM Treasury, 2022).

Lesson 3. Evidence on approaches that do not work is policy relevant

Some plausible approaches do not generate defensible deadweight estimates under current conditions, including metric-based classification without a credible counterfactual and highly disaggregated estimates in low sample settings. Documenting these limits is essential to prevent repetition and to focus investment on enabling conditions for robust estimation. This aligns with evaluation guidance that emphasises learning, transparency, and proportionate claims (European Commission, 2021; HM Treasury, 2022).

Lesson 4. Environmental aid requires outcome concepts distinct from general enterprise aid

Environmental aid is a subset of enterprise support but often operates through distinctive outcome pathways, including emissions reductions, energy performance improvements, and technology adoption, with longer lags. Reliance solely on short term firm level economic outcomes risks missing the mechanism of impact. Additionality guidance recognises timing, scale, and quality as legitimate channels of impact, and evaluation guidance recommends outcome monitoring aligned to expected lags (Homes and Communities Agency, 2014; HM Treasury, 2022; European Commission, 2023).

Lesson 5. Counterfactual surveys are feasible but require bias mitigation and representativeness planning

Recipient counterfactual surveys can capture partial deadweight effectively, particularly for timing and scale effects. However, they require careful question design to reduce strategic and hindsight bias, clear assurances that responses will not influence future funding decisions, and a representativeness plan that includes follow up protocols and linkage to administrative records. These principles align with counterfactual evaluation guidance on data quality, selection bias, and triangulation (European Commission, 2021; HM Treasury, 2022).

5.4 RECOMMENDATIONS FOR ROADMAP FOR FUTURE REVIEWS

Minimum evidence standard for publishable deadweight estimates

Future reviews should adopt explicit standards for reporting deadweight estimates. These should include minimum analytic sample thresholds for any subgroup estimate, automatic aggregation or suppression below thresholds, mandatory reporting of treatment and control sample sizes and basic matching diagnostics, and uncertainty statements that reflect the estimator used. This is consistent with counterfactual evaluation guidance and with methodological literature on matching-based estimation (European Commission, 2021; Abadie and Imbens, 2009).

Tiered counterfactual toolkit

Given variation in cohort sizes and programme design, future work should use a tiered counterfactual toolkit. Matching based approaches should be the default where overlap and sample size permit. Where treatment samples are small, but a sufficient comparison pool exists, synthetic comparison approaches should be used with transparent uncertainty reporting. Where programme rules generate clear thresholds, quasi-experimental approaches should be considered. This aligns with counterfactual evaluation guidance emphasising selection of methods that match the data and implementation context (European Commission, 2021; Imbens and Rubin, 2015).

Comparison groups built from administrative pipelines

The evaluation highlights practical challenges in constructing survey-based control groups. A more feasible approach is to build comparison groups from administrative pipelines, including unsuccessful applicants near decision thresholds, deferred or withdrawn applicants, and future recipients who receive support later. This embeds comparators before delivery and reduces reliance on ex post recruitment. Such approaches are consistent with counterfactual evaluation guidance that encourages evaluation ready programme design. (European Commission, 2021)

Performance metrics and measurement conditions

Firm performance metrics remain valuable where measurement conditions are met. These conditions include baseline availability at or immediately before the award decision, defined impact windows aligned to expected lags by grant type, consistent rules for handling missing and zero values, and a published rationale linking each metric to the programme theory of change. Where these conditions do not hold, metrics should be used as contextual description rather than for deadweight classification.

Environmental aid: from stated intent to measured outcomes

To strengthen environmental deadweight estimation, programmes should incorporate standardised outcome fields at application and completion, including expected and realised energy savings, expected and realised emissions savings, technology installed, and commissioning dates. A defined post completion measurement point should be adopted to capture realised performance. These measures should be linkable to grant records to allow triangulation between counterfactual intent and realised outcome additionality. This direction is consistent with guidance on monitoring arrangements and counterfactual evaluation (European Commission, 2023; European Commission, 2021).

Data roadmap

A future proof deadweight evidence base requires a harmonised grant taxonomy that is stable over time and consistent across agencies, reliable unique identifiers and cross dataset linkage across grant, application, monitoring, and outcome datasets, and an evaluation plan at programme launch that sets out baseline capture, comparator strategy, and follow up schedule. These actions align with guidance on evaluation ready policy design. (HM Treasury, 2022; European Commission, 2021).

It is also important to improve data readiness through consistent identifiers, harmonised grant taxonomies, and baseline capture at the point of decision making. It would also be beneficial to implement monitoring and follow up arrangements aligned with expected impact windows, particularly for environmental and innovation related supports. Notably the benefits of these types of supports would take longer to materialise.

5.5 CONSOLIDATED MINIMUM EVIDENCE STANDARDS

A unified standard should apply to both enterprise and environmental domains, with domain-specific additions where necessary.

- **Sample adequacy:** For matched designs, a minimum of ≥5 matched pairs and ≥10 total observations per reported cell after common-support restrictions. For survey-based estimates, achieved effective sample sizes sufficient to yield margins of error ≤ ±10 percentage points at the 95% confidence level for any published cell.
- **Diagnostics:** Demonstrated covariate balance (e.g., standardised mean differences within conventional thresholds), visual confirmation of common support, and—in surveys—calibration diagnostics showing acceptable alignment to the population frame on observable characteristics.
- **Uncertainty reporting:** Confidence intervals (or bootstrap intervals) and p-values for treatment effects; survey design effects where applicable; clear indication where intervals could not be reliably computed due to thin samples.
- **Measurement alignment:** For environmental programmes, verification of a defined subsample against monitoring or metered data; for enterprise supports, alignment of outcome windows to programme theory with documented rationale.

- **Transparency and replicability**: Documented suppression/aggregation rules, treatment of zeros and missing baselines, versioned data definitions, and grant taxonomy mappings.

Cells failing these standards should be suppressed or aggregated, with a short explanatory statement.

5.6 IMPLEMENTATION PLAN

Short term

- Agree a minimum evidence standard for any future parameter publication, including treatment and control counts, basic matching diagnostics, and confidence intervals.
- Finalise a baseline capture template at decision stage so that core pre-treatment covariates are consistently recorded across agencies.
- Confirm suppression and aggregation rules for low sample cells to avoid over-precision in small cohorts.

Medium term

- Pilot 3-year pooled cohorts for one or two priority schemes to stabilise estimates in a small-economy context.
- Begin identifier linkage using the planned Unique Business Identifier and harmonise grant taxonomies across agencies to improve comparability.
- Standardise environmental outcome fields (energy and emissions metrics, technology specification, commissioning dates) and set a single post-completion measurement point for follow up.

Next review cycle

- Report updated range-based deadweight parameters for the pilot schemes, accompanied by diagnostics and uncertainty statements that meet the agreed evidence standard.
- Decide whether to extend pooled estimation and the publication approach to additional schemes based on pilot results and data readiness.

This staged plan keeps ambition in check, prioritises feasible improvements in methods and data collection, and uses each cycle to add tested building blocks to a more robust evidence base on deadweight in Ireland.

Deadweight is a material consideration for both enterprise and environmental grant aid. Under current data conditions, the evaluation provides indicative estimates and a limited pathway to decision-grade parameters. Implementing minimum evidence standards, pooling cohorts, and improving identifiers, baseline capture and outcome monitoring would help strengthen future deadweight estimation.

5.7 RISKS, DEPENDENCIES, AND MITIGATIONS

A key dependency is the operationalisation of Unique Business Identifiers (UBIs) across grant administration, ABSEI, and monitoring datasets. The expected wait period for full implementation may extend beyond the next review cycle, creating a risk that linkage remains partial and comparator quality is constrained. This delay could limit the feasibility of robust matching and verification until identifiers are fully embedded. Mitigation requires early engagement with the identifier implementation programme, prioritisation of interim linkage solutions (e.g., probabilistic matching using firm name and address), and phased roll-out focusing on high-leverage datasets first.

Other risks include delays in baseline capture changes, which would prolong reliance on incomplete covariates; thin cohorts, which remain a structural constraint even with improved data; and non-response or measurement error in survey-based estimates. These should be managed through mixed-mode fieldwork, targeted follow-ups, calibration to administrative frames, and validation against monitoring data for defined subsamples. Finally, there is a risk of misinterpretation of numeric outputs; mandatory disclosure notes, uncertainty ranges, and suppression rules reduce this risk.

5.8 NEXT REVIEW CYCLE AND EVALUATION PLAN

The next review cycle should commence once Phase 1 actions are completed, using the new standards and data architecture. Estimation plans should be registered in advance, specifying cohorts, methods, outcomes, impact windows, diagnostics to be achieved, and publication thresholds. A formal learning loop should be embedded: each cycle should document which standards were met, where gaps persisted, and what adjustments are planned. For environmental programmes, verification rates and measurement alignment should be tracked and reported. For enterprise supports, overlap diagnostics and matched-pair counts by stratum should be monitored to inform future aggregation rules.

5.9 CONCLUSION

Under current conditions, decision-grade deadweight parameters could not be produced for either general or environmental grant aid. Nonetheless, the evaluation has clarified the enabling conditions for credible estimation and has developed proportionate, practical recommendations including a roadmap. By embedding evaluation-ready design, harmonising data and identifiers, adopting pooled cohorts with transparent diagnostics, and aligning methods and outcomes to programme logic, future reviews can move from indicative signals to robust, publishable parameters. Implementing the standards and plan set out in this chapter will improve the credibility of the Economic Appraisal Model (EAM) and support evidence-based resource allocation across the enterprise and environmental policy portfolios.

The review makes a significant contribution to the application of theory within the deadweight literature. The adoption of the well-established Enhanced Propensity Score Matching enabled the Irish context to be examined and situated within the existing literature. In doing so, the review offers additional insight into the effectiveness and limitations of applying the theoretical framework. In terms of future steps, the findings and recommendations presented in this document will be used to inform future reviews and have indicated that for environmental aid appraisals, a more appropriate approach at this stage may be a qualitative assessment, pending the availability of more comprehensive data in the future. At this stage, no changes are proposed to the deadweight levels currently applied within the model. Additionally, this research contributes to the wider literature on the appraisal of enterprise expenditure in a small open economy.

6 REFERENCES

[1] Afonso, A., Schuknecht, L. and Tanzi, V. (2005), "Public sector efficiency: An international comparison", Public Choice, 123: 321-347.

[2] Antonelli, C. and Crespi, F. (2013), "The "Matthew effect" in R&D public subsidies: The Italian evidence", Technological Forecasting and Social Change, 80(8): 1,523-1,534.

[3] Anyadike-Danes, M., Hart, M., & Lenihan, H. (2011), "New business formation in a rapidly growing economy: the Irish experience", Small Business Economics, 36(4): 503-516.

[4] Angrist, J. D. and Pischke, J. S. (2010), "The credibility revolution in empirical economics: How better research design is taking the con out of econometrics", Journal of Economic Perspectives, 24(2): 3-30.

[5] Athey, S. (2017), "The impact of machine learning on economics", in Agrawal, A., Gans, J. and Goldfarb, A. (Eds.), The economics of artificial intelligence: An agenda (pp. 507-547). University of Chicago Press: Chicago, United States.

[6] Bachtler, J. and Wren, C. (2006), "Evaluation of European Union Cohesion policy: Research questions and policy challenges", Regional Studies, 40(2): 143-153.

[7] Barkenov, T., Hart, D. and Benfer, W. (1990). US Experience in Evaluating Urban Regeneration. Inner Cities Directorate, Department of the Environment. London, United Kingdom.

[8] Becker, S. O, Egger, P. H. and von Ehrlich, M. (2013), "Absorptive Capacity and the Growth and Investment Effects of Regional Transfers: A Regression Discontinuity Design with Heterogeneous Treatment Effects", American Economic Journal: Economic Policy, 5(4): 29-77.

[9] Bennear, L. S. and Stavins, R. N. (2007), "Second-best theory and the use of multiple policy instruments", Environmental and Resource Economics, 37(1): 111-129.

[10] Bérubé, C. and Mohnen, P. (2009), "Are firms that receive R&D subsidies more innovative?", Canadian Journal of Economics, 42(1): 206-225.

[11] Bloom, N., Schankerman, M. and Van Reenen, J. (2013), "Identifying Technology Spillovers and Product Market Rivalry", Econometrica, 81(4): 1,347-1,393.

[12] Blomquist, J. and Waldo, S. (2022), "Do Firm Support Increase Investments? Evidence from the Aquaculture and Fish Processing Sectors in Sweden", Journal of Agricultural and Applied Economics, 54: 306-318.

[13] Bia, M. and Mattei, A. (2012), "Assessing the effect of the amount of financial aids to Piedmont firms using the generalized propensity score", Statistical Methods & Applications, 21: 485-516.

[14] Biagi, F., Bondonio, D. and Martini, A. (2015), "Counterfactual Impact Evaluation of Enterprise Support Programmes. Evidence from a Decade of Subsidies to Italian Firm", ERSA Conference Papers,

[15] Bondonio, D. and Greenbaum, R. T. (2014), "Revitalizing regional economies through enterprise support policies: an impact evaluation of multiple instruments", European Urban and Regional Studies, 21(1): 79-103.

[16] Brandsma, A., Kancs, d'A. and Ciaian, P. (2013), "The Role of Additionality in the EU Cohesion Policies: An Example of Firm-Level Investment Support", European Planning Studies, 21(6): 838-853.

[17] Bronzini, R. and Iachini, E. (2014), "Are Incentives for R&D Effective? Evidence from a Regression Discontinuity Approach", American Economic Journal: Economic Policy, 6(4): 100-134.

[18] Buisseret, T., Cameron, H. M. and Georgiou, L. (1995), "What differences does it make? Additionality in the public support of R&D in large firms", International Journal of Technology Management, 10(4-5): 587-600.

[19] Busom, I. (2000), "An empirical evaluation of the effects of R&D subsidies", Economics of Innovation and New Technology, 9(2): 111-148.

[20] Busom, I., Corchuelo, B. and Martínez-Ros, E. (2017), "Participation inertia in R&D tax incentive and subsidy programs", Small Business Economics, 48: 153-177.

[21] Cantner, U. and Kösters, S. (2012), "Picking the winner? Empirical evidence on the targeting of R&D subsidies to start-ups", Jena Economic Research Papers, 2009,093.

[22] Cartwright, N. and Hardie, J. (2012). Evidence-based policy: A practical guide to doing it better. Oxford University Press: Oxford, United Kingdom.

[23] Castellacci, F. and Lie, C. M. (2015), "Do the effects of R&D tax credits vary across industries? A meta-regression analysis", Research Policy, 44(4): 819-832.

[24] Clarysse, B., Wright, M. and Mustar, P. (2009), "Behavioural additionality of R&D subsidies: A learning perspective", Research Policy, 38(10): 1,517-1,533.

[25] Cin, B. C., Kim, Y. J. and Vonortas, N. S. (2017), "The impact of public R&D subsidy on small firm productivity: evidence from Korean SMEs", Small Business Economics, 48(2): 345-360.

[26] Conlon, G., Patrignani, P. and Litchfield, A. (2012), "Assessing the deadweight Loss Associated with Public Investment in Further Education and Skills", BIS Research Paper (Department for Business Innovation & Skills), 71 [Prepared by London Economics].

[27] Creswell, J. W. and Plano Clark, V. L. (2017). Designing and conducting mixed methods research. Sage publications.

[28] Czyzewski, B., Matuszczak, A., Polcyn, J., Smędzik-Ambroży, K., & Staniszewski, J. (2020), "deadweight loss in environmental policy: The case of the European Union member states", Journal of Cleaner Production, 260, 121064.

[29] Czarnitzki, D. and Fier, A. (2002), "Do innovation subsidies crowd out private investment? Evidence from the German service sector", Applied Economics Quarterly, 48(1): 1-25.

[30] Czarnitzki, D., & Lopes-Bento, C. (2013), "Value for money? New microeconometric evidence on public R&D grants in Flanders", Research Policy, 42(1), 76-89.

[31] Czarnitzki, D., & Lopes-Bento, C. (2014), "Innovation subsidies: Does the funding source matter for innovation intensity and performance? Empirical evidence from Germany", Industry and Innovation, 21(5): 380-409.

[32] Davenport, S., Grimes, C. and Davies, J. (1998), "Research collaboration and behavioural additionality: A New Zealand case study", Technology Analysis and Strategic Management, 10(1): 55-68.

[33] DETE (2025). Statement of Strategy 2025–2028. Available at: https://www.gov.ie/en/department-of-enterprise-tourism-and-employment/publications/statement-of-strategy/

[34] Di Cataldo, M. (2017), "The impact of EU Objective 1 funds on regional development: Evidence from the U.K. and the prospect of Brexit", Journal of Regional Science, 57(5): 814-839.

[35] Dimos, C. and Pugh, G. (2016), "The effectiveness of R&D subsidies: A meta-regression analysis of the evaluation literature", Research Policy, 45(4): 797-815.

[36] Doucouliagos, H. and Paldam, M. (2005), "Conditional aid effectiveness: A meta study", Institut for Økonomi Working Paper, University of Aarhus, 2005-14.

[37] Dvouletý, O. and Blažková, I. (2019), "The impact of public grants on firm-level productivity: Findings from the Czech food industry", Sustainability, 11(2): 552.

[38] Dvouletý, O. and Blažková, I. (2021), "Determinants of competitiveness in the Czech SME sector: An analysis of firm-level data", Competitiveness Review: An International Business Journal, 1059-5422.

[39] Dvouletý, O., Blažková, I. and Potluka, O. (2021). 'Estimating the effects of public subsidies on the performance of supported enterprises across firm sizes'. Research Evaluation, 30(3): 290-313.

[40] Edler, J., Cunningham, P., Gök, A. and Shapira, P. (Eds.) (2016). Handbook of innovation policy impact. Edward Elgar Publishing.

[41] Einav, L. and Levin, J. (2014), "Economics in the age of big data", Science, 346(6210): p.1243089.

[42] Enright, S., Newman, K. and Coates, D. P. (2024). 'State Enterprise Agency Client Firms: Climate Change, Planning, and Investment' (Data Evaluation Unit, DETE). Irish Government Economic and Evaluation Service: Working Paper Series.

[43] European Commission (2021) Design and Commissioning of Counterfactual Impact Evaluations: A Practical Guide for ESF Managing Authorities. Directorate General for Employment, Social Affairs and Inclusion, Publications Office of the European Union.

[44] European Commission (2023) Better Regulation Toolbox. European Commission Staff Working Document, July 2023.

[45] Falk, R. (2007), "Measuring the effects of public support schemes on firms' innovation activities: Survey evidence from Austria", Research Policy, 36(5): 665-679.

[46] Feldman, M. P. and Kelley, M. R. (2006), "The ex-ante assessment of knowledge spillovers: Government R&D policy, economic incentives and private firm behavior", Research Policy, 35(10): 1,509-1,521.

[47] Flanagan, K., Uyarra, E. and Laranja, M. (2011), "Reconceptualising the 'policy mix' for innovation", Research Policy, 40(5): 702-713.

[48] Garrido-Prada, P., Lenihan, H., Doran, J., Rammer, C. and Perez-Alaniz, M. (2021), "Driving the circular economy through public environmental and energy R&D: Evidence from SMEs in the European Union", Ecological Economics, 182, 106884.

[49] Georghiou, L. (2002a), "Impact and Additionality of Innovation Policy", IWT-Studies, 40: 57-65.

[50] Georghiou, L. (2002b), "Additionality and impact of R&D subsidies", IWT-Studies, 57-65.

[51] Georghiou, L. (2004), "Evaluation of Behavioural Additionality. Concept Paper", IWT-Studies, 48: 7-22.

[52] Guellec , D. and Van Pottelsberghe De La Potterie, B. (2003), "The impact of public R&D expenditure on business R&D", Economics of Innovation and New Technology, 12(3): 225-243.

[53] Haapanen, M., Lenihan, H., & Mariani, M. (2014), "Government policy failure in public support for research and development", Policy Studies, 35(6): 557-575.

[54] Haapanen, M., Lenihan, H. and Tokila, A. (2017), "Innovation expectations and patenting in private and public R&D projects", Growth and Change, 48(4): 744-768.

[55] Hall, P. A. and Soskice, D. (Eds.) (2001). Varieties of capitalism: The institutional foundations of comparative advantage. Oxford University Press: Oxford, United Kingdom.

[56] Hart, M. and Lenihan, H. (2006), "Estimating additionality and leverage: the interplay between public and private sector equity finance in Ireland (2000-2002)", Venture Capital: An International Journal of Entrepreneurial Finance, 8(4): 331-351.

[57] HM Treasury (2022) The Green Book: Appraisal and Evaluation in Central Government. HM Treasury and Government Finance Function.

[58] Homes and Communities Agency (2014) Additionality Guide: Fourth Edition. Homes and Communities Agency, United Kingdom.

[59] Huergo, E. and Moreno, L. (2017), "Subsidies or loans? Evaluating the impact of R&D support programmes", Research Policy, 46: 1,198-1,214.

[60] Iammarino, S. FDI and regional development policy. J Int Bus Policy 1, 157–183 (2018). https://doi.org/10.1057/s42214-018-0012-1

[61] Indecon (2018). Indecon Review of the Enterprise Agencies Economic Appraisal Model in Ireland. Available at: Indecon Review of the Enterprise Agencies' Enterprise Model in Ireland.

[62] Imbens, G. W. and Wooldridge, J. M. (2009), "Recent Developments in the Econometrics of Program Evaluation", Journal of Economic Literature, 47(1): 5-86.

[63] Ipinnaiye, O., Dineen, D. and Lenihan, H. (2017), "Drivers of SME performance: a holistic and multivariate approach", Small Business Economics, 48(4): 883-911.

[64] Jaffe, A. B., Newell, R. G. and Stavins, R. N. (2005), "A tale of two market failures: Technology and environmental policy", Ecological Economics, 54(2-3): 164-174.

[65] Kemp, R. (2000), "Technology and environmental policy – innovation effects of past policies and suggestions for improvement", Innovation and the Environment, 1: 35-61.

[66] Keohane, N. O. (2009), "Cap and trade, rehabilitated: Using tradable permits to control US greenhouse gases", Review of Environmental Economics and Policy, 3(1): 42-62.

[67] Kattel, R. and Mazzucato, M. (2018), "Mission-oriented innovation policy and dynamic capabilities in the public sector", UCL Institute for Innovation and Public Purpose (IIPP) Working Paper, IIPP WP 2018-05

[68] Kung, J. Y. (2023). 'Elicit'. Journal of Canadian Health Libraries Association, 44(1): 15-18.

[69] Lenihan, H. (1999). 'An evaluation of a regional development agency's grants in terms of deadweight and displacement'. Environmental and Planning C: Government and Policy, 17(3): 303-318.

[70] Lenihan, H. (2011), "Enterprise policy evaluation: Is there a 'new' way of doing it?", Evaluation and Program Planning, 34(4): 323-332.

[71] Lenihan, H. (2004), "Evaluating Irish industrial policy in terms of deadweight and displacement: a quantitative methodological approach", Applied Economics, 36(3): 229-252.

[72] Lenihan, H. and Hart, M. (2006), "Evaluating the additionality of public sector assistance to Irish firms: a question of ownership?", Policy Studies, 27(2): 115-133.

[73] Lenihan, H. and Hart, M. (2004), “The use of counterfactual scenarios as a means to assess policy deadweight: an Irish case study”, Environment and Planning C: Government and Policy, 22(6): 817-839.

[74] Lenihan, H., Hart, M. and Roper, S. (2007), “Industrial policy evaluation: Theoretical foundations and empirical innovations: New wine in new bottles”, International Review of Applied Economics, 21(3): 313-319.

[75] Lenihan, H., Hart, M. and Roper, S. (2005), “Developing an evaluative framework for Industrial Policy in Ireland: fulfilling the audit trail for an Aid to Policy Development”, Quarterly Economic Commentary, Summer 2005, Economic and Social Research Institute, 69-85.

[76] Lenihan, H., McGuirk, H. and Murphy, K. R. (2019), “Driving innovation: Public policy and human capital”, Research Policy, 48(9), 103791.

[77] Lenihan, H, Mulligan, K, Doran, J., Rammer, C. and Ipinnaiye, O. (2024), “R&D grants and R&D tax credits to foreign-owned subsidiaries: Does supporting multinational enterprises’ R&D pay off in terms of firm performance improvements for the host economy?”, The Journal of Technology Transfer, 49(2): 740-781.

[78] Lenihan, H., Mulligan, K. and O’Driscoll, J. (2020), “A cross-country repository of details on the innovation and science policy instruments available to firms in eight countries (2007-2020): The devil is in the detail”, Kemmy Business School, University of Limerick Working Paper.

[79] Lenihan, H., Mulligan, K., Perez-Alaniz, M. and Rammer, C. (2025), “R&D policy instrument mix sequencing: evaluating the impact of receiving R&D grants and R&D tax credits over time on firm-level R&D”, Industry and Innovation, 32(5): 540-573.

[80] Lerner, J. (2002), “When bureaucrats meet entrepreneurs: the design of effective 'public venture capital' programmes”, The Economic Journal, 112(477): F73-F84.

[81] List, J. A. (2011), “Why economists should conduct field experiments and 14 tips for pulling one off”, Journal of Economic Perspectives, 25(3): 3-16.

[82] Martinez-Covarrubias, J. L., Lenihan, H. and Hart, M. (2017), “Public support for business innovation in Mexico: a cross-sectional analysis”, Regional Studies, 51(12): 1,786-1,800.

[83] Mazzucato, M. (2018), “Mission-oriented innovation policies: challenges and opportunities”, Industrial and Corporate Change, 27(5): 803-815.

[84] McGuirk, H., Lenihan, H. and Hart, M. (2015), “Measuring the impact of innovative human capital on small firms’ propensity to innovate”, Research Policy, 44(4): 965-976.

[85] Medhurst, J., Marsden, J., Jugnauth, A., Peacock, M. and Lonsdale, J. (2014), “An Economic Analysis of Spillovers from Programmes of Technological Innovation Support”, ICF GHK Report for the Department for Business, Innovation & Skills.

[86] Meleddu, M. and Pulina, M. (2018), “The efficiency of the public intervention on the environment: Evidence based on non-parametric and parametric approaches”, Journal of Cleaner Production, 183: 744-759.

[87] Merton, R. K. (1968), “The Matthew Effect in Science”, Science, 159(3810): 56-63.

[88] Mikulić, D., Bakarić, I. R. and Slijepčević, S. (2016), “The economic impact of energy saving retrofits of residential and public buildings in Croatia”, Energy Policy , 96: 630-644.

[89] Mulligan, K., Lenihan, H. and Doran, J. (2019), “More subsidies, more innovation? Evaluating whether a mix of subsidies from regional, national and EU sources crowds out firm-level innovation”, Regional Studies, Regional Science, 6(1): 130-138.

[90] Mulligan, K., Lenihan, H., Doran, J. and Roper, S. (2022). "Harnessing the science base: Results from a national programme using publicly-funded research centres to reshape firms' R&D", Research Policy, 51(4), 104468.

[91] Neumark, D., Wall, B., & Zhang, J. (2011), "Do small businesses create more jobs? New evidence for the United States from the National Establishment Time Series", The Review of Economics and Statistics, 93(1): 16-29.

[92] OECD (2006). Government R&D Funding and Company Behaviour: Measuring Behavioural Additionality. OECD Publishing: Paris, France.

[93] Pawson, R. and Tilley, N. (1997), "An introduction to scientific realist evaluation", in Chelimsky, E. and Shadish, W. R. (eds.), Evaluation for the 21st century: A handbook, 405-418. Sage Publication: Thousand Oaks, United States.

[94] Perez-Alaniz, M., Lenihan, H., Doran, J., and Hewitt-Dundas, N. (2023), "Financial resources for research and innovation in small and larger firms: Is it a case of the more you have, the more you do?", Industry and Innovation 30(2): 189-232.

[95] Petrakou, M., Bruno, R., & Phelps, N. (2023). The Impact of FDI and Financial Depth on EU Regional Growth: Income and Spatial Heterogeneity. Economic and Business Review, 25(3), 164-181. https://doi.org/10.15458/2335-4216.1325

[96] Pfeiffer, P., Varga, J. and in 't Veld, J. (2021), "Quantifying Spillovers of Next Generation EU Investment", European Commission Discussion Paper, 144.

[97] Rausch, S. and Karplus, V. J. (2014), "Markets versus regulation: the efficiency and distributional impacts of U.S. Climate policy proposals", The Energy Journal, 35(1): 199-227.

[98] Rodrik, D. (2008), "Normalizing industrial policy. Commission on Growth and Development", World Bank Working Paper, 3.

[99] Roper, S. and Hewitt-Dundas. N. (2016), "The legacy of public subsidies for innovation: input, output and behavioural additionality effects", Enterprise Research Centre, ERC Research Paper (Enterprise Research Centre), 21.

[100] Rosenbaum, P.R. and Rubin, D.B. (1983) The Central Role of the Propensity Score in Observational Studies for Causal Effects. Biometrika, 70(1), 41 to 55.

[101] Sanz-Díaz, M. T., Velasco-Morente, F., Yñiguez, R. and Díaz-Calleja, E. (2017), "An analysis of Spain's global and environmental efficiency from a European Union perspective", Energy Policy, 104: 183-193.

[102] Spillias, S., Ollerhead, K., Andreotta, M., Annand-Jones, R., Boschetti, F., Duggan, J., Karcher, D., Paris, C., Shellock, R. and Trebilco, R. (2024). 'Evaluating Generative AI to Extract Qualitative Data from Peer-Reviewed Documents' (preprint). Research Square, 4922498.

[103] Srhoj, S., Lapinski, M., and Walde, J. F. (2019), "Size matters? Impact evaluation of business development grants on SME performance", Working Papers in Economics and Statistics, University of Innsbruck, Research Platform Empirical and Experimental Economics (eeecon), 2019-14.

[104] Stern, N. (2015). Why are we waiting?: The logic, urgency, and promise of tackling climate change. MIT Press.

[105] Takalo, T., Tanayama, T. and Toivanen, O. (2013), "Estimating the benefits of targeted R&D subsidies", Review of Economics and Statistics, 95(1): 255-272.

[106] Tokila, A. and Haapanen, M. (2009), “Evaluating project deadweight measures: evidence from Finnish business subsidies”, Environment and Planning C: Government and Policy, 27(1): 124-140.

[107] Tokila, A., Haapanen, M. and Ritsilä, J. (2008), “Evaluation of investment subsidies: When is deadweight zero?”, International Review of Applied Economics, 22(5): 585-600.

[108] Varian, H. R. (2014), “Big data: New tricks for econometrics”, Journal of Economic Perspectives, 28(2): 3-28.

[109] Venetoklis, T. (2001), “Business subsidies and Bureaucratic Behaviour – A Revised Approach”, VATT Institute for Economic Research, Research Reports, 83.

[110] Vlontzos, G., Niavis, S. and Manos, B. (2014), “A DEA approach for estimating the agricultural energy and environmental efficiency of EU countries”, Renewable and Sustainable Energy Reviews, 40: 91-96.

[111] Wang, P. (2018), “Analysis of the Efficiency of Public Environmental Expenditure Based on Data Envelopment Analysis (DEA)-Tobit Model: Evidence from Central China”, Nature Environment and Pollution Technology, 17(1): 43-48.

[112] Warwick, K. and Nolan, A. (2014), “Evaluation of Industrial Policy: Methodological Issues and Policy Lessons”, OECD Science, Technology and Industry Policy Papers, 16 [OECD Publishing: Paris, France].

[113] Yin, R. K. (2017). Case study research and applications: Design and methods. Sage publications.

[114] Zhao, B. and Ziedonis, R. H. (2020), “State governments as financiers of technology startups: Evidence from Michigan's R&D loan program”, Research Policy, 49(4): p.103926.

[115] Zúñiga-Vicente, J. Á., Alonso-Borrego, C., Forcadell, F. J. and Galán, J. I. (2014), “Assessing the effect of public subsidies on firm R&D investment: A survey”, Journal of Economic Surveys, 28(1): 36-67.