Tax and R&D investment: policy impact calculator

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This report was commissioned by the Australian Government Department of Industry and Science with the objective of helping provide a better understanding of the costs and benefits of the R&D Tax Incentive scheme and the possible outcomes from varying the existing policy. The outcome of this research includes two components, a written report and a simple analytic calculator which provides an estimate of the impacts of varying the existing R&D tax policy.

1. Introduction

The Department of Industry and Science has commissioned this research to inform a better understanding of the costs and benefits of the R&D Tax Incentive and the possible outcomes from varying the existing policy. The outcome of this research includes two components: (1) a written report and (2) a simple analytic calculator based on Microsoft Excel. The function of the calculator is to provide a ready estimate of the impact on private sector R&D of varying the existing R&D tax policy.

It is important to keep in mind that inducing additional R&D is not an end unto itself. The rationale for subsidising R&D is to induce positive spillover benefits to other firms and consumers. If left to themselves, for-profit organisations will under invest in R&D and thereby forgo welfare enhancing spillover benefits. Both theory and extensive empirical evidence support the notion that each dollar of R&D investment makes a contribution to the material well-being of Australians considerably greater than one dollar.

Tax policy affects R&D investment by changing the breakeven cost-benefit ratio of the marginal prospective R&D investment. If this ratio falls, firms will be expected to conduct more R&D and society will capture more spillover benefits. The ratio is composed of:

(a) After tax cost of R&D (the out of pocket cost of every dollar spent on R&D taking into account all deductions, rebates, concessions and depreciation)
(b) After tax income (from the prospective R&D investment)

The breakeven cost-benefit ratio is given by the ratio of (a)/(b) and is called the *tax-price of R&D*. The tax-price of R&D often varies by firm type, size, history of R&D expenditure and (sometimes) by industry. Analysis included in this report will focus on the domestic effect underpinned by variation in the tax-price. The potential for taxation to influence the location of R&D performing multinational firms will also be discussed based on international economics literature.

The process of assessing the direct impact of changes to taxation, including changes to the rebate or corporate income tax rate, can be broken into three stages:

1. Calculate the implied change to the breakeven cost-benefit ratio (tax-price) of prospective R&D investments.
2. Estimate the *proportional* change in R&D to changes in tax-price. This is called the elasticity of R&D investment with respect to its tax-price
3. Extrapolate the value of additional R&D investment based on current R&D spending, the estimated elasticity (2) and the hypothetical variation in the tax-price (1).

Terms used to describe policy

Before proceeding it is helpful to define key terms used to describe R&D tax policy, both in general and specifically relating to the Australian policy context. In the international literature, R&D subsidies that are distributed via the tax system are commonly known as *tax incentives*. Internationally, R&D tax subsidies are typically provided either as an *augmented deduction* or a *tax credit*. A tax credit is a reduction of company tax liabilities. In Australia a tax credit is known as tax *offset*. An augmented deduction allows companies to deduct a multiple of R&D spending, typically greater than 100 percent, from their taxable income. In Australia, an augmented deduction was previously referred to as a tax concession. The current Australian Government policy is known as the R&D tax incentive scheme and is provided as an offset (credit). A company with no tax liabilities cannot benefit from an offset that is *non-refundable*. A *refundable* offset is paid to a company even if they have no tax liabilities.

2. Background

Why subsidise R&D?

Yale Economist William Nordhaus recently estimated that innovators capture as little as two percent of the total social value of their inventions (Nordhaus 2004). The rest of us are getting a pretty good deal.

A country’s standard of living largely reflects its economic output per capita. It is differences in technology – rather than capital accumulation – which explain long-run per capita economic growth and the most of the per capita differences in income between countries (Abramovitz 1956; Solow 1957; Kendrick 1973). Sustained growth in productivity over the long term requires that we find ways to invest that avoid diminishing returns and this invariably means innovation and new technology.

Some of the attributes of technology which make it central to economic performance also make its socially optimal provision incompatible with a perfectly competitive market. That is, private profit making businesses do not invest enough in innovation left to their own devices. There are two fundamental sources of market failure: limited appropriability and risk.

Limited appropriability refers to the fact that innovating firms do not generally capture the full benefit of their investments in research and development. Considerable benefits are typically captured by other firms and customers usually in the form of lower prices. These benefits not captured by the firm are referred to as spillovers or externalities. If firms are unable to capture enough benefit to cover the opportunity cost they will underinvest.

It is very difficult to stop imitation and learning by observation. The development of a new product or process of production, which can incur considerable costs to the originator, can be quickly copied by other firms operating in similar market or technological space. IP laws and trade secrecy offer important protection from imitation, but they are most effective in only a few industries and for a well-resourced sub-set of firms. There would be substantial net benefits to other firms and consumers if firms undertook more R&D than they would chose to under ‘normal’ market conditions – where the firm can use intellectual property rights, trade secrecy, and strategic use of complementary assets to aid the appropriation of innovation profits. There is strong evidence that the spillover benefits from R&D are economically important (Hall, Mairesse and Mohnen 2009).

It might be considered that strengthening intellectual property protection could help improve matters; though there are important limitations to such a strategy. First, appropriation of benefits can be difficult or impossible where R&D has unobservable and far-reaching benefits. Second, charging a price for a good (technology) that has zero social cost results in a static deadweight loss. This just means that by charging for the use of technology (which has no cost in use once it has been created) means that the technology will not be used everywhere it could create value. Intellectual property rights can also have a negative effect on sequential technological progress (Glasso and Schankerman 2014).

The second source of market failure is the risk and uncertainty inherent in the innovation process. Risk and uncertainty can undermine private provision of R&D because the party who has the capability and appetite to innovate may not be the party with the investment funds. Markets are good at dealing with well understood risks. For example, private markets effectively supply car insurance because companies can observe the average accident rate over a large sample of drivers and price their policies based on that. But innovation is different. Research and development involves trying something that has never been done before. Unlike well understood risks in our economy uncertainty such as is inherent in research cannot be reduced through pooling. However, if the marginal cost of bearing risk increases with the amount of risk held, the total *cost* of a given level of uncertainty can be reduced by spreading it across many parties (Arrow and Lind 1970). Government funding effectively represents spreading the uncertainty of R&D across the entire tax base. Evidence confirms that capital markets often fail to effectively service some high-risk R&D activities (Hall 2005). Limitations to efficient allocation in the presence of uncertainty and risk is effectively codified in the current Australian R&D Tax Incentive programme in that business R&D expenditure must exhibit risk to be eligible for the programme.

The theoretical considerations are well supported by empirical evidence. Empirical studies consistently find that the social rate of return to R&D is considerably higher than the social discount rate (see Jones and Williams 1998; Frantzen 2000; Lederman and Moloney 2003). Hall, Mairesse and Mohnen (2009) provide an extensive review of the very large empirical literature produced over the past 50 years on returns to R&D. The authors conclude that the estimated total rate of return to R&D over the past half century to be in the 2030 percent range. Moreover, the authors observe that the social rate of return is estimated to be substantially greater than the private rate of return. This is consistent with there being a large spillover benefits. That is, much of the benefit of R&D is not captured by the innovator but rather ‘spills-over’ to other firms in the economy.

As well as long run productivity growth, R&D and technological capacity also play an important role in determining a number of more proximate indicators of economic performance. Researchers have also established a strong and robust relationship between measures of innovation – such as R&D investment and patent registrations – with firms’ market value (Griliches 1981; Hall et al. 2000; Bosworth and Rogers 2001; Feeny and Rogers

2003, Griffiths and Webster 2006). Technological differences are also important in explaining differences in trade performance (Cantwell 1989).

Why use the tax system?

Observing that R&D is a significant contributor to productivity growth and overall economic performance, it is widely held that policies that successfully stimulate additional R&D will deliver substantial economic benefit. Governments exercise a range of policy options to overcome possible market failure and to ensure socially optimal investment in R&D.

There is no silver bullet. Each policy approach has costs and benefits. In a world of perfect information the first-best solution is for government to invest in R&D directly and give resulting technology away freely so all who place any value on the generated knowledge are free to use it. Public provision simultaneously solves the problems caused by the non-rivalry, non-excludability and the long-time horizon of benefits.

Unfortunately, the optimal provision of R&D is subject to very significant information costs due to the fundamental uncertainty inherent in technological progress. Efficient allocation requires identifying the most valuable research projects, determining who should tackle them, knowing how much resources are required and how investment should be spread over time. An example of the perils of over-reliance on government R&D is illustrated by the innovation system in the Soviet Union. Despite a disproportionate share of highly educated scientists and engineers, the country was unable to shift from a capital-deepening to growth based on broad technological change.

Good innovation policy should include a mix of mechanisms, in order to ‘hedge’ between the strength and weaknesses of each. Policies that decentralise decision making and harness market forces to allocate resources to research play an important role. Patents, trademarks, and other forms of IP are important market-oriented R&D policies. By providing legal protection from imitation, IP rights help innovators to extract rent (royalties) from consumers. The greater is the pecuniary value placed by consumers, the greater is the reward to the investor. However, the privatisation of spillovers is rarely complete or exact and is itself subject to uncertainty.

Since the late 1970s countries across the OECD have increasingly using tax-based subsidies for R&D. The effect of an ad valorem R&D subsidy is to lower the investment hurdle rate. The potential welfare improvement arises because projects that were considered not profitable, but should on average have considerable spillover benefits, will become profitable in the presence of the subsidy. Tax incentives are subsidies for investment that have a perceived advantage over traditional government provision of R&D in that market forces allocate the subsidy thereby minimising the potential for ‘government failure’.

Firms’ response to tax based subsidies – Empirical evidence

How much additional R&D will each company to do in response to a change in the tax-price? This is a question of behavioural response. In principle, the answer depends on the investment opportunities available to each firm which of course is unobservable. In practice each individual firm will respond differently so the aim is to arrive at an estimate of the average response, which will be based on the large international literature on this issue. This section of the report reviews the Australian and international literature, covering the range of estimates and outlining the basis of research design.

Analysis effectively involves modelling the impact of tax policy on R&D investment using firm, industry or country level data. In order to measure the effect of tax credits on private R&D investment researchers confront the difficult problem of finding an exogenous measure of tax policy that exhibits sufficient variation to support robust identification.

The standard formulation for measuring the relative generosity of tax policy is called the ‘tax-price of R&D’. The measure reflects an adaptation of Jorgenson’s (1963) ‘user cost of capital’. The measure is commonly referred to as the ‘tax-price of R&D’ and was first proposed by McFetridge and Warda (1983) and subsequently used by Bloom *et al.* (2002), Guellec and van Pottelsberghe (2003), Wilson (2009) and others. The measure reflects the breakeven benefit-cost ratio for the marginal R&D investment to be profitable after tax and is given by:

$$\text{taxprice} = \frac{\text{ATC}}{1 - \text{CIT}} \tag{1}$$

where ATC is the after-tax cost of R&D allowing for reductions in corporate income tax liabilities that result from the expenditure; and CIT is the corporate income tax rate.

For example, if the rate of corporate income tax is 30 percent and all R&D costs are expensed then the tax price is unity. In this case the after tax cost of a $100 project is $70. Such a project is commercially viable if the pre-tax return is $100 or more (a return of $70 after tax). If however, R&D expenditure attracts a 40 percent offset, then the after tax cost is 60 cents on the dollar; the tax price is 0.86 (0.6/0.7). In this case the project is viable if it returns only $86 ($60 after tax). The lower the tax price, the lower the pre-tax required rate of return.

Published applied econometric analysis typically reports the elasticity of R&D with respect to its tax price. This means the proportional change in R&D that can be anticipated given a given proportional change in its tax price. Existing research has primarily taken one of two approaches: cross-country (or jurisdiction) or firm-level. The novel cross-industry cross-country approach developed in this note addresses many of the drawbacks reflected in these traditional approaches. The firm-level approach involves modelling R&D investment on firms' effective benefits from the prevailing tax policy in a single country. Since tax policy treats all equivalent firms the same way, variations in firms' effective benefits from tax credits arise solely from differences between firms, typically differences in firms' profit status and their historic R&D expenditure. Unfortunately, from a statistical perspective, these are endogenous to the current choice of R&D investment. Put another way, R&D investment and its after-tax cost are jointly determined because firms' R&D investment decisions effectively determine their benefit from tax credits (Hall 1995). Collectively, firm-level analysis has not generated a consensus, with results depending on the specific context and methodology employed. Estimates of the short-run elasticity of R&D with respect to tax-price have varied considerably—ranging from zero (Eisner *et al.* 1984; Thomson 2010) to around unity (Hall 1992). Hall's (1992) estimate of the long run elasticity is -2.7.

Cross-country analysis is the principal alternative to firm-level studies. Cross-country analysis exploits variation in policy between countries to estimate the effect of tax credits on aggregate R&D investment. Variation in national tax policy is ostensibly exogenous and studies using cross-country data have made important inroads. These studies estimate that the short-run tax-price elasticity with respect to demand for R&D is somewhere between 15 and 30 percent in the short run and about unity in the long run (Bloom *et al.* 2002; Guellec and Pottelsberghe 2003; Falk 2006). Thomson (2014) proposes a novel cross-industry cross-country approach to identification which exploits the fact that different tax treatments of different expenditure categories imply that tax policies vary in their relative generosity across industries. The most recent revised version of this analysis suggest a short run elasticity in around 0.5.

The most recent serious econometric evaluation of the Australian experience reports that the response of firms to variation in the financial cost of R&D (incorporating variation in tax policy) is statistically indistinguishable from zero (Thomson 2010). This finding is consistent with the statistical analysis undertaken by the Bureau of Industry Economics in the 1990s (BIE 1995). If this result is a true reflection of the impact of tax policy on R&D then this implies that changes in the generosity of the R&D tax concession induced no observable (statistically significant) increase in R&D spending. It should be highlighted that a conclusion of zero elasticity represents an outlier result when viewed in comparison to the increasingly large international body of literature. It difficult to tell whether the result for Australia reflects something special about the Australian tax environment (such as dividend imputation) or whether this is just reflects the inherent statistical difficulties in accurately identifying the effect. There is also some evidence that frequent revision of policy settings may diminish their efficacy (e.g., Guellec and Pottelsberghe 2003; Thomson and Webster 2012).

There are several reasons why the long-run effect of tax policy on R&D investment is expected to be different to the short-run effect. First, it is generally held that it takes time for companies to adjust their R&D spending in response to variations in fundamentals such as tax policy. Adjustment takes time due to frictions associated with the cost of hiring new staff and building laboratories and the loss of human capital that would arise in the event of layoffs (see e.g., Hall 1992; Guellec and Pottelsberghe 2003). Firms' long run response to tax incentives depend on the rate of adjustment in R&D spending i.e., the speed with which firms adjust their R&D spending toward the optimal long-run level. This is called the adjustment parameter and reflects the proportion of the gap between actual and target R&D spending that the firms adjust in a single year.

R&D data do show considerable persistence. This means expenditure in the previous year is a strong predictor of expenditure in the current year; if the level of R&D expenditure varies due to some exogenous factor, the change 'persists' across multiple periods rather than reverting immediately back to the pre-shock level. Aggregate R&D series exhibit a high degree of persistence and even company R&D investment schedules exhibit low variation over time relative to ordinary investment spending. In statistical estimation, failure to take serial correlation into account leads to bias in estimates of standard errors and problems for inference. The large autoregressive coefficient implies that any mismeasurement of the short-run elasticity will be magnified when considering the long-run elasticity. Estimates of the adjustment 'speed' are typically reported in the empirical literature but are subject to their own statistical complexities such as dynamic panel bias (Nickel 1982). There is also a lack of consensus on the appropriate dynamic structure in estimating R&D models; adjustment costs are not the only viable interpretation of persistence in the data.[1] The estimates or adjustment provided by the literature typically imply long adjustment periods (e.g., 10 years). Such long adjustment periods might be considered somewhat implausible and may also be considered outside the horizon of policy interest.

In summary, existing estimates of the elasticity of R&D with respect to the tax price are in the order of 0.2 to 0.5 and estimates of the long run impact between about unity and 3. The range of estimates are discussed below, but the short run estimate is around negative 0.5. An elasticity of 0.5 implies that if the tax price goes down 10 percent then the aggregate R&D will increase by 5 percent. An elasticity of 0.5 implies that if the tax price goes down 10 percent then the aggregate R&D will increase by 5 percent. It is worth considering how this should be interpreted. One benchmark metric is the dollar increase in R&D spending for every additional dollar of tax revenue foregone. Here, it is important to recall that the objective of subsidising R&D is the extent of spillovers, so this benchmark is just that – it is not a complete cost benefit assessment – a tax incentive policy may generate a net social welfare surplus even if it costs more (in terms of revenue foregone) than the additional R&D it induces. The calculation for additional R&D induced for each dollar of tax revenue foregone is straightforward and is detailed in Appendix 1. For illustrative purposes it can be noted that an elasticity of 0.5 implies that for a country with a corporate income tax rate of 30 percent a 10 percent credit induces 58 cents of R&D for every dollar of tax revenue foregone.

The results from many econometric studies point to a conclusion that there is some crowding out in the short run – tax credits cost more to governments than the additional R&D

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[1] For example, Guellec and van Pottelsberghe's (2003) estimate of the country-level autoregressive coefficient is below 0.1 which contrasts to the more typical estimates in the order of 0.6 and 0.9. Since the model they estimate a differenced model with an autoregressive term, this coefficient could also be interpreted as a second order autoregressive term with a unit root imposed.

induced – but that in the long run, tax credits induce substantially more additional R&D than their cost in terms of revenue forgone.

Australian R&D tax policy

Business investment in R&D in Australia has received some form of effective subsidy via the tax system for nearly 30 years. The R&D tax concession was first introduced in 1985 at a rate of 150 percent. In November 1987, eligibility of expenditure on R&D buildings was exempted from the concessional treatment (depreciation was also extended from 3 years to the usual 40 years). Also in 1987, syndicates of firms were able to access the scheme to encourage pooling of resources but the syndication was effectively used by firms to trade tax losses (Lattimore, 1997 Banks, 2000). A limited amount of R&D undertaken by Australian companies abroad as eligible expenditure (IT 244, 1987). In 1994, the minimum expenditure threshold was reduced from $50 to $20 thousand (Lattimore, 1997).

In 1996, the rate of deduction was cut from 150 percent to 125 percent of eligible expenditure and the scope of eligible expenditure revised. Interest on debt and non-consumed feedstock in pilot plants is no longer eligible.

In 2001, an incremental scheme was introduced, known as the 175 percent premium deduction. Under the incremental scheme, firms can claim an additional 50 percent deduction on the portion of expenditure exceeding average nominal expenditure over the prior three years. This is in addition to the 125 percent deduction available on all R&D expenditure, meaning ‘incremental’ expenditure attracts a 175 percent deduction in total. The rationale behind the bonus concession was to provide additional incentive while limiting deductions on infra-marginal R&D investment though there is little or no empirical evidence available to confirm the effectiveness of such schemes.

A small businesses tax offset scheme was introduced in 2002. Under the 2002 tax offset scheme, firms with a turnover of less than $5m could claim the concession as a tax offset (rebate) of 30c for each dollar of eligible R&D expenditure, provided expenditure is between the floor ($20 thousand) and a maximum (cap) of $1 million. A special scheme for foreign contract R&D was introduced in 2007. Up until 2007, eligibility for the concession depended on the resultant IP being vested with the researching firm, which reduced the attractiveness of the scheme to an Australian affiliate of a foreign-owned firm (BIE 1993; ATO 2002).

The current scheme has been in place since 2011. It comprises a 45 percent offset (rebate) for small companies (turnover less than $20 million) and a 40 percent offset (rebate) for large companies (turnover greater than $20 million). The cost to budget in 2012-13 was estimated at over $2.48 billion.

As of 2012-13, more than 10,000 companies were registered for the R&D Tax Incentive performing nearly $20 billion in R&D. The ABS (8104.0) report that a total of $18.3 billion in R&D was undertaken in 2011-12 implying that registered firms are responsible for the majority of total R&D. However, differences in definitions, reporting and estimation methods may mean that not all R&D identified by the ABS is attracting some form of subsidy and not all expenditure which is attracting the incentive/concession would be included in the ABS measure.

In order to codify the current policy settings it is necessary to understand how these are applied. The 45 percent R&D tax offset will be a refundable tax offset, which means that if a company's tax liability is reduced to zero, companies may be entitled to a refund of any unused offset amount. The 40 percent R&D tax offset is non-refundable tax offset, which means that companies cannot access a refund for any unused offset amount if their corporate income tax liability has been reduced to zero. However, any excess offsets may be carried forward for use in future income years.

The offset has a potentially large impact on the effective relative generosity of the offset for companies which have no taxable profit. If all R&D is expensed, a company with a positive tax liability is only 15 percentage points better off with the tax incentive scheme, since any expenditure reduces taxable profit. In contrast, for a company with no tax liability the policy reduces the after tax cost of R&D by a full 45 percent.

Under the R&D Tax Incentive scheme the following expenditure is excluded from the receiving the tax rules):

1. expenditure that is not at risk
2. core technology expenditure

3. expenditure included in the cost of a depreciating asset (decline in value notional deductions may apply however)
4. expenditure incurred to acquire or construct a building (or part of a building or an extension, alteration or improvement to a building).

Other tax policy reforms, not directly linked to R&D investment, also affect the effective relative after tax cost of R&D. For example, variation in the rate of corporate income tax rate. This impact was most direct when the subsidy was provided in the form of enhanced deduction. Between 1985 and 2005, the corporate income tax rate was adjusted 6 times and ranged from 49 percent to 30 percent.

The tax treatment of dividends also influences the effective value of the R&D tax concession and the R&D Tax Incentive. For example, the dividend imputation system can lead to “clawback of the R&D subsidy to companies through the taxation of their shareholders” (BIE, 1993 p.220). The dividend imputation system was introduced in 1989 and aims to avoid the double taxation of company profits when they are paid out to shareholders. Under the dividend imputation system, firms are eligible for franking credits (also known as imputation credits) commensurate with the corporate income tax they pay. Franking credits are allocated to shareholders with dividend payments and effectively reduce personal income tax liabilities by the amount already paid by the company as corporate income tax. Franked dividends paid to foreign shareholders are also exempt from withholding tax (ATO, 2006). The portion of company profits that is exempt from corporate income tax on account of the concession/incentive is not eligible for franking credits.

The benefit of this tax exemption to shareholders depends on what the firm does with the tax savings (see also BIE, 1993). The firm can retain and reinvest it; it can be paid out as unfranked dividends; or, if the firm has excess franking credits,[2] it can be paid out as franked dividends. If offset ‘income’ is paid out as unfranked dividends, the marginal dollar when it reaches the shareholder is taxed at the shareholder’s marginal rate. If the shareholder pays a marginal rate of taxation equal to or greater than the prevailing corporate income tax rate (currently 30 percent) the shareholder pays as personal income tax all of the tax that the company avoided through the concession/incentive. When this happens, the benefit of the

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[2] For example franking credits may be carried over from ordinary profit that has previously not been returned to shareholders.

concession is said to be 'washed out.' If the shareholders marginal rate of taxation is less than 30 percent a fraction of the benefit is washed out. In practice, almost all of the benefit of the offset paid out as franked dividends to individual Australian taxpayers will be washed out. It is likely that very little will be washed out when paid to superannuation funds. Half the benefit will be washed out if the concessionary income is paid to foreign shareholders as unfranked dividends.[3] This implies that the R&D subsidy will have a larger impact on firms which do not pay dividends but rather reinvest earnings, and those with superannuation shareholders.

The interaction between the imputation system and the incentive will not be considered in the empirical analysis in this paper. However it is important to note that the imputation system acts to dilute the impact of the R&D tax incentives. There is some evidence that firms respond less to R&D tax incentives when they operate in a country that also has a dividend imputation system (Thomas *et al*., 2003).

3. A tax policy impact calculator

The Department of Industry and Science requested a calculator tool to estimate the effect of different R&D tax treatments on business R&D. The calculator uses parameter estimates from existing empirical research. The workings of the calculator can be summarised in the following steps:

1. Estimate the proportional change in tax price(s) resulting from the hypothetical policy reform.
2. Extrapolate the change in R&D spending using elasticity of R&D with respect to the tax price based on existing empirical literature. That is, the extent to which firms have been found to respond to changes in tax-price.

That is, in simple terms, the calculator is applies the following logic:

(change in tax-price) x (expected proportional response) x (existing spending on R&D)

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[3] Shareholders in most countries are subject to a 15 per cent withholding tax on unfranked dividend payments, franked dividend payments are generally exempt from withholding tax.

Measuring the value of R&D tax credits

As noted above, the tax price of R&D reflects the breakeven cost-benefit ratio of the marginal prospective R&D investment. The formula for the tax-price of R&D is given by:

$$\text{taxprice}=\frac{\text{ATC}}{1\text{-}\text{CIT}} \tag{1}$$

where ATC is the after-tax cost of R&D allowing for reductions in corporate income tax liabilities that result from the expenditure; and CIT is the corporate income tax rate. The after-tax cost of R&D investment can be expressed in general terms as:

$$\text{ATC} = 1-\ (\text{CIT})\times\overbrace{(\text{NPV of allowable claims})\times(\text{proportion deductable})}^{\text{Total value of allowable deductions}}-(\text{credit}) \tag{2}$$

Equation (2) states that a firm’s after-tax cost is reduced by allowable deductions multiplied by the corporate income tax rate (CIT) as well as any tax credits. The value of deductions is determined by two factors: (1) the net present value (NPV) of the stream of allowable claims; and (2) the proportion of the NPV that can be deducted.

Two types of capital expenditure are considered: buildings and structures and machinery and equipment. The net present value of allowable deductions for these are calculated using the straight line method allowing 40 years for buildings and structures and five years for machinery and equipment. The applicable formula for the net present value is: $NPV_{SL}=\frac{1}{T}\frac{1-(1+r)^{-T}}{r/(1+r)}$ where r is the discount rate, or required rate of return. In Australia relevant non-labour current expenditure is eligible for the tax credit. To measure the net present value of deductions on eligible capital expenditure we require a rate of return. The discount rate can be thought of as the nominal opportunity cost of the capital. In practice firms place a heterogeneous value on capital, with the discount rate increasing in the case of capital constrained firms. Benchmark such as the risk-free or total return index from stock market indices are subject to some limitations for example regarding assumed liquidity. For this calculator we follow international convention and use a rate of 10 percent. As will be discussed below, capital expenses represent only a minority of total R&D expenditure so varying the assumed discount rate has a minimal effect on the calculator output.

To estimate the impact of changes to tax policy on aggregate R&D, it is necessary to calculate the impact on different sub-groups of firms (e.g., large and small firms). In accordance with the policy design, *inter alia*, the after-tax cost of R&D depends on:

- the type of expenditure (e.g., capital or labour);
- the rate of allowable deprecation
- firm size;
- profit status; and
- the firm's discount rate.

The after tax cost depends on the type of spending because capital items must be depreciated over time. Additionally, spending on buildings and structures is not eligible for the incentive. The calculator assumes the current distribution of type of expenditure rate of allowable depreciation, firm size, profit status and the firm discount rate is fixed. The distribution are estimated using data from the ABS survey of R&D (Cat 8104.0), IBIS World and the programme data published in the Innovation Australia annual report (Innovation Australia 2013).

How much R&D is eligible for the 45 percent offset? Considering the R&D incentive scheme, $4 billion of the $20 billion in R&D performed by eligible entities is undertaken by those with a turnover of less than $20 million. Extrapolating this suggests that around 20 percent of R&D is eligible for the 45 percent offset. This share seems plausibly consistent with the share of all R&D expenditure undertaken by firms of that size based on ABS data. The ABS survey on business expenditure on research and experimental development (Cat. 8104) does not report R&D expenditure by turnover which would be helpful to compare with this figure from the tax incentive/concession programme administration. However, the ABS does report R&D expenditure by number of employees. In 2011-12 something over 30 percent of total R&D was undertaken by firms with 199 or fewer employees. 13 percent of total R&D was performed by firms with fewer than 20 employees. It seems unlikely that R&D active firms with 199 employees commonly turn over less than $20 million (or less than $100,000 per employee).

Table 1 Parameters and assumptions used in the R&D calculator

Parameter	**Proportion**	**Source and justification**
Share of expenditure by firms with turnover less than 20m	20 %	Share of R&D Tax Incentive claimants in practice from Innovation Australia annual report
Labour + other current expenditure share	93.15 %	ABS Cat 8104.0
Capital share (buildings and structures)	1.08 %	ABS Cat 8104.0
Capital share (machinery and equipment)	5.76 %	ABS Cat 8104.0
Share of benefit that would be captured if not refundable (small firms).	69 %	Innovation Australia / IBIS World
Share of benefit that would be captured if not refundable (large firms).	91 %	Innovation Australia / IBIS World
Discount rate	7 %	International convention
Short run elasticity with respect to tax price	-0.4	International economics literature
Long run elasticity with respect to tax price	-2.0	International economics literature

The ABS R&D survey reports the expenditure share mix, though in the published reports this is not disaggregated by company size. The available data suggest that in aggregate 93.15 percent of R&D reflects labour and other current expenditure, only 1.08 percent reflects expenditure on buildings and structures and a further 5.76 on other capital equipment (machinery and equipment).

Firms without a tax liability do not benefit from a non-refundable offset. Those reporting a taxable profit larger than the prospective offset are indifferent to a refundable and non-refundable offset. The figures for actual claimants are shown in table 2 below. However, in considering the counterfactual policy of a non-refundable offset, it is important that firms that are ineligible for the refundable offset can carry forward any unused benefit. In this case the benefit of the offset is not lost, it is only deferred. The net present value of the deferred offset depends on the number of years until the company reports a taxable profit (and therefore can benefit) and the firm's discount rate.

Table 2. R&D Reported tax position of companies for the 2012-13 income year

	Under $20m	**Over $20m**	**All companies**
Tax Loss	57%	22%	51%
Tax Profit	43%	78%	49%
Total	**100%**	**100%**	**100%**

Source: Department of Industry and Science 2014

Firms which report zero taxable income in any given year are expected to report a positive profit in some subsequent years, at least in the case of those which remain solvent. The expected net present value of the reduction in corporate income tax liabilities as a result of R&D expenditure is the discounted sum over all future years weighted by the probability that each year is the first in which the company returns a profit. For example, if the 57 percent of small firms who report no profit in 2012-13 persistently do not report a profit while the other 43 percent always do report a profit then the tax losses are reduced by 57 percent. In contrast, if firms all have the same likelihood of reporting a taxable profit in any given year then these figures suggest that the net present value of reductions in income tax is 0.92 for small firms and 0.98 for large firms.[4] To inform the calculator we need some measure of the persistence of taxable income status. Data from IBIS World, which includes approximately 2000 large Australian enterprises, indicate that about 25 percent of firms pay no tax in any year. This is largely consistent with the figures reported by firms that are actually accessing the scheme. If we look at the highest taxable income reported by the firms in IBIS over the years 2009-2013 90 percent of firms report a positive taxable income. That is two fifths as many as in any single year. In the absence of better data, we adjust the small firm figure by the same fraction. That is we assume the share of benefit lost to firms who cannot claim a refundable offset is 9 percent for large firms and 31 percent for small firms.

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[4] For firms with equal probability of reporting a profit in any given year (denoted by ρ) then the net present value of the income tax reductions are given by $\frac{1-\rho}{1-\rho\beta}$ where β is the discount factor. The figures are calculated as $\beta = 0.93$ (7 percent discounting) and $\rho = 0.57$ and 0.22 for small and large firms, respectively. These may appear large, but the intuition is that the probability that a fair coin lands on heads repeatedly diminishes quickly over subsequent trials.

The impact of changes in tax price to R&D spending

How much additional R&D will each company to do in response to a change in the tax-price? This is a question of behavioural response. In principle, the answer depends on the investment opportunities available to each firm which of course is unobservable. In practice each individual firm will respond differently. The approach here is to apply a single estimate of the elasticity based on the large international literature on this issue. The elasticity should be interpreted as the average response of the population of firms. Based on the discussion in Section 2 we consider short run elasticity between -0.3 and -0.5 and a long-run elasticity between -1.0 and -3.0.

Other assumptions and caveats

The first caveat that applies to this report relates to the interpretation of tax law. The author of this report is a specialist in econometrics, the economics of innovation and relevant programme evaluation methodologies. He is not an accountant. While all care has been taken to correctly interpret the provisions of the R&D Tax Incentive scheme, please be mindful in using the calculator that the performance of the calculator hinges on accurate interpretation of tax law, *inter alia*. In this regard, credit is due to Departmental officers for expert advice on these matters.

The results do not differentiate between the average elasticity of R&D with respect to its own tax rate is equal to the marginal elasticity. The calculator assumes that the same elasticity is apparent regardless of the magnitude of the policy shift. Empirical estimates derived from a linear model represent an average effect. In practice it is possible the response in R&D spending is non-linear that is, big changes may have a larger or smaller proportional effect than small changes.

Since the benefit firms receive from the R&D Tax Incentive varies by firm attributes such as profit status and turnover, the calculator uses estimates of the attributes of the average firm. To make these estimates we rely to a considerable extent on the ABS survey on business expenditure on research and experimental development (Cat. 8104). As noted previously, the ABS estimate that business expenditure on R&D in Australia amounted to approximately $18.3 billion in 2011-12 which is about the same amount as the R&D reported by the registered firms. However, it is likely that not all R&D identified by the ABS is attracting a tax subsidy; and similarly that not all expenditure which is attracting the incentive/concession would be included in the ABS measure. These discrepancies are due to differences in definitions, eligible expenditures, reporting rules and norms and estimation methods used by the ABS.

A number of additional limitations and caveats should be observed. First, it is possible that some of the observed effect of tax credits represents a reclassification of existing expenditure. This is a universal caveat to all studies focusing on the impact of tax incentives on R&D investment; there is no established method for ruling this out. Second, it is possible that, if inputs to R&D are inelastic, subsidising R&D investment will lead to inflated factor input prices rather than increased real expenditure (Goolsbee 1998). Though in this regard, recent evidence indicates that input price inflation is not a significant concern in aggregate (Thomson and Jensen 2013).

Using the calculator

The calculator is set up to compare the current policy settings with any hypothetical policy changes. The user should first alter the panel titled “INPUT”. Here two hypothetical policy options can be entered including the offset rate and whether or not the hypothetical offset is refundable. The offset rate is gross of standard deductions (that is a firm claiming a 40 percent offset cannot also expense the R&D costs).

The outcome of the policy change on the cost of the scheme (revenue foregone) and R&D investment are indicated in the panel title “OUTPUT”.

The panel titled “ASSUMPTIONS” should also be carefully considered. These can be amended or changed if better data estimates become available. It is a simple matter to consider the sensitivity of any findings to this decomposition and in general this will not affect the outputs substantially.

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Appendix 1 The additional R&D for every dollar of current revenue foregone

ATC – after tax cost of R&D

R – R&D

τ corporate income tax rate

With $s = 1 - ATC$ then the revenue foregone is given by $s \times R$.

So we want: $\dfrac{dR}{d\left(sR\right)}$

The (estimated) tax price elasticity is:

$$\eta = \frac{dR}{R} / \frac{d\left(\frac{1-s}{1-\tau}\right)}{\left(\frac{1-s}{1-\tau}\right)}$$

Holding constant τ (that is only varying the explicit credits) the elasticity of R&D w.r.t. tax price can be written:

$$\eta = -\frac{dR}{R} / \frac{ds}{\left(1-s\right)} = \frac{dR}{ds} \times \frac{\left(s-1\right)}{R}$$

So: $\dfrac{ds}{dR} = \dfrac{s-1}{\eta R}$

And: $\dfrac{dR}{d\left(sR\right)} = \dfrac{dR}{Rds + sdR} = \dfrac{1}{R\,{}^{ds}\!/_{dR} + s} = \dfrac{\eta}{s-1+\eta s}$