Encouraging Research and Development in Ireland's Biotechnology Enterprises

KATE JOHNSTON*
COLETTE HENRY*
SIMON GILLESPIE*

ABSTRACT

Over the last ten years, the Irish government has actively promoted the biotechnology industry. Following an extensive series of funding and investment programmes introduced in the early 1990s, Ireland is beginning to emerge as an attractive location for multinational biotechnology and pharmaceutical companies worldwide, with nine of the ten major international pharmaceutical companies now carrying out manufacturing operations within the state (US Department of State, 2005).

To date, the Irish government's strategy has tended to focus on building up an industrial profile and in developing world-class bio-researchers. However, more recently attention has begun to shift to developing Ireland's emerging indigenous biotech sector (Enterprise Ireland, 2003). Currently there are less than sixty indigenous bio-enterprises in Ireland, most of which are micro companies and at an early stage of development. Furthermore, due to the nature of their activities, most bio-enterprises do not generate profit in the early years. Even those bio-companies that have some revenues tend to invest the bulk of their turnover in long-term product development.

* *Centre for Entrepreneurship Research, Dundalk Institute of Technology*

This paper provides an overview of the Irish biotechnology sector and examines the government's strategy for promoting the sector to date. Drawing on examples from the UK, France and the USA, the authors consider the use of tax credits as a possible means of encouraging R&D within the sector and thus open the discussion on whether such incentives might be used to promote R&D within the Irish biotech sector. In this regard, some issues that would require further research and analysis are identified.

INTRODUCTION

Biotechnology is now considered a key emerging sector in Ireland's economic landscape. Defined as 'the application of scientific and engineering principles to the processing of materials by biological agents' (Forfás, 2005), biotechnology is now the main high technology driver affecting industries as diverse as food, agriculture, human health and environmental protection. In 2002 it was estimated that over 400,000 people worldwide were employed in biotech (InterTradeIreland, 2002), with the market for biotechnology products worth an estimated €100 billion (European Commission, 2002). However, according to the Technology Foresight Report (1999), these figures are predicted to increase significantly, with the expectation that, by the end of 2006, the biotechnology sector will be worth an estimated €250 billion and will employ more than three million workers.

With regard to Ireland specifically, there are currently sixty bio-enterprises and, while most are micro companies and at an early stage of development, collectively they employ some 5,000 people. Their activities range from developing new methods of diagnosing and treating disease to products that assist in remedying mean environmental damage and the prevention of such issues.

A core objective of the Irish government's current biotechnology strategy is to stimulate growth and development within its emerging indigenous sector (Enterprise Ireland, 2002). To date this strategy has tended to focus on investment and funding, on building up an industrial profile and on developing a world-class bioresearch base. In some countries, indirect fiscal incentives are being used as a means of stimulating growth within the indigenous biotech sector. Such incentives include taxation credits designed to encourage research and development (R&D) in biotech SMEs (Small and Medium-sized

Enterprises). Indeed, some of the more successful biotech countries already have some form of tax incentive in place, which is often seen as a cost-effective means of promoting growth in the indigenous sector by encouraging more R&D.

A key objective of this paper is to provide an overview of the Irish biotechnology sector and examine the government's strategy for promoting the sector to date. By drawing on examples from the UK, France and the USA, and by referring to some of the effectiveness studies conducted to date, the authors also aim to open the discussion surrounding the use of tax credits as a means of promoting the sector by encouraging R&D. In this regard, some issues for further analysis and research are identified.

The paper is structured as follows: firstly, the case for biotechnology and the need to promote the sector are reviewed. Secondly, the current state of Ireland's biotech sector is examined, and the Irish government's strategy in promoting the sector to date is discussed. Thirdly, using examples from three of the world's leading biotechnology countries, the nature of tax credits is considered. Fourthly, the need to further promote Ireland's biotech sector is highlighted, and some of the advantages and disadvantages associated with using tax credit incentives are discussed. In this regard, by way of opening the debate on whether tax credits could be used to promote R&D among Ireland's biotech enterprises, the authors suggest that further discussion is merited. Finally, the paper concludes by identifying some of the key issues that would require further analysis and research if tax credits are to be given full consideration as potential biotech R&D stimulants.

RESEARCH CONTEXT

The Case for Biotechnology

Countries such as the UK, the USA, Australia and parts of continental Europe have already identified biotechnology as the next major driver of economic growth in the twenty-first century. In the United States, for example, biotechnology now generates more than $40 billion in annual revenues (Ernst & Young, 2004). While in Europe the value of products and services using biotechnology is estimated to be worth €250m, which in turn affects (both directly and indirectly) more than three million jobs (EuropaBio Report, 1997).

Increasingly, this leading-edge area of technology is not relegated solely to the wealthy nations of Europe and America. India, China, South Africa and even Cuba are now moving into the innovative and dynamic realms of biotechnology as well, providing a means for these countries to reduce their economic dependency on commodities (sugar, nickel, tobacco, rum), as well as delivering scientific advancements in biotechnology terms (Chen, 2003).

In the broadest sense, biotechnology concerns the use of biological processes or elements to solve technology needs or problems, enabling the application of engineering, technology and science principles to improve the health, quality and utility of plants and animals. From an economic perspective, the commercialisation of biotechnology is the primary focus, with the technology set to deliver potentially huge gains in all primary industries such as health care, food and agricultural industries, as well as environmental protection. The end result is new sustainable wealth and knowledge creation, as well as potentially life-enhancing innovations.

Like that of any other sector, the case for supporting the growth and development of biotechnology is ultimately an economic one. While governments around the world are increasingly keen to stimulate the growth of high-technology industries, biotechnology must compete with other technology-based industries such as nanotechnology, electronics and telecommunications, as well as traditional industries.

The State of Biotechnology in Ireland

According to Ernst & Young (2002), Ireland is now recognised among the top 25 global locations for biotechnology. However the biotechnology sector in Ireland is still at a very early stage of development. There are currently fifty-nine bio-companies in Ireland, forty-one indigenous and eighteen multinational, with the indigenous companies consisting of primarily private, early discovery, seed-stage companies (Martin, 2005).

In terms of economic contribution, bio-enterprises currently employ approximately 5,000 people in Ireland, with the majority (n=3,000) employed in multinational enterprises. Indigenous bio-enterprises account for less than 2,000 or 40 per cent of total employment for the sector. Most indigenous enterprises are small, with 60 per cent (n=26) in the micro category, employing less than ten people, and less than 10 per cent employing more than fifty (Enterprise Ireland, 2005).

In relation to age distribution, most of Ireland's indigenous biotech businesses are seed companies, with an average age of five years, reflecting the relatively recent nature of both the technology and the industry. In terms of industrial focus, the majority (n=21) are involved in diagnostics, followed by pharmaceutical biologics (n=16) and agri-food (n=11), with pharmaceutical services and bio-environmental activity making up the remaining eleven companies. The concentration of bio-enterprises in diagnostics, which is primarily concerned with the production of diagnostic kits for use in hospitals and clinics, reflects the low entry barriers both in terms of manufacturing costs and regulatory controls associated with this activity. However, access to R&D expertise and facilities is a major issue for Ireland's early stage biotech companies and for this reason most bio-enterprises in Ireland are located in close proximity to high technology centres, such as universities, institutes, hospitals, etc. Forty-six of the fifty-nine biotechnology companies are located in five major areas of activities, including Dublin (16), Belfast (14), Cork (8), Galway (5) and Coleraine (3). This is consistent with comparative analysis which suggests that biotechnology tends to cluster regionally (Prevezer, 1998; Shohet, 1998).

In many cases, biotech companies are spin-offs from universities; around twenty-five Irish biotech companies have originated in this way (IntertradeIreland, 2002), while several others are significantly dependent on technologies licensed from universities in other countries.

Government Policy on Biotechnology

The Irish government has been aware of the potential of biotechnology for many years. While initial reports were drawn up in the early 1980s, it was not until the 1990s that a number of significant reports emerged, including Forfás, 'Shaping Our Future – A Strategy for Enterprise in Ireland in the 21st Century' (1996), which identified biotechnology as a key enabling technology for Ireland's future industrial development. However, it was not until the publication of the Technology Foresight Ireland Report in 1999 on Health and Life Sciences that the Irish strategy on biotech was finally established. At this time Ireland was not perceived as an international centre of biotechnology. In fact, after Greece, Ireland had the lowest level of government-supported R&D, at less than 1 per cent of total government expenditure (European Commission, 1997). The overall structure of the Irish national biotechnology research programme was weak; outputs were small and the number of top quality biotechnology research groups was limited. Irish biotechnology graduates were leaving the country in large numbers and Irish science students were not encouraged or educated to become science, technology and innovation (STI) entrepreneurs. In the area of commercialisation, there was little funding available for start-up companies, and Irish venture capital funds had little experience of biotechnology investments (Irish Council for Science, Technology & Innovation, 2002).

The 2002 ICSTI Report argued that Ireland could not afford to ignore biotechnology and concluded that:

> [U]nless investment does occur, Ireland will not only fail to benefit from the new biotechnology in terms of a large number of new, high quality, high added-value jobs, but many existing jobs in the pharmaceutical and chemical industries, the food and drink industries and in agriculture will be jeopardised. (2002: 6)

Since the publication of these early reports, over twelve separate reports on biotechnology related issues have been published in Ireland. Collectively they have resulted in a comprehensive package of measures designed to promote and prioritise biotechnology in Ireland. Table 9.1 below summarises these measures:

Table 9.1: Summary of Ireland's Biotech Measures

Measure(s) Introduced	Impact on Industrial Policy
The development of a quality R&D programme to foster 'leading-edge' research.	The government set up the National Biotechnology Programme (1987) to develop commercially oriented biotechnology research in Irish universities. In 1995 less than €1.2m was received in research grants in science and technology in Ireland. In 2000, through the Technology Foresight Fund, over €650m was invested in technological and scientific research.

(Continued)

Table 9.1: (*Continued*)

Measure(s) Introduced	Impact on Industrial Policy
Additional focus on the commercialisation of research outputs through the creation of BioResearch Ireland (BRI).	BRI is a contract research organisation responsible for commercialising existing biotechnology and developing the expertise and facilities needed for biotech R&D. BRI's principal role is the commercialisation of technologies arising from university research through directly assisting the development and transfer of technology from research facilities to industry.
Developing imaginative schemes to foster an indigenous industry while also attracting foreign investors.	In early 2000 Enterprise Ireland established the first dedicated Biotechnology Start-Up Fund, with €15m allocated to biotech companies in the early stages of development.
Putting in place a communications strategy to increase public awareness and participation.	This was achieved through the publication of several policy documents, including the Irish Council for Science Technology & Innovation (ICSTI) Report on Biotechnology (2002).
The establishment of Science Foundation Ireland (SFI) in 2003 to enhance, develop and promote the scale and quality of basic research in Ireland.	SFI's role was to fund research in biotechnology and information and communications technology development. To date, SFI has invested over €646 million in academic researchers and research teams working in leading-edge technologies and competitive enterprises in biotechnology and ICT (Information and Communications Technology).
The establishment of a coordinated strategy involving the three main support agencies on the island of Ireland – Enterprise Ireland (EI), Industrial Development Authority (IDA) and InterTradeIreland (ITI).	EI launched a number of programmes and initiatives on biotechnology. The IDA promotes Ireland as a location for foreign investment for overseas multinational science and pharmaceutical companies. ITI has published a number of reports and studies mapping biotechnology in Ireland.

The above measures were complemented by a series of funding programmes administered by the Higher Education Authority (HEA)[1] to boost both capital and recurrent expenditure on university-based research. Life sciences gained more than half of the €600 million that has been disbursed by the HEA, resulting in the creation of new institutes throughout the country's university system, focusing on areas such as genomics, cellular biotechnology, biomedical engineering, immunology, biopharmaceuticals and molecular medicine, and food and health science.

More recently, the government has announced a €1 million funding initiative targeted at boosting the number of women scientists in Ireland. This initiative consists of three SFI-funded programmes aimed at addressing the under-representation of women in Irish science and engineering research.

Collectively, such initiatives have resulted in five core centres of biotech research located on the campuses of Irish universities. Biotechnology research is predominately carried out at these five centres, along with Teagasc, the national body providing advisory, research, education and training services for agriculture and the food industries. The five leading centres for biotechnology research in Ireland include the National Agricultural and Veterinary Biotechnology Centre at University College Dublin (animal and plant health and reproduction); the National Diagnostics Centre at National University of Ireland, Galway (immunoassays, diagnostic technology); the National Cell and Tissue Culture Centre at Dublin City University (animal cell culture, MAB production); the National Food Biotechnology Centre at University College Cork (food processing technology, bioremediation); and the National Pharmaceutical Biotechnology Centre at Trinity College Dublin (vaccines, inflammation, neurobiology). In 1992 a total of 765 people were involved in biotechnology research in Ireland. Currently, this figure is estimated to be 2,000 (European Commission, 1996). In 1995 the Centre for Innovation in Biotechnology (CIB), an associate member of BRI,[2] was launched in Northern Ireland, presenting a significant opportunity to raise the profile of biotechnology research on the island as a whole (Forfás report, 2002).

The Nature of Tax Incentives

In modern economies governments apply various policy instruments to promote R&D in the business sector. Reflecting the link between R&D and productivity, performance, competitiveness, foreign investment and entrepreneurship, the literature has identified high levels of R&D as crucial factors in maintaining a high and stable growth rate in the economy (Stokey, 1991).

Both theoretical and empirical evidence indicate that R&D is subject to market failure, due to a combination of imperfect information in the market and financing gaps induced by asymmetric information (see, for example, David et al. (2000) and Hall (2003) for surveys on both topics). However, how best to encourage R&D on an ongoing basis is proving problematic in practice.

Increasingly governments are turning to fiscal incentives in response to this R&D market failure. The UK, France and the USA, three of the most successful biotech countries in the world, have all adopted tax as a stimulus for R&D. However, as the discussion below suggests, fiscal policies vary considerably in terms of scope and operation, and hence comparison between the various tax-based incentives can prove problematic.

Essentially, there are two main types of tax credits for R&D:

1. Tax relief in proportion to the volume (i.e. total amount) of R&D expenditure incurred by the company. This volume basis means that any tax relief will be calculated in proportion to the total amount of R&D spent in that year.
2. The alternative approach is known as the incremental approach. In this case, the tax relief is based on how much the company increases its R&D expenditure compared to previous years (i.e. incremental basis).

The section below briefly discusses the approaches adopted in three of the most successful biotech countries in the world.

United Kingdom

According to Devereux (2003), promoting innovation and R&D is a fundamental component of the UK government's strategy for improving productivity, performance and competitiveness. The UK had relatively low levels of investment in R&D and, until recently, business spending on R&D as a percentage of GDP actually decreased compared to most other major industrialised countries. To facilitate and influence innovation, and to increase R&D, the government announced a new R&D tax incentive package for large companies in the 2002 Budget (effective from 1 April 2002), building on the existing R&D tax credit for small and medium-sized companies. The UK system adopts a volume approach, i.e. the relief is based on a company's total qualifying R&D expenditure (Devereux, 2003).

Before 2000 virtually all scientific research and development was classed as eligible expenditure. For example, there was a Research and Development Allowance for all firms, allowing plant machinery and buildings to be immediately written off against profits. However, because capital expenditure was normally only a small percentage of R&D costs (approximately 10 per cent), this was not considered to be a significant factor. In contrast, wages, salaries and current expenditure have no special tax treatment.

In 2000 the government introduced special tax relief (R&D tax credits) for SMEs under the Finance Act (2000). Similar relief was introduced for large companies in the subsequent 2002 Finance Act. Under the Act, SMEs can claim an extra 50 per cent tax relief, and larger businesses can claim 25 per cent, subject to certain restrictions.

In terms of cost eligibility, guidelines issued by the UK Department for Trade and Industry define eligible R&D costs as expenditure relating to 'creative or innovative work in the fields of science or technology and undertaken with a view to the extension of knowledge and breaking new ground, whether that be through resolving some uncertainty or creating a new or substantially improved product, process or service' (PLASA, 2002).

Under the current system, small and medium-sized companies are eligible for relief at 150 per cent of actual expenditure. If the company has no taxable profits, they can in fact obtain cash repayment from the Inland Revenue. Expenditures that qualify for R&D tax relief include:

- Staff directly involved in carrying out the R&D.
- Consumable stores used in the R&D work. However, costs of employees providing secretarial, administrative or similar services in support of others' activities do not qualify.

- Software, fuel, power and water.
- 65 per cent of the costs of subcontracting specific elements of the R&D work to a third party.
- In addition, where a company incurs capital expenditure on R&D, it is entitled to an immediate 100 per cent tax depreciation allowance in relation to this expenditure.

An interesting feature of the UK system is that there is no requirement for the R&D to be actually carried out in the UK. The benefit of the UK approach is its simplicity and predictability, which is perceived as critical for management and investment decision-making.

France

In France a company becomes eligible for certain research incentives when it has incurred expenditure on any technical and scientific research operations. The French system's tax credit is calculated on an incremental basis, thus the current year's expenditure is compared to the average expenditure during the preceding two years (adjusted for inflation). The tax credit amounts to 50 per cent of the incremental amount, but is capped at €61m per year. Costs eligible for this relief include that of personnel assigned to do the research, i.e. scientists or engineers working on the design or invention that is eligible. However, it does not include support personnel, i.e. secretaries, cleaning or physical maintenance of facilities. According to the European Commission (2002), costs eligible for the purposes of calculating the tax credit include:

- Operating costs, calculated as a fixed percentage of 75 per cent or 100 per cent of the research personnel costs, with the particular percentage depending on the relevant qualification of the personnel involved.
- Other consumable types of expenses, including, for example, any small tools, apparatus, materials and supplies.
- External research expenditure incurred if the research has been entrusted to other public or private research organisations. Experts approved by the Ministry of Industry and Research are also eligible.
- Depreciation on assets directly assigned to the conduct of the research operations (provided they are located in France).

The benefit of this approach is that, if the tax credit is higher than the tax liability, it can be carried forward in the three years that follow. After this, if still not used, it is refunded in cash by the tax authorities. This is considered a very beneficial cash flow feature of the French incentive.

A drawback of this particular method, compared to countries where a volume-based approach is taken, is that, even though the percentage of the credit is higher than most countries, a company will not be eligible for a tax credit if it has spent less on research in the current year compared to the prior two years. Commercially, a company's R&D spend might not increase on a year-to-year basis and, if this is the case, it will not benefit from this incentive. Even if R&D spend does increase, it may still not qualify for this benefit, as any 'negative' credits from prior years (amounts corresponding to a decrease in expenditure) must be offset against subsequent research tax credit amounts to ensure the preceding year's deflated basis does not affect the increase unfairly.

United States

As in most other countries, research eligible for financial relief in the USA has a fairly wide definition and generally includes research undertaken to discover information that is technological in nature and intended to be useful in the development of a new or improved business component, irrespective of where it is undertaken. Furthermore, the research must relate to elements of a process of experimentation that leads to a new or improved function, performance, reliability or quality.

The USA allows a general deduction of research or experimental expenditures during the tax year in which such expenditure is paid or incurred, including any capital expenditure. In addition, for expenditure incurred on R&D, the USA allows a company a deduction or credit against its income tax liability on an incremental research basis, i.e. for increased research activities. The calculation of the tax credit is based on a fairly complex formula and depends, among other things, on how many years a company has been involved in R&D activities. A key benefit of the American system is that, if the taxpayer is unable to use all the R&D credits in the year in which they are earned, the unused credit may be carried back to the preceding tax year or carried forward for twenty years (Sarnia Lambton, 2005).

Research expenses that qualify for this tax credit include expenses incurred for the company's own research, i.e. salaries or wages of employees engaging in or directly supervising or supporting research activities. Other costs included are:

- Consumable supplies, materials and computer use charges.
- 65 per cent of subcontracted expenditure incurred for qualified research that is performed by a person other than an employee of the taxpayer. This percentage increases to 75 per cent of the expenditure if the research is performed by a 'qualified research consortium' (i.e. a tax-exempt organisation whose primary function is to conduct scientific research).

DISCUSSION

Invariably, the case for further supporting biotechnology in Ireland is based on three related arguments. Firstly, Ireland's industrial profile is well placed to embrace biotechnology. Ireland has, for example, successfully attracted a large number of major pharmaceutical manufacturing companies, with nine of the top ten pharmaceutical companies in the world having manufacturing operations in the State (US Department of State, 2005). In addition, Ireland has a major indigenous multinational biotechnology company – Elan – and some of the country's core sectors, such as food, drink and agriculture, offer huge potential for the application of biotechnology.

Secondly, the strong software industry in Ireland offers huge synergistic opportunities through combining health and life sciences with ICT. In this respect, the Irish government views biotech and ICT as delivering sustainable economic growth, consistent with its policy of creating a competitive knowledge-based economy.

Finally, at the wider economic level, the case for further supporting biotechnology is justified in terms of reducing the productivity and innovation gap between Europe and the USA. As highlighted in studies by, for example, Fagerberg (1987), Freeman (1995), Lundvall (1992) and Bygrave et al. (1998), Europe was falling behind the USA in science and technology. The USA had a strong science base and was a world leader in the fields of medical research, agricultural bioscience and diagnostics. Thus, investment in high technology industries and research and development were seen as crucial to addressing this gap.

By way of further supporting the sector and encouraging R&D among Ireland's indigenous biotechnology enterprises, tax credits as a support mechanism may merit further consideration. Although a thorough analysis of the potential benefits of tax credits in an Irish context is beyond the scope of this paper, in opening this debate, the authors suggest that, from a theoretical perspective at least, tax credits may be more influential than direct grants or other forms of government support. Indeed, tax credits are often preferable, as they have the lowest level of compliance costs. According to the OECD (2002), tax credits are advantageous because they:

- entail less interference in the marketplace, and thus allow private-sector decision-makers to retain autonomy;
- require less paperwork and entail fewer layers of bureaucracy;
- avoid the need to set nebulous and detailed requirements for receiving assistance;
- have the psychological advantage of achieving a favourable industry reaction;
- have a high degree of political feasibility.

However, notwithstanding the above, tax incentives may also be disadvantageous because they can:

- bring about unintended windfalls by rewarding what would have been done without the tax incentive;
- lead to undesirable inequities;
- raid the national treasury;
- represent an ineffective means to achieve focused results.

In assessing the effectiveness of R&D tax credits, supporters cite evidence from empirical studies that have attempted to measure their direct impact on R&D activity (Bloom et al., 2000). Due to data limitations, the micro-economic evidence regarding the effectiveness of tax credits is restricted. For this reason, most studies to date have examined the macroeconomic impact, principally the general effect of government taxation on R&D expenditure (see for example, Klette et al., 2000; Hall and van Reenen, 2000; and Czarnitzki et al., 2005).

Table 9.2 below lists some of the main studies conducted to date which have examined the amount of R&D induced by the tax credits. These studies have reported the R&D price elasticities associated with tax credits and have sought to measure the additional amount of R&D performed for each dollar decrease in the cost of the R&D.

Table 9.2: Effectiveness Studies of R&D Tax Credits

Study (Date)	Estimated Elasticity of R&D to Tax Credit	Period of Study	Country
McFetridge and Warda (1983)	–1.0	1982–82	Canada
Bernstein (1986)	–0.13	1975–84	Canada
Mansfield (1986)	–0.35	1981–83	USA
Berger (1993)	–1.0 to –1.5	1981–88	USA
Baily and Lawrence (1992)	–0.75	1981–89	USA
Hall (1993)	–1.0 to –1.5	1981–91	USA
McCutchen (1993)	–0.28 to –0.7	1982–85	USA
Bloom, Griffith and van Reenen (2000)	–0.16 (short run) to –1.1 (long run)	1979–94	G7 Plus Australia
Hall and van Reenen (2000)	–0.34	1990s	USA
Lach (2000)	–1.5	1996–2000	Israel
Mulkay and Mairesse (2003)	–1.6	1995–2001	France
Czarnitzki, Hanel and Rosa (2005)	–0.69	1990s	Canada

Adapted from Hall and van Reenen (2000)

In most cases, the sign of the elasticity is negative, reflecting this inverse relationship.

Table 9.2 reveals that, from the various studies that have estimated the elasticities for R&D tax credits, all have reported negative elasticities, indicating that provision of tax credits increases levels of R&D, although the magnitude of the impact differs significantly from country to country. In some cases, the impact is marginal, while in other studies, tax credits result in a two-fold increase. While Hall and van Reenen (2000) report a neutral effect, Lach (2000), and Mulkay and Mairesse (2003) document a significant positive impact. According to the latter, the long-run increase in R&D is three to four times the budgetary cost.

In interpreting these results, critics point to a number of weaknesses. Firstly, the majority of the studies are from the USA and Canada, hence direct comparison with the UK and Europe is problematic. The existing evaluations have been conducted for different countries and cannot be compared due to the use of different types of data, methodologies, scope and time periods. Moreover, as highlighted in this paper, there is little, if any, consistency in R&D fiscal policy internationally. Secondly, there are methodological difficulties in establishing the effect of fiscal incentives. There is a lack of micro-level data, which is necessary to estimate the true impact of such policies. In addition, tax credits can lead firms merely to reclassify current expenditure as R&D, rather than encouraging firms to raise their level of innovative activity, as this is not measured in many of the current studies. In most cases, studies are based on economic estimates, using highly restrictive assumptions and models. Finally, most of the studies do not estimate the potential externalities (R&D spill over), hence it is difficult to evaluate the amount of additional direct and indirect R&D per unit of foregone public revenue due to taxation credits.

SUMMARY AND CONCLUSIONS

This paper has discussed the case for biotechnology and has reviewed the need to promote the sector. The authors examined the current state of Ireland's biotech sector and discussed the Irish government's strategy in promoting the sector to date. Drawing on examples from three of the world's leading biotechnology countries, the nature of tax credits as a means of encouraging R&D was considered. The need to further promote Ireland's biotech sector was highlighted, and some of the advantages and disadvantages associated with using tax credit incentives were discussed.

This paper has indicated that, while the Irish biotechnology sector is still at a very early stage of development, its importance in terms of economic contribution is clearly recognised (Enterprise Ireland, 2005). This importance is evidenced in part by the range of reports that have been issued on the sector since the 1980s, the more recent of which have strongly argued for continued investment in the sector (Technology Foresight Ireland, 2002). A complex package of funding and support measures focused on developing Ireland's biotech sector has been developed over the past ten years. However, it might be argued that there is more foreign direct investment (FDI) rather than indigenous evidence of the effectiveness of such support measures, as nine of the world's top ten pharmaceutical companies now have manufacturing operations in the state (US Department of State, 2005). In this regard, there may be a case for re-thinking support mechanisms to further encourage indigenous biotech enterprises so that the productivity and innovation gap between Europe and the USA does not continue to widen (Freeman, 1995; Lundvall, 1992; Bygrave et al., 1998).

With regard to tax credits, the paper considered examples from three of the world's leading biotech countries, illustrating how such fiscal policies can vary considerably in terms of scope and operation. The paper also highlighted that the actual efficiency of tax credits is difficult to assess, with both advantages and disadvantages (OECD, 2002) being noted. Furthermore, due to data limitations, inconsistencies in the methodological approaches adopted and differing economic contexts, the literature revealed conflicting results in terms of the long term effectiveness of tax credits (Hall and van Reenen, 2000; Lach, 2000; Mulkay and Mairesse, 2003).

While, as already acknowledged, a full analysis of the potential benefits or otherwise of tax credits in the Irish biotech context is beyond the scope of this paper, the authors have simply endeavoured to open the discussion surrounding their potential use as R&D stimuli, suggesting that such incentives at least merit due consideration. Given the early stage of development of biotechnology companies in Ireland (Ernst & Young, 2002; Martin, 2005), the use of taxation incentives might well represent an effective mechanism for the Irish government to stimulate further growth and development. Furthermore, in view of the huge amount of funding invested in the sector to date, tax credits may offer a more economic means of providing ongoing support to indigenous biotech enterprises by actively encouraging and rewarding R&D. Clearly, further investigation is needed.

However, as the authors have already highlighted, there is still considerable academic debate regarding the actual impact of tax credits on R&D activity, despite the existence of a number of international studies (Hall and van Reenen, 2000). With regard to Ireland specifically, tax credits may well be capable of playing an effective role in further developing the biotech sector, but it is the nature and extent of that role that needs further investigation. By way of further research, some of the questions that need to be addressed include the following: firstly, given the early stage of Ireland's biotechnology sector, how cost effective would tax credits actually be? Secondly, what are the practical, legal and compliance costs involved? Thirdly, and perhaps more importantly, given the array of systems adopted in various countries, which type of tax credit system would be best for Ireland? In attempting to address these questions, researchers and policy makers cannot ignore the successful track record of the UK, France and the USA, however they must also be mindful of the need for further effectiveness studies with regard to the actual economic impact of tax credits. If tax credits are to be given due consideration in the Irish context, then indigenous empirical studies which consider the actual needs of Ireland's fledging biotech enterprises, their capacity for meaningful R&D and their actual R&D capability are urgently required. Only then can a real debate begin.

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1 The HEA manages the third level education sector.

2 BioResearch Ireland – part of Enterprise Ireland's development strategy for the development of Irish biotech companies.

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