An Economic Approach to Evaluate the R&D Tax Credit in Ireland

Working Paper

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Contents

Acknowledgments

The authors, Terence Hynes and Brendan O'Connor, are economists in the Economics Division of the Department of Finance.[1] The analysis and views set out in this paper are those of the authors only and do not necessarily reflect the views of the Minister or Department of Finance.

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[1] The authors would welcome comments on this working paper which may be submitted to Terence Hynes at terence.hynes@finance.gov.ie

1. Introduction and Executive Summary

1.1 This working paper discusses the various methodologies available for evaluating research and development tax credits. It was undertaken as part of a wider review of the R&D tax credit published as part of Budget 2014 in October 2013. The 2013 review included an economic literature review, an analysis of data from the Revenue Commissioners, a public consultation on the R&D tax credit, the results of a survey of R&D active companies, and a discussion of how the Irish credit compares to those operated in other jurisdictions.[2] This paper complements the economic analysis in the 2013 review by considering methodological options for quantitative evaluation of the R&D tax credit in the future.

1.2 The R&D tax credit forms part of the Government's strategy for meeting targets under the Europe 2020 strategy. Among other targets Ireland is aiming to invest 2% of GDP in R&D by 2020. Ireland's gross expenditure on R&D amounted to 1.72% of GDP in 2011 which was a substantial increase from 1.16% of GDP in 2003. Given its importance in reaching policy goals and the cost of the R&D credit, which amounted to €261m in 2011, an evaluation was deemed necessary.

1.3 Beyond support in the form of the R&D tax credit, the State also directly subsidises business expenditure on R&D (BERD) through grants administered by IDA and Enterprise Ireland as well as other state agencies. These grants amounted to €118 million in 2011.

1.4 R&D tax credits are difficult to assess using the normal cost-benefit analysis framework largely due to issues surrounding the measurement of the benefits of firm expenditure on R&D amongst other concerns. An alternative approach – used in previous evaluations of R&D tax credits by both HMRC (2010) and Thompson (2009) – is to measure the response (or elasticity) of R&D spending by firms to changes in the tax credit. This approach was pursued by the Department but a number of data limitations were encountered and are described later.

1.5 These data challenges may diminish over time. The Revenue Commissioners are currently introducing a new data collection system which will request additional data pertaining to firms' financial accounts while minimising the compliance burden through electronic filing (known as iXBRL). The availability of such data would significantly improve the capacity for quantitative evaluations of tax incentives of this type. However, the extra data required to evaluate particular tax expenditures will often be unique to that incentive.

1.6 With this in mind, it is recommended that before tax expenditures are implemented, an ex-ante review of suitable evaluation methodologies for the tax expenditure in question is undertaken. One output of this exercise would be to determine what data would be necessary to evaluate the intervention in order to ensure that these data are captured over the life-time of the scheme. This will of course have to be balanced against the need to minimise compliance and administrative burden. By putting in place arrangements to collect

[2] More detail is available in the published review "Review of Ireland's Research and Development Tax Credit (2013) available here: http://budget.gov.ie/Budgets/2014/Documents/Department%20of%20Finance%20Review%20of%20R&D%20Tax%20Credit%202013.pdf.

these data the resources required to undertake evaluation would be lower. More importantly, the availability of appropriate data would enable important issues around the effectiveness and impact of interventions such as the R&D tax credit to be addressed.

1.7 The remainder of the paper is set out as follows

- *Sections 2 and 3* describe the evolution of BERD in the Irish economy over the lifetime of the R&D credit as well as the operation of the R&D credit.
- *Section 4* provides a review of the economic literature on R&D with a particular focus on macroeconomic and firm-level impacts of R&D, market failures that can lead to an underinvestment by the private sector, and economic evaluations of R&D tax credits undertaken in other jurisdictions.
- *Section 5* describes some methodological options for a quantitative evaluation of R&D incentives based on the literature review in Section 4.
- *Section 6* describes the data collected for the purposes of the method pursued by the Department in 2013.
- *Section 7* discusses problems that emerged with the data and issues arising in estimation.
- *Section 8* concludes with lessons learned.

2. Business Expenditure on Research & Development

2.1 Business expenditure on in-house R&D activities reached an estimated €1.96 billion in 2012, an increase of 5.5% on the 2011 level of €1.86 billion, itself a 1.3% increase in the 2010 level. BERD has grown by nearly 80% since the level of €1.1bn recorded in 2003, the year before the introduction of the R&D Tax Credit.

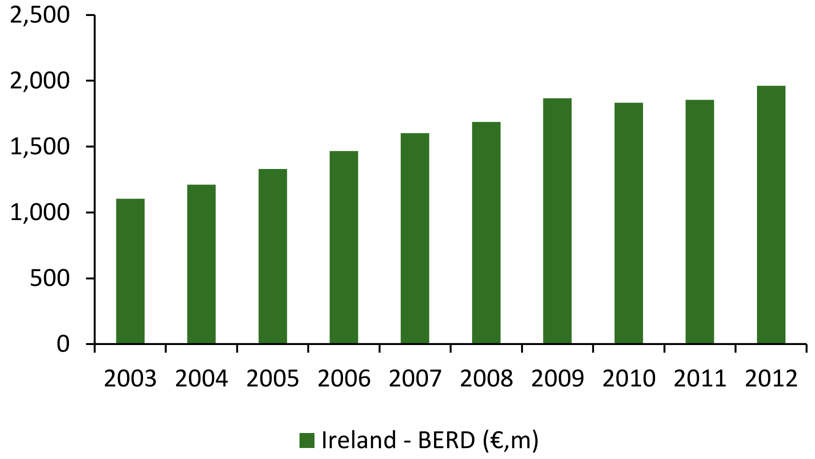

Figure 1: Business expenditure on R&D, € billion 2003-2012
Source: Eurostat

2.2 Business R&D intensity (BERD as a percentage of GDP) reached 1.17% in 2011 (1.46% of GNP). This has risen from 0.78% in 2003 and compares with a euro-area average of 1.31% and an EU-28 average of 1.26%. Finland had the highest BERD intensity in the EU with 2.67% of GDP.

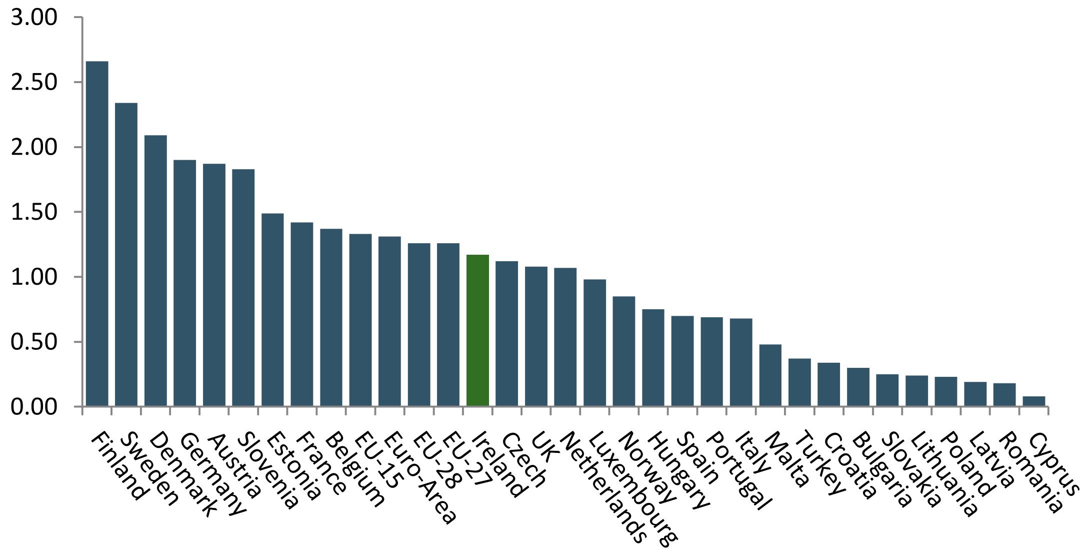

Figure 2: Business expenditure on R&D as a share of GDP, European Union, 2011
Source: Eurostat

2.3 60% of BERD was generated in the services sector in 2011 with 40% taking place in the manufacturing sector. Within the services sector 10% was spent in 'Wholesale and Retail Trade and Transport and Storage' (NACE sectors G-H), 31% in Information and Communications Services (NACE sector J), and 16% in 'Professional, Scientific and Technical Activities' (NACE sectors L-M).

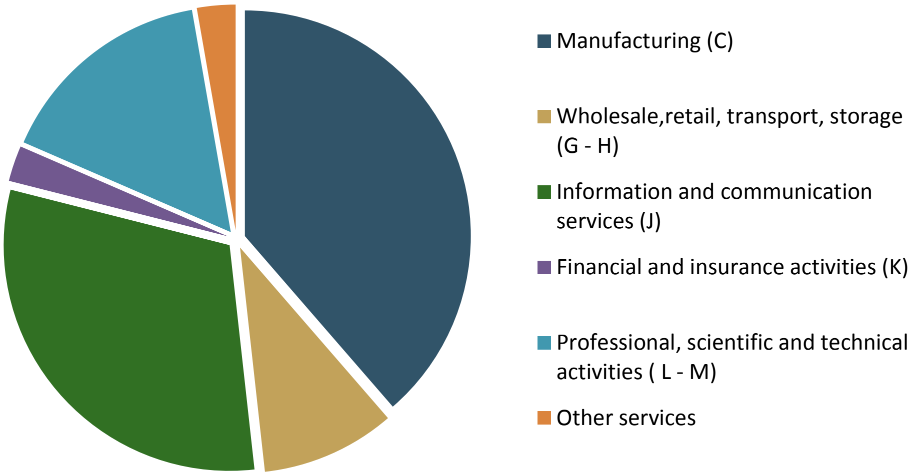

Figure 3: Business expenditure on R&D, sectoral distribution, 2012
Source: CSO

3. R&D Tax Credit

Operation of the R&D tax credit

3.1 The tax credit regime for Research and Development (R&D) was introduced in Finance Act 2004. The key features of the regime include:

- A tax credit of 25% on R&D expenditure, in addition to the normal 12.5% trading deduction.
- The regime is based on incremental spend and provides for expenditure on R&D that is in excess of a company's R&D expenditure in the base year of 2003 to qualify for the credit.
- The base year has been permanently set at 2003, making it effectively volume based for new entrants.
- In line with the Programme for Government commitment, Finance Act 2012 provided that the first €100,000 spend on R&D can qualify for the credit on a full volume basis and Finance Act 2013 subsequently increased this to €200,000.
- There is no ceiling to the level of eligible expenditure over the 2003 base year level.
- Unused tax credits can be carried back for set-off against a company's prior year corporation tax liabilities thus generating a tax refund. Where there is insufficient current or prior year Corporation Tax liabilities, the company can claim unused tax credits in cash over three years (in three instalments over 33 months from the end of the accounting period in which the expenditure is incurred).
- Eligible expenditure includes direct and indirect costs so long as they are incurred in the carrying on of R&D in addition to capital expenditure on related plant and machinery.
- A credit also exists in respect of buildings or structures used for R&D and operates on a fully volume-based approach (i.e. expenditure does not need to exceed a level of expenditure in a base year).

Analysis of R&D Tax Credit Claims Data

3.2 As the econometric approach followed in this study relates to the period 2008-2011, quantitative data on the R&D credit is presented for this period. The data presented below comes from company tax returns submitted to the Revenue Commissioners.

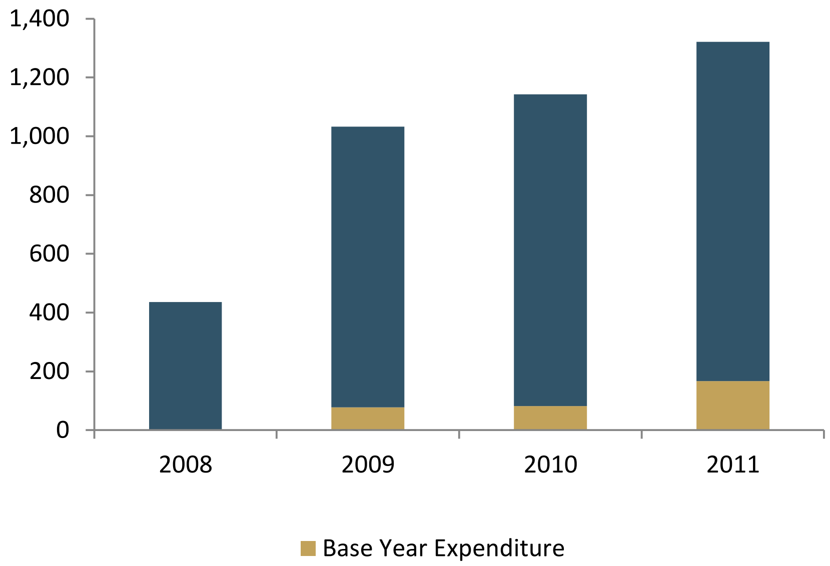

Figure 4: Total allowed and base year expenditure, €m, 2008-2011
Source: Department of Finance analysis of Revenue Commissioner data

3.3. Eligible expenditure for the R&D Tax Credit appeared to increase significantly between 2008 and 2009. This is partly due to the requirement to report base year expenditure on the CT1 form from 2009 onwards but, even accounting for this, the eligible expenditure still experiences a significant climb from €436 million to €955 million. Part of this increase may have been due to the introduction of a system of payable credits for companies which could not previously make use of the credit due to insufficient taxable income. Another reason may have been due to an increased awareness arising from marketing and promotional efforts by government departments and agencies as well as private tax advisors.

3.4 From 2010 to 2011 the allowed expenditure rose from €1,061 million to €1,167 million, a change of €106 million. As the base year expenditure rose from €77 million to €167 million it seems likely that there was a substantial amount of increased reporting of base year expenditure as well as an increases in claims for firms whose R&D spending just breached their base year expenditure.

3.5 In 2011 the difference between overall economy-wide BERD expenditure and the expenditure supported through the R&D credit was about €0.5 billion. A certain proportion of this difference is made up by public grants which are given to firms to carry out R&D as only the non-grant proportion of this funding is eligible for the credit. In 2011 these grants amounted to €263 million.

3.6 The excess expenditure could be the result of firms performing R&D and not claiming the R&D credit. It could also be due to the BERD data being sourced through surveys. It is possible that firms were less stringent in their classification of R&D expenditure on BERD forms than that claimed to the Revenue Commissioners on their CT1 returns. As such, BERD figures could include expenditure not included in the Revenue Commissioner allowed expenditure definition which is based off the OECD's *Frascati Manual.* This implies that the amount of R&D activity being carried out in the economy which is not supported by the R&D credit is relatively small though could still be in the hundreds of millions of euro.

3.7 A system of payable credits has been in place since 2009.[3] Figure 5 shows the amount of payable credit paid out in the years 2009-2011. The amount paid out for 2009 represents payable credit attributable to R&D expenditure in that year. In 2010 and 2011 it represents payable credits attributable to expenditure in that year as well as payable credits related to expenditure in previous years.

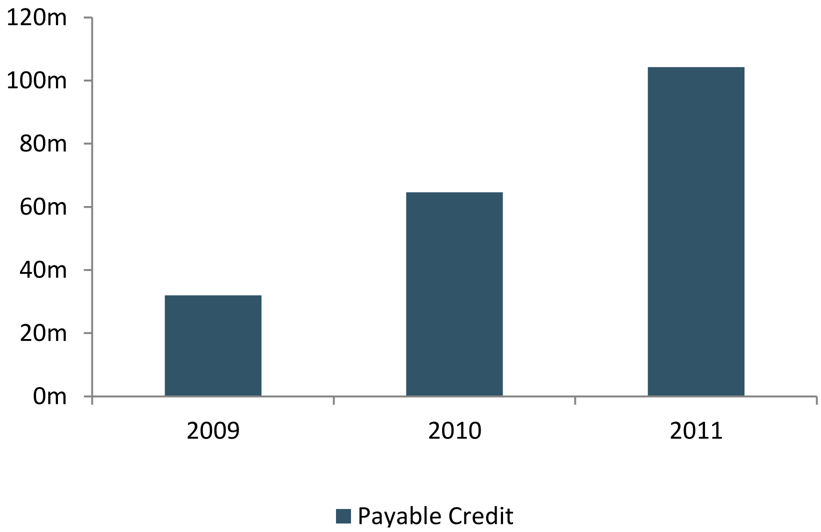

Figure 5: Payable Credit, €m, 2009-2011
Source: Department of Finance analysis of Revenue Commissioners data

3.8 Given the payable credit is received by firms in three instalments it is not unexpected that the cost would double in the first period from €31 million in 2009 to €64 million in 2010 and rise in 2011 by half to €106 million. It can also be expected that the climb in the cost of the payable credit will have stabilised in 2012 with changes in cost only being observed due to changes in firm expenditure and tax liability rather than additional instalments coming online as happened in the first three years of its operation.

[3] A payable credit is available to a firm when they have no taxable income left to reduce in the current tax year and the previous tax year.

3.9 The distribution of companies claiming by number of employees is given in Table 1. The table gives the percentage of total credit claimed in 2011 for a given size of company as well as the numbers of companies in that size category. A company's claim in a given year can include the amount of credit claimed for R&D expenditure in that year, unclaimed credit from previous years, payable credit accruing from previous years as well as a few other small items.

	Value of claim	Numbers of employees
Micro <10	6%	29%
Small <50	23%	40%
Medium <250	28%	22%
Large >250	43%	9%

Table 1: Credit claims by value of claim and by number of employees, for 2011
Source: Revenue Commissioners data, Department of Finance analysis

3.10 As can be seen, the percentage of large firms claiming the credit is quite low at 9% but the percentage of claim that they represent is large at 43%, reflecting the fact that the credit is used by a small number of firms with significant R&D activities.

Findings from the Consultation Process and Survey of Firms

3.11 As part of the R&D review completed in the Department in 2013 both a survey and consultation were undertaken. The outcomes of these interactions with the public and users of the credit are outlined below.

3.12 The majority of the submissions and feedback received from the consultation process and survey were very positive about the R&D Tax Credit in terms of its impact on companies availing of it.

3.13 The importance of the R&D Tax Credit in attracting mobile Foreign Direct Investment (FDI) into Ireland was highlighted extensively in the public consultation with companies.

3.14 In FDI terms, the principal benefit of the R&D Tax Credit is that it reduces the costs of undertaking R&D in Ireland by 25%. The payable credit can effectively be treated as a grant for accounting purposes – this allows a company to account for the credit as income 'above the line' in their annual accounts.

3.15 There is qualitative evidence that the R&D Tax Credit has assisted some traditional manufacturing companies to engage in more knowledge-intensive activities with higher valueadded and win R&D investment from parent companies which can, in turn, act to further embed the manufacturing activity in Ireland.[4]

3.16 The survey indicated that eighty-seven per cent of firms who responded to the survey said expenditure on R&D had increased since they started claiming the tax credit.

3.17 The type of R&D conducted differs between the multinational corporations and indigenous firms – more indigenous firms are doing basic and applied research.

3.18 Smaller indigenous firms reported that the tax credit plays an important role in mitigating some of the financial risks involved in carrying out R&D. In the survey, smaller firms indicated that they would have undertaken less risky R&D activity in the absence of the R&D Tax Credit.

3.19 Eighty-two per cent of survey respondents who claimed the tax credit in 2011 were also in receipt of government grants.

3.20 The survey shows the breakdown of responses from companies when they were asked what would have happened in the absence of the tax credit:

- 60% of those who answered indicated that they would have invested less in R&D, and
- 27% of those who answered indicated that they would have lost R&D projects to other locations.

3.21 The survey identified that, of the relatively small number of companies with expenditure in the 2003 base year, 52% had expenditure of less than €200,000. This would suggest that the base year issue has been addressed for the majority of companies by the recent changes to the tax credit which allow the first €200,000 of R&D expenditure to qualify without reference to the base year.

[4] See R&D tax credit review published as part of Budget 2013:www.taxpolicy.gov.ie

4. Literature Review

Economic Rationale for Incentivising R&D

4.1 Research and Development activity by firms tends to be publicly welcomed due to the perceived tax revenues, highly paid jobs, and perceived wider benefits for the economy associated with large R&D investments. However, economists tend to view the benefits of R&D in terms of their contribution to productivity and thus to economic growth. This section summarises the literature in this area.

Importance of R&D to Economic Growth

4.2 Economists tend to view the productive capacity of an economy as a function of the capital stock and labour supply in the economy. The Solow growth model developed in the 1950's represented production as a function of these two variables. Under the assumptions that capital is subject to diminishing marginal returns and that technological change is exogenously determined, the implication of this model is that additions to capital do not increase output per capita in the long-run. This focused attention on the technological change being determined within the model allowing for an examination of its effects on growth.

4.3 The equation below represents a production function for an economy. It is composed of economic output (Y) and labour (L), physical capital (K) and multi factor productivity (A);

$$\mathbf{Y = F(L, K, A)}$$

4.4 The parameter A captures innovations and technological change in the economy. The role of R&D in fuelling economic growth has been estimated in terms of its contribution to multi-factor productivity (MFP). Coe and Helpman (1993) investigate the effects of both own country and foreign country R&D capital stocks in increasing MFP, finding that that both domestic and foreign R&D make large contributions to MFP and importantly for Ireland; that foreign-owned R&D capital stocks have a particularly large effect on smaller, open economies.

4.5 The link between R&D in the Irish economy and economic growth has also been explored. Analysis has been conducted using the QUEST III endogenous growth model developed by the European Commission specifically for the task of examining structural reform. The research, published by the Department of Finance in the Stability Programme Update 2011, considered the effect of R&D subsidy in the form of a tax credit of 0.1 percent of GDP. In this model, the increase in business expenditure on R&D results in a permanent increase in GDP of 0.22% in the long-run.

R&D Investment, Spillovers and Firm Productivity

4.6 Using a panel of 12 countries Griffith, Redding and Van Reenen (2004) examine whether a country's investment in R&D has an effect on MFP growth and on whether the effect of R&D on MFP growth is dependent on that country's distance from the technological frontier.[5] The authors find that the further a country lies behind the technological frontier, the greater the

[5] This latter test is a proxy for the potential of a country to engage in technological transfer with more technologically advanced countries.

potential for R&D to increase MFP growth through technology transfer from more advanced countries. They also find that human capital plays an important role in innovation but international trade much less so.

4.7 At the firm level, increases in productivity due to R&D are generally seen to occur through two main avenues. The first avenue is through innovations generated internally as a result of R&D activity. The second is through a firm's capacity to absorb the knowledge spillovers occurring in other firms and incorporate them into their own production processes. This latter channel is seen to be dependent on the research and development capacity of the firm.

4.8 At the firm level, increases in productivity due to R&D are generally seen to occur through two main avenues. The first avenue is through innovations generated internally as a result of R&D activity. The second is through a firm's capacity to absorb the knowledge spillovers occurring in other firms and incorporate them into their own production processes. This latter channel is seen to be dependent on the research and development capacity of the firm.

4.9 For instance, Jaffe (1986) investigates innovation and its transfer at the firm level. Jaffe's approach tests the effect of neighbouring firms' R&D intensity on a firm's own R&D success as measured by patents, finding a positive effect, with a larger effect for those firms with higher R&D intensities. In addition, the effect of neighbouring firms' R&D intensity on own firm's profitability and market share is positive where the firm's own R&D intensity is high and negative for those firms with relatively low R&D intensities.

4.10 In the Irish case, Siedschlag et al. (2011) find evidence that all types of innovation and especially organisational innovation has a positive effect on labour productivity. Doran et al. (2012) present evidence that R&D expenditure increases the probability of a firm innovating. Their work finds that Irish firms are more likely to generate innovation from R&D expenditure than foreign firms.

4.11 While R&D expenditure is an important driver of innovation there are many factors beyond R&D expenditure which serve to induce or provide the framework conditions for innovation and productivity, such as broader tax policy, human capital accumulation, competition policy etc. In addition, Irish firms benefit from R&D expenditure in other countries through inter-country spillovers. One commonly observed channel for this exists where R&D activity in the USA is embedded in Irish production processes.

Market Failure

4.12 While the preceding section demonstrates the importance of R&D for economic growth, this does not automatically imply that the State should intervene to encourage R&D investment. Economists usually require the existence of a market failure, for instance underinvestment by the private sector relative to a societal optimum level, as a necessary condition for intervention. There is a significant body of literature describing the market failures which exist around firm investment in R&D and this is discussed below.

4.13 The literature identifies two main forms of market failure that arise with R&D; positive externalities and asymmetric information.

Externalities

4.14 From a societal point of view, firms in the marketplace are generally considered to under-invest in R&D relative to an 'optimal' or desired level that society would choose. This is due to the societal rate of return being higher than the private rate of return available to a firm or investor. The benefit to a private firm is lower than that available to society as a whole due to the inability of firms to fully capture all the benefits arising from R&D conducted internally. This is due to the nature of R&D as a partially non-excludable good i.e. once an idea or innovation is introduced to the marketplace its use by other firms can no longer be restricted effectively by the firm. The ability of firms to absorb and innovate using knowledge developed in other firms is a positive externality often described as a knowledge spillover.

Asymmetric Information

4.15 Another market failure is existence of asymmetric information in R&D investment as first described by Arrow (1962). Entrepreneurs and inventors are often reluctant to provide potential financiers with enough information to make an investment decision. This reluctance to share the information is due to the possibility for replication by competitors. The market failures occur because financiers cannot distinguish between good and bad projects due to insufficient information and thus good projects are not financed and do not take place.

Estimates of Private and Social Returns to R&D

4.16 While previous research has made attempts to estimate the social return of R&D, it is generally acknowledged that accurate measurement is difficult and therefore estimates vary. Hall et al. (2010) reviewed the literature measuring both private and social returns to R&D. They find that the estimates of spillover returns from R&D can range from statistically insignificant to above 100%, though the estimates typically were in the 20%-100% range.

4.17 Empirical evidence on international level spillovers produced by Coe and Helpman (1993) indicates that roughly a quarter of the benefits of conducting R&D accrue to a country's trading partners. This implies that Ireland benefits significantly from the R&D conducted in our R&D intensive trading partners i.e. US, UK and Germany.

Government Means of Affecting Business Expenditure on R&D

4.18 There are a myriad of ways through which Governments try to influence the level of private R&D expenditure in an economy. These range from the more direct and commonly known methods such as grants and tax credits, to the legal, regulatory and competitive environment fostered in a country through patent law; competition, tax, and immigration policy; and the efficiency of public administration. In addition, the ability of a country to supply highly educated staff through its higher education system is critical. The three most prominent methods, patent laws, grants and tax credits, are outlined below taking into account their efficacy as assessed by the empirical literature.

4.19 Patent law increases the appropriability of private returns to R&D by offering legal protection to intellectual property. However, this approach has drawbacks as it inherently trades off public benefits for private. The limitations on the free use of new ideas inhibit both further research and the development of valuable commercial innovations which are a source of spillover benefits. Thus, although patent protections and similar rules maintain a prominent role in innovation policy (for example in the pharmaceutical industry), governments have also turned to direct support of R&D activities.

R&D Tax Credits and Grants

4.20 One pillar of supports for R&D expenditure is grants tied to specific R&D projects and/or capital investments as a means of increasing R&D expenditures. A grant-based system allows a more targeted approach to the investments made in an economy while also giving certainty to the exchequer regarding ultimate cost. However, this targeted approach is in itself an issue as it places a significant burden on the granting authority when deciding among many applicants and rent seeking that may arise for a specific research area once grants are committed. Often these R&D projects require a significant level of expertise in specific areas of science which may not be readily available to a granting authority.

4.21 As the purpose of this review is to evaluate the R&D Tax Credit the rest of this chapter concerns itself with this topic.

4.22 The theory of optimal taxation requires that a form of tax be neutral on an individual's or a company's decisions, for example between one form of investment and another. Neutrality would therefore imply that a company should not be incentivised to invest in R&D over other investments. However given the externalities that exist in respect of private sector investment in R&D, R&D incentives are regarded by economists as one of a small number of examples of where policy makers should explicitly depart from neutrality.[6] For example, the Mirrlees Review in the UK explicitly identified R&D tax incentives as one of the few areas where Governments should depart from the concept of neutrality in terms of the concept of optimum taxation.[7]

4.23 Tax incentives are a market-orientated means of delivering an increase in private R&D expenditures which also allows the support offered by the credit to respond flexibly to market demand. Tax credits allow expenditure to be directed by market aware firms rather than a centralised authority. While the flexibility of a credit to respond to market demand is useful it also creates an uncertain and open-ended demand on the exchequer. Their operation varies between countries but in general companies can deduct a percentage of eligible R&D expenditure from Corporation Tax liability.

[6] Other examples include the taxation of environmental or social bads, which seek to reduce *negative* externalities.

[7] See Section 2, the Economic Approach to Tax Design in 'Tax by Design', the Mirrlees Review, Institute of Fiscal Studies, London, 2011.

4.24 Eligible R&D expenditure in most countries is guided by the OECD *Frascati Manual* which places strict limits on what are considered R&D expenses and activities. In certain jurisdictions such as Ireland there are provisions allowing the credit to be retrospectively applied, carried forward into future years and/or refunded to the company if profit is insufficient in a given year. The latter option is considered to be especially important as a cash flow source for start-up companies which often do not have profits on which to offset a credit or ready access to liquidity or early stage financing.

Ability of Government to Correct the Market Failure

4.25 The existence of a gap between the private and social returns to R&D, as outlined previously, is not sufficient in itself to justify a government support such as a tax credit. A significant concern with regard to government supports for R&D is their efficacy in eliciting additional R&D expenditure from firms. The danger is that firms may just substitute the government's funds for internal funds they would have otherwise invested themselves. Where an R&D credit replaces existing firm expenditure it imposes a deadweight loss on society as this has to be financed from elsewhere in the economy through taxation. In addition, there are unintended consequences associated with government incentives for R&D which are supported by empirical research. These are set out below.

Additionality

4.26 There is a large body of literature which attempts to evaluate the additionality of R&D Tax Credits by calculating the benefit-to-cost ratio. This ratio gives the amount of firm R&D expenditure induced for a given amount of tax foregone. Benefit-to-cost ratios greater than one are considered to be effective interventions.

4.27 The body of literature which attempts to calculate a benefit-to-cost ratio is varied by methodology, jurisdiction, data type, time period etc. which makes any two comparisons between results difficult. However, a series of such evaluations reviewed by HMRC in the UK found that for every one euro foregone in each jurisdiction, between €0.29 and €3.6 was induced from private firms.[8] HMRC's own analysis of the UK's R&D Tax Credit scheme found the benefit to cost ratio to be up to £3 in private R&D expenditure for every £1 foregone in tax revenue.

4.28 However, this measure alone is by no means a complete endorsement of the R&D Tax Credit. While the ability of R&D Tax Credits to effect an increase in private R&D expenditures is crucial, other consequences need to be considered in making a judgement on the ability of the R&D credit to have a positive effect on the economy.

The Unintended Consequences of Stimulating Private R&D

4.29 A classic concern raised by Goolsbee (1998) is that that tax credits along with other similar government incentives only serve to increase the wages of scientists and researchers as opposed to increasing knowledge creation in firms because in the short run the labour supply of researchers is inelastic. While this phenomenon would fail to result in the normal benefits associated with an increase in research activity, in the long-run the increased wages may

[8] http://www.hmrc.gov.uk/research/report107.pdf

induce people into the technical and research based careers thus serving to reduce wages and increase output of scientific research and commercial innovation.

4.30 Evidence presented in Bloom, Griffith and Van Reenen (1999) suggests that the location of R&D may be affected by tax-induced changes in the cost of R&D. So while tax credits may demonstrate themselves to increase R&D activity within a given jurisdiction, this may not result in as large a net increase globally. This concern was raised recently by the OECD.[9] They discuss the consequences of incentives created by multiple tax systems to produce knowledge-based capital, embed it in production and hold the patent rights for it in different jurisdictions. In this scenario it is unclear how the spillover benefits from R&D are distributed between economies. In addition, the OECD argue that domestic firms will be at a disadvantage due to their limitations in accessing the benefits of tax-planning via multiple jurisdictions which would limit their ability to compete and grow in a globalised world.

Results of Reviews of R&D Incentives in Other Countries

4.31 The following paragraphs outline the results of reviews of R&D tax incentives in other jurisdictions. The countries included are France, Norway, Canada, Australia, and the United Kingdom. These have been authored varyingly by institutions under whose aegis the R&D Tax Credit operates or by academics familiar with the literature surrounding R&D.

4.32 The difficulty surrounding measurement of the benefits and causation of R&D schemes results in several lines of research. The most common are concerned with the responsiveness of BERD to the credit regime. As such, the reviews below tend to deal with some aspect of this measure. Australia and the UK receive special focus given that their methodology is the same as that followed by the Department for the Irish R&D credit. Other methods such as the Cappelen et al. (2011) research discussed below focus on impacts on innovation outcomes.

France

4.33 A review France's R&D Tax Credit was undertaken by the French Evaluation Committee for Tax Expenditures and Social Contribution Exemptions which reported in 2011. The report produced by the Ministry of Finance was tasked with identifying tax expenditures with opportunities for reform. The authors evaluated the R&D credit in general as well as the reforms of the scheme previously implemented in 2008.

4.34 At the time of their introduction the reforms were projected to have the capacity to raise GDP by 0.3% after 15 years. Acknowledging the dynamic process of R&D investment and the early stage of the reforms effects, the Committee considered that any attempt to quantify their macroeconomic impact would be premature.

4.35 Other findings include:

- In many industrial sectors, R&D expenditures as a percentage of the turnover improved between 2007 and 2008;

[9] http://www.oecd.org/sti/inno/newsourcesofgrowthknowledge-basedcapital.htm

- French affiliates of foreign companies increased their R&D expenditures faster than other French companies. This suggests that the tax credit improved France's international attractiveness; and,

- Corporate R&D expenditures continued to grow in 2009 despite a sharp decline in GDP due to international crisis.

4.36 Mulkay and Mariesse (2004) look at an earlier period than the committee and find that the estimated impact of a €1 tax credit on R&D expenditures to be in the range of an increase of €2 to €3.6 in the long term. However, as mentioned, the credit has been reformed since then. As such it is unclear how these elasticities may have been affected.

Norway

4.37 Cappelen et al. (2011) estimate the impact of the Norwegian tax credit on firms' innovation outputs. Their probit model controls for self-selection into the R&D credit scheme in a two-step estimation process. The data used is from the Community Innovation Survey of Norway.

4.38 A key result of their research is that the tax credit stimulates innovation in products and production processes for the firm. However, it is less associated with major product innovations. The authors suggest that this finding indicates that the credit may not result in significant spillover effects although this may reflect the nature of the credit in Norway which targets smaller companies.

Canada

4.39 Possibly the most comprehensively studied research and development tax credit is the Canadian tax credit. Parsons and Phillips (2008) review the literature on Canada for three key areas: spillover benefits of R&D; opportunity cost of public funds; and administration and compliance costs. Using parameter values in these areas and the elasticity of R&D to the credit the authors build a general equilibrium model of changes in welfare over three stages.

4.40 The first stage considers changes in welfare in a world where there are no externalities associated with R&D and no tax distortions (or compliance costs) associated with the scheme.[10] This scenario concludes that the R&D credit is net welfare reducing. This result confirms that, in the absence of externalities, government subsidies lower welfare since the gain in producer surplus of R&D subsidised firms is lower than the loss to other firms, which must pay for the subsidy.

4.41 The next stages add in the welfare benefits of spillover effects from conducting R&D as well as the distortionary impacts of taxation on the economy. Spillovers are included by adding the benefit private firms receive from R&D conducted in other firms. The effects of taxation enter the model in two ways. Taxes taken from the economy distort the allocation of resources and therefore impose a welfare loss on society. In addition, the increased R&D generates its own tax revenue, thus reducing the need to raise taxes elsewhere thereby reducing the welfare loss of the endeavour. The authors also include administration and compliance costs, part of which also has to be financed by government, resulting in further welfare losses from distortionary taxes.

[10] No tax distortions in the economy are allowed for by a flat tax on the economy.

4.42 The model requires estimates of key parameter values such as the long-run R&D incrementality ratio, the spillover benefit from conducting R&D and the cost to society of distorting the allocation of resources.

4.43 The general equilibrium model is used to estimate the welfare gain to society of subsidising private R&D. The authors calculate that the net welfare gain per dollar of tax subsidy is 0.109. In other words the gross gain per dollar of subsidy is approximately $1.10.

4.44 As the estimation approach described for the Irish tax credit relies heavily on that produced for the Australian and UK credits these reviews are discussed in greater detail below.

Australia

4.45 Thomson (2009) examines the role of tax policy in determining firm investment in R&D. The analysis uses an unbalanced panel of financial data for about 500 large Australian firms between 1990 and 2005.[11]

4.46 The approach to estimating the role of tax policy in firm's R&D investment involves constructing a user cost of R&D for each firm. This approach was first attempted by Hall (1992a) who introduced it to a R&D investment demand equation.

4.47 The user cost incorporates the required rate of return for the firm which should reflect firms' industry and company characteristics as well as the effect of the tax credit on lowering the cost of financing R&D and in theory should serve to increase firm investment in R&D.[12]

4.48 Thomson attempts to approximate a firm's required rate of return by calculating the Weighted Average Cost of Capital (WACC) and the Return on Assets (ROA). The WACC however is only available for publicly listed companies which are a subset of the dataset.

4.49 The basis for using the ROA is that on average, over the medium to long-term, firms must earn enough from assets employed to pay back their cost of capital otherwise they will be forced into liquidation and as such reflects the firms cost of capital. Return on assets is calculated as profits plus interest over total assets.

4.50 The R&D investment demand equation is derived from the firm's capital accumulation constraint and the firms profit maximising choice of R&D stock which incorporates the effects of the R&D credit. A common issue in estimating relationships to R&D is the difficulty of estimating R&D stock. Thomson deals with this issue by including instead a lag of R&D expenditure in with the independent variables.

4.51 As demonstrated by Nickell (1981) the inclusion of the lagged dependent variable means that estimating the model in fixed effects will cause dynamic panel bias.[13] This is where the lagged

[11] An unbalanced panel dataset is one where the same firms are observed repeatedly over time but the time period covered for each firm is allowed to vary.
[11] The required rate of return is the minimum return necessary for a project before it will be undertaken by a firm.

[13] Estimating in fixed effects removes the unobserved time invariant effects on firms such as managerial quality.

dependent variable is correlated with the error term.[14] Using own lags to instrument for this variables, as under the Arellano and Bond (1991) GMM estimator, overcomes this issue.

4.52 Data used comes from the IBISWorld database which has information on company financial accounts and their expenditure on R&D. Data on firm liquidity, sales, ROA, and WACC is used. Macro variables such as the risk free rate on 5 year government bonds and GDP are also included as control variables.

4.53 The results show the user cost of R&D variable to be insignificant in firms' decision to undertake R&D. The relationship between R&D investment and employee numbers is significant and positive showing that larger firms are more likely to invest in R&D. Sales is also positive which reflects that demand for output is an important determinant in firms' investment in R&D.

4.44 Thomson provides possible reasons for why the user cost might be insignificant in firm's decisions to undertake R&D. It may reflect a poor firm responsiveness to the return on assets which forms a key component of the user cost of R&D. Another reason is the volatile policy environment the R&D credit experienced in Australia during the period. Thomson cites Guellec and van Pottelsberghe (2003) as evidence that changing policies on R&D tend to be less effective. A third reason is the statistical difficulties entailed in measuring what can be a small policy effect on the decision to undertake R&D among many other factors involved in R&D investment decision making.

United Kingdom

4.45 A review of the United Kingdom's R&D Tax Credit was carried out in 2010 by HMRC. The report is built on an earlier feasibility study by Oxera (2006) recommending that the estimation of an elasticity of R&D expenditure to the credit could provide the most accurate indication of the impacts of the R&D credit scheme. Oxera also suggested that a potential control group could be formed through the identification of firms that have similar characteristics but do not claim R&D Tax Credits or through the use of data from the same firms before the introduction of the policy. HMRC found difficulties in developing a control group according to those methods outlined in the Oxera report.[15]

4.46 HMRC's model indirectly estimated the impact of the credit by estimating how changes in the user cost of R&D (mentioned in the discussion of Australia above) impact on levels of expenditure on R&D. In their model increasing the R&D credit rate decreases the cost of financing R&D, and correspondingly (in theory) increases the level of R&D investment.

4.48 Similar to the Thomson study of Australia above, the user cost of R&D incorporates the R&D credit and the required rate of return into a single variable. The process of constructing the

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[14] The mean of the lagged dependent variable contains observations t=1,…,T-1 on the independent variable and the mean error - which is being conceptually subtracted from each error term - contains contemporaneous values of the error term for t=1,…,T. The resulting correlation creates a bias in the estimate of the coefficient of the lagged dependent variable which is not mitigated by increasing the number of units.

[15] The use of control groups in evaluating the impact of Ireland's R&D Tax Credit was also recommended by the OECD in its recent economic survey on Ireland.

dataset in this study is similar to that completed by the Department of Finance as described in the data chapter later. The authors constructed a panel of 451 companies which consistently claimed over the period 2003 to 2007. Data from each firm's profit and loss account were taken from company tax returns. Balance sheet items and employee numbers were taken from FAME.[16] Missing data in for companies' variables resulted in a 40% loss in observations.

4.49 Reported long-run elasticities for SMEs were significant and in the range of -1.11 to -1.9. So in the long-run a one per cent increase in the tax credit would increase private expenditure on R&D by between 1.11%-1.9%. For large companies the long-run elasticity was -3.65. In addition, they report that short-run elasticities were smaller than the long-run elasticities indicating that there is a lag in the response of firms to the credit.

4.50 Their review also contained a qualitative element featuring interviews with managing directors, finance directors and the directors responsible for R&D in sixty-nine companies. The main purpose of these interviews was to assess the degree to which these companies would be engaged in R&D if the credit did not exist. The results of the interviews suggested that the credit had little effect on decisions to conduct individual pieces of R&D work, a finding that would seem inconsistent with the quantitative results.

4.51 The authors believed however, that these views were a function of the timing of claims (after the expenditure has been incurred), and of the communication gap between the R&D and the finance functions of companies. They also note a generally poor understanding of the operation of the credit among interviewees.

[16] FAME is a large database which holds information on Irish and UK companies.

5. Methodological Options

5.1 This chapter discusses the various methodological approaches that can be taken to investigating the impact of R&D credits.[17] It discusses:

- Cost-Benefit Analysis;
- Randomised Control Trials;
- Statistical Control Groups;
- Surveys
- Simulation Methods; and,
- Structural investment modelling.

Cost-Benefit Analysis

5.2 Ideally, the evaluation of a policy measure requires a Cost-Benefit Analysis to be completed. While the costs of the R&D tax credit are relatively easy to measure in terms of the amount of tax forgone and refundable credit paid out, the benefits are difficult to measure and harder to causally associate with the R&D credit. The benefits for the economy arise through the positive externalities from firms discovering new products and processes that other firms can replicate and innovate from. These spillovers exist due to the non-excludability of information which also contributes to its difficulty in measurement as discussed earlier. It is difficult to ascertain what level of societal benefit accrues to that extra R&D which can be accounted for by the credit. Canada uses estimates of the social rate of return and BERD elasticities in a general equilibrium model to associate the benefits of R&D with the increase in R&D activity. The results have been presented in the literature review section.

5.3 Given the difficulty estimating the societal benefits directly attributable to R&D credits many evaluations try to assess the degree to which the credit increases private R&D expenditure (such as in HMRC (2010) and Thomson (2009) discussed in chapter 4). This is a necessary but not sufficient condition for a credit to be effective.

Randomised Control Trial

5.4 An ideal evaluation would be based on a randomised control trial. This would involve randomly assigning the R&D tax credit to some firms who applied for the credit and not to others.

5.5 Firms utilising the credit could then be compared to those firms who did not receive the R&D credit to see if their R&D activity adjusted over time to a higher level in response to the lower cost of doing R&D. However, the conditions necessary for this evaluation are prohibitive. The

[17] See OECD (2010a) for a discussion of the various evaluation techniques that might be employed in R&D credit evaluations and their limitations.

most severe constraint is that it may not be possible to legally withhold a credit from certain firms. Thus the randomised trial may be subject to significant legal challenge.

Statistical Control Group

5.6 It is possible to approximate this scenario by constructing a statistical control group through propensity score matching methods. By taking firms who are in receipt of the credit and conducting R&D, and comparing them to firms who are not in receipt of the credit but are conducting R&D the treatment effect of the credit can be observed and measured. The control group in this scenario is constructed by taking the characteristics of the treatment group such as NACE sector, geography, profit status, sales, size etc. and finding companies comparable to the treatment group based on these variables but are not in receipt of the credit.

5.7 The OECD have recommended that Ireland use this method to evaluate the R&D credit:

"Ireland needs to carry out more evaluation of the effectiveness of its particular scheme using statistical methods that generate control groups to isolate the effect of the credit beyond other factors" (OECD, 2013)

5.8 However, there are difficulties around constructing this control group mainly due to absence of data on firms that are not claiming the credit. It is possible that these firms are captured as part of the BERD survey and could be identified from that source. While this remains a possible avenue for future research it appears that, as of now, this approach may only be feasible for 2007 BERD data as the number of firms performing R&D and not claiming the credit diminished substantially after this point. Moreover, given the significant changes in the structure of the Irish economy and the R&D credit since then, the policy relevance of the research findings would be limited.

Surveys

5.9 Survey data from key personnel in R&D performing companies can be used. The Department of Finance carried out a survey as part of the wider review of the R&D tax credit in 2013 which is available on the website. However, information from surveys may not provide appropriate results for econometric evaluation due to its subjectivity. For example, opinions on the impact of the R&D tax credit can vary by whether or not the survey respondent is part of the research or financing function within the company which, can in turn, introduce noise into the data. In addition, respondents may have strategic reasons for over or understating the impact.

Simulation methods

5.10 Where empirical research is limited it is possible to develop simulation models of the firms in the economy. These models use parameters from empirical literature to simulate the potential effects of the R&D tax credits on firms R&D investment. These scenarios, while empirically grounded, do not give estimates of the actual performance of the R&D credit in the Irish economy. An example of this approach is that of Bond, Denny and Devereux (1993), who calculate that a 1-2 per cent fall in the cost of capital can increase firm investment by 5 per cent.

Structural Econometric Modelling-R&D demand equation

5.11 The difficulties and limitations mean that the above methods of evaluation are often bypassed in the literature in favour of a structural model of R&D demand by firms. This approach, used in the UK and Australia as outlined in section 4, is taken by the Department. This model captures the firm's demand for R&D as a function of the user cost of R&D. The user cost of R&D is itself a function of the R&D credit and as such allows for the estimation of the increase in firm expenditure on R&D as a result of the credit. While this does not, strictly speaking, result in benefits to the economy from knowledge spillovers (positive externalities) an assumption can be made that spillovers rise with the amount of BERD such that the credit can be deemed successful in delivering knowledge spillovers.

5.12 However, questions remain as to the nature of the R&D that arises. If the additional projects firms choose to engage in on receipt of the R&D credit have lower spillover, the benefits to the economy of these projects are lower. Responses from the R&D survey carried out by the Department indicated that some firms undertook riskier R&D projects as a result of R&D. This implies that the existence of the credit does change the nature of the R&D project undertaken though it is not clear whether it serves to reduce or increase R&D quality or societal spillovers.

5.13 The extent to which firms raise their R&D investment in response to a tax credit is clouded by the possibility that some firms are conducting the amount of R&D activity they would otherwise have had if the credit had not been in existence but are using the credit to replace their own internal funds. In this scenario the credit would be an inefficient means of increasing expenditure on R&D. If it can be shown that firms who face a lower cost of doing R&D conduct more R&D then the credit, to the extent that it can be shown to lower the cost of conducting R&D, can be said to successfully increase BERD.

5.14 The next section deals with the estimation methodology for structural econometric modelling.

Estimation of R&D demand equation

5.15 The estimation methodology followed by the Department is an R&D demand equation approach based Thomson (year) and HRMC (year) and outlined in the previous chapter.

The key difficulty in estimating the effect of R&D tax incentives in a firm's R&D demand equation is finding an exogenous measure of the benefit of the R&D credit to a firm.

5.16 This problem is due to the nature of how the R&D tax credit operates. In most R&D tax credit systems the benefit of the R&D tax credit to the firm is a function of the amount of R&D investment taking place.[18] This creates an endogeneity problem in the model between the level of R&D investment and the user cost of capital.

5.17 Hall (1992a) includes tax policy in the demand equation by calculating the firm's effective realised value of the tax incentive. To deal with the endogeneity problem, Hall uses forecasts

[18] For example, in Ireland's case the user price of R&D is lowered by 25% of the amount of R&D eligible expenditure which is over and above the base year expenditure.

of the firm's expected tax price of R&D based on information at t-1 such as sales, R&D growth rates, and the past tax status of firms.

5.18 However, the benefit of the US tax credit during the period was dependent on expenditure in the previous three periods. As such, firm expenditure was not exogenous with respect to the next period but rather optimised with respect to it. In addition, the variables used are not strictly exogenous either.

5.19 Thomson (2009) and HMRC (2010) approach the user cost in another fashion. Their method constructs the user cost of R&D from the firms required rate of return and the effect of tax policy on lowering this value. As discussed in the literature review the required rate of return is proxied by the return on assets (ROA).

5.20 In the case of Thomson, variation in the user cost of R&D is due to the individual firm's ROA and the change in tax policy which affects all firms simultaneously. For HRMC's review, the policy environment was stable through the period and the variation is solely through the ROA. Beyond whether the user cost of R&D is significant in estimation results, the approach requires the acceptance that the credit is effective at lowering the cost of R&D for the firm before inferences can be made about the effect of the credit on R&D for this research.

5.21 While Ireland's R&D credit rate changed from 20% in 2008 to 25% in 2009 an additional and more useful source of quasi-exogenous variation in the R&D credit comes from the base year expenditure limit which affected about 14 percent of firms applying for the credit in 2011. This creates a variation of the credit's generosity which is unique to each firm i.e. each firm will have a base year expenditure which is independent of each other firm. This base year expenditure limit means that firms receive the benefit of the credit at different amounts of expenditure which should feed through to different effects on R&D expenditure if the credit is effective.

5.22 While adding the base year expenditures effect to the user cost risks introducing endogeneity between in the variables, it appears acceptable given the decision to invest in 2003 was made before the introduction of the R&D credit and 5 years before the earliest year in our observation period. In addition, data is held on firm's actual depreciation which could add to the variability of the user cost.

5.23 Thus the R&D investment decision is a function of the user cost of doing R&D which is a mixture of tax policy (i.e. the credit) and the required rate of return proxied by the ROA. The decision to invest in R&D is also a function of other factors such as the firm's cash flow position represented by the firms liquidity ratio; demand, which is accounted for by the firms turnover; and the size of the company, which is theorised as both a disadvantage and an advantage in conducting R&D. [19] These variables function as control variables in the equation.

[19] Size is perceived as an advantage in allowing a firm to diversify R&D streams while smaller firms are thought to be more dynamic in responding to new innovations or market opportunities.

5.25 One problem with this model is that it relies on knowledge of the stock of R&D capital. There are significant difficulties in measuring this variable. However, it is possible to deal with this issue by including a lagged R&D expenditure in its place as per in Thomson and by HMRC.

5.26 A common issue in the use of panel data is the heterogeneous missing variable of managerial quality which is specific to each firm. This is commonly dealt with by estimating the model in fixed effects. However, this results in the transformed lagged dependent variable being correlated with the transformed error term which is called dynamic panel bias. [20]

5.27 The issue requires estimation by differenced general methods of moments as demonstrated in Arellano and Bond (1991). The AB estimation method also allows for possibly endogenous variables such as sales to be dealt with by replacing them with their own lags. The user cost is also estimated in logs which gives the coefficient the interpretation of being an elasticity. The model specification is given below:

$$\Delta\log(k_{it}) = \beta 1\Delta\log(k_{i,t-1}) + \beta 2(x_{it}) + \beta 3\Delta\log(\text{user cost}_{it}) + \Delta u_{it}$$

5.28 where k_{it} is expenditure on R&D for firm i in period t, x_{it} is a vector of the control variables sales, liquidity ratio etc., and u_{it} is an unobserved error term.

5.29 The coefficient on the user cost variable is the short-run elasticity. The long-run elasticity (α) is given by:

$$\alpha = \beta 3/(1- \beta 1)$$

5.30 The formula for the user cost of R&D is:

$$(1 - \rho)/(1 - \tau)*(r_{it} + \delta)$$

5.31 Where ρ is the R&D tax credit rate, τ is the corporation tax rate, r_{it} is the financial cost of capital for firm i in period t and δ is the depreciation rate which is firm and time invariant.

[20] Fixed effects estimator subtracts from each observation the mean of all observations for a given unit as which takes out unobserved time-invariant effects.

6. Data

6.1 This section contains a description of the data available on companies claiming the credit. The data requirements were outlined in the previous section discussing the estimation technique.

6.2 The necessary data were located in both the Revenue Commissioners database and in accounts filed at the Companies Registration Office (CRO). See Box 1 for the steps taken in constructing the dataset.

6.3 Table 2 below gives the main variables necessary and their location in either the CRO or the Revenue Commissioners or both in the case of the interest variable.

Variables	Source
R&D Expenditure	Revenue Commissioners CT1 form
Profit	Revenue Commissioners CT1 form
Sales	Revenue Commissioners CT1 form
Net Interest	Revenue Commissioners/CRO
Total Assets	CRO
Current Assets	CRO
Current Liabilities	CRO
Employee Numbers	Revenue Commissioners P35

Table 2: Variables needed for econometric study and their source(s)

6.4 Firm level R&D expenditures, profit, interest, and employee numbers come from the Revenue Commissioners CT1 corporation tax return form and company tax return and P35 tax return forms.[21] However, interest is not a mandatory field on the CT1 form and this resulted in a significant loss of useable firms. A number of firms were recovered by including, where available, interest from companies' accounts filed with the Companies Registration Office (CRO). The balance sheet items- total assets, current assets and current liabilities were all taken from the CRO.

6.5 As the number of firms in 2007 was too small to allow for an adequate sample of firms, 2008 was chosen as the start year for the analysis. The most up to date data were for the year 2011. A necessary condition for a firm to be used in the dataset was that it claimed the credit in all 4 years and had all the necessary items in . This condition significantly reduced the sample size available for study. For example, the number of firms claiming the credit in 2008 was circa 700. The number of these firms claiming the R&D credit in each of the following

[21] P35 forms are submitted by firms to the Revenue Commissioners to administer the collection of employee taxes and social security contributions

three years 2009-2011 was circa 400. Given the requirement for interest and balance sheet items from the CRO the number of firms remaining after matching with the Revenue Commissioner data was reduced to 51. This number is quite small and presents its own difficulties in estimation and interpretation of the results.

6.6 Box 1 below lists the steps taken in the collection of data necessary for the econometric evaluation, the difficulties encountered and the attrition of data due to these difficulties.

1. Authorisation on a confidential basis was required from the Revenue Commissioners (RC) before accessing any data on corporation tax or P35 returns.

2. The data requested covered items on the CT1 form related to R&D credit claims as well as firm turnover, profit, loss, depreciation and interest covering the period from the credit's inception in 2004 to 2011. P35 data were also requested which gives numbers of employees for each company. Data related to 2012 were not available at the time.

3. A matching process was undertaken to identify to find companies consistently claiming in each period 2008-2011 inclusive which was facilitated by using the firms' internal id number used by Revenue. This process resulted in 400 companies which claimed in each year.

4. Firms with missing variables were dropped from this dataset. In the main, companies had missing observations for interest payable which is a non-mandatory item on the CT1 form.

5. Firms were matched with their accounts as filed with the CRO.[22] This allowed for the balance sheet items current assets, current liabilities, and fixed assets to be identified.

6. Some of the firms dropped due to missing observations in the interest field were recovered here by taking interest from their profit and loss accounts, where it existed.

7. The final dataset resulted in 51 firms observed in all years over the period 2008-2011 inclusive. Of these firms 10 had base year expenditure in 2003.

Box 1: Steps taken in building the dataset

[22] Data were compiled by Vision-Net.ie. Vision-net.ie collects firms' accounting information from the CRO and digitises it into a database format.

7. Data Availability & Estimation Issues

7.1 As discussed in the estimation section, the firm's cost of capital which is an input into the user cost of capital and is a key feature of the firm's capacity to undertake R&D investment is proxied by the firms' ROA. Of the 51 firms, 23 had negative ROA's during the period 2008-2011. This is perhaps a reflection of wider economic developments at the time. The effect of the negative return on assets for these companies is that it yields a proxy for cost of capital which does not make economic sense as the actual financial cost of capital has a lower bound of zero. Excluding these firms results in a dataset of 28 from the initial 400 companies with R&D tax credit claims in all 4 years. Accordingly, the estimation of the firms R&D demand equation is unlikely to yield accurate results.

1.8 Due to the problems of using the ROA to proxy for the cost of capital during the time period, use of the weighted average cost of capital was considered as in Thomson (2009). However, there would be considerable difficulties calculating CAPM for firms in the profile. [23] Given the costs that would be involved in estimating the WACC for these firms the option was deemed infeasible.

7.3 Consideration was given to expanding the sample by estimating an unbalanced panel dataset however, this approach is quite demanding in that the Arellano and Bond estimator requires firm-level data spanning at least three periods to form an unbalanced panel. As the number of firms claiming the R&D credit in 2007 is quite low, this reduces the number of firms who could be captured over 5 years. These limitations restrict the increase in observations that might be obtained from an unbalanced dataset.

7.4 The number of firms in the final sample which had base year expenditure in 2003 was 10. This number is low at 20% of the sample and as such removes some key exogenous variation in the user cost of R&D.

7.5 More data for the evaluation method presented here may become available upon the next release of CT1 data for 2012. The number of firms claiming the credit jumped by over 40% from 2008 to 2009 and as such the upper bound on the number of firms claiming consistently in a four year period will have increased. This however, may not overcome the difficulty presented in using return on assets as a proxy for the financial cost of capital given the considered is still unstable in macroeconomic terms. Nevertheless, the longer the period of time under observation the better, so greater than 4 years would be ideally desired for study.

7.6 For the estimation approach followed in this evaluation, the currently collected data have limitations. As already mentioned, the Revenue Commissioners only request interest payable from companies. While it is possible that firms interpret this as net interest which is the variable required for the return on assets, it is likely that only interest payable and not interest receivable is reported there. In addition, some firms reporting assets in company accounts filed with the CRO are reporting the assets of multinational firms consolidated accounts between for example, Britain and Ireland. The degree to which this asset base reflects the

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[23] The WACC is a weighted average of the cost of debt and equity both weighted by a company's gearing. Cost of equity is estimated using the Capital Assets Pricing Model which requires market data, including company's share price which would not be available for the majority of companies in the dataset.

asset base of the R&D conducting entity is not certain and could underestimate the ROA through a denominator effect. Transfer pricing could also distort profit and loss variables introducing further measurement error.

7.7 The Revenue Commissioners are currently instituting a new system of electronic filing for firms. Filing financial statements electronically will be mandatory for all firms, (not excluded based on exemption criteria), from late 2014 onwards.[24] Electronic filing requires that each item from the firm's financial statements e.g. profit and loss account, balance sheet etc. is tagged and submitted in a digital format. Where data from this system can be accessed for statistical analysis this should greatly enhance the ability of the Department to effectively evaluate tax policy.

7.8 The Companies Registration Office is a significant repository of data on Irish firms' balance sheets. Currently, firms are not required to submit their tax reference number with their company accounts. If such an obligation existed, it would significantly increase the capacity to link data sets with Revenue Commissioner data.[25] In addition, data at the CRO is stored in image files which makes extraction time-consuming.

7.9 While the above enhancements in data collection on the part of the Revenue Commissioners are welcome it is likely that challenges will remain in policy evaluation where firms' accounts are affected by transfer pricing and reporting of assets outside Ireland. In the case of R&D a significant proportion of expenditure in the state is by multinational firms. Where data on these firms do not allow for accurate statistical inference any future analysis is likely to be based more on domestic or indigenous enterprises. The extent to which this analysis can be extended to the activities of MNCs will place limits on our understanding of the performance of the R&D tax credit for a significant proportion of its users.

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[24] To be excluded from the Phase 2 filing obligation, a company must meet all three of the following criteria viz : (i) The balance sheet value of the company does not exceed €4.4 million; (ii)The amount of the turnover of the company does not exceed €8.8 million; and (iii)The average number of persons employed by the company does not exceed 50.It is intended that all remaining Corporation Tax Payers will be included in the next phase which will commence in 2015. Further details will be announced in early 2014

[25] The authors' understanding is that the Revenue Commissioners have some firms CRO numbers but these are not comprehensive and difficult to construct into a useable dataset.

8. Conclusions

8.1 This working paper discussed the various methodologies available to evaluate research and development tax credits as well as the approach pursued by the Department of Finance in 2013.

8.2 The nature of R&D activity and the difficulty in isolating its benefits, as well as the operation of R&D tax credits, create complications in its evaluation. A variety of evaluation measures are discussed in the paper as well the as the approach deemed most feasible based on an R&D demand equation.

8.3 The evaluation methodology chosen for this review encountered significant challenges in respect of data availability. These challenges may diminish over time. The Revenue Commissioners are currently introducing a new data collection system which will request additional data pertaining to firms' financial accounts while minimising compliance burden through electronic filing (known as iXBRL). The availability of such data would significantly improve the capacity for quantitative evaluations of tax incentives of this type. However, the extra data required to evaluate particular tax expenditures will often be unique to that incentive.

8.4 With this in mind, it is recommended that before tax expenditures are implemented an ex-ante review of suitable evaluation methodologies for the tax expenditure in question is undertaken. One output of this exercise would be to determine what data would be necessary to evaluate the intervention in order to ensure that these data are captured over the life-time of the scheme. By putting in place arrangements to collect these data the resources required to undertake evaluation would be lower. More importantly the availability of appropriate data would enable important issues around the effectiveness and impact of interventions such as the R&D tax credit to be addressed.

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