The Design of R&D Support Schemes for Industry[1]

Background material for the Garnaut Climate Change Review Update 2011

IPRIA Occasional Report

by

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Executive summary

This paper assesses the design features of R&D support schemes for private sector firms. Government intervention, via such support schemes, can be justified to the extent external benefits (spillovers) and the need to the spread risk of highly innovative activities exists.

There are four types of industry R&D support schemes:

1. *Service provision schemes*: information or advice to firms on a walk-in-the-door basis (we do not consider these schemes further).

2. *Entitlement schemes*: all firms that meet specified threshold criteria qualify for support (the most common being the R&D tax concession).

3. *Competitive schemes*: support is awarded by committees only to the highest ranked eligible firms.

4. *Industry R&D corporations*: research priorities are identified by the industry through a range of consultative activities. Funding is sourced from industry levies and general taxation.

We consider four design parameters, in general, and specifically relate to three of our four types of support.

1. *Firm engagement*: How does the scheme recruit business interest?

2. *Project selection* What criteria are used and who selects the projects?

3. *Payment structure*: How is financial support structured?

4. *Administrative costs*: How to minimise the burden.

Summary of schemes against design parameters

Design parameters	Entitlement schemes	Competitive schemes	R&D corporations
Firm engagement	Reasonably well-known except for some SMEs; flexible with respect to industry and technology.	Costly to engage firms; hard for firms to discover; commercial sensitivity problems; can be inflexible with respect to industry.	Not sustainable without strong engagement. Excludes firms outside target industry
Project selection	Eligibility rules determined by bureaucratic units such as ATO. Firms self evaluate. Limited scope to target spillovers.	Often use government appointed selection committees. Selection is subjective and potentially discretionary. Often target spillovers, but little evidence this is successful.	Selection by industry members (ballot or member committee). Targets intra-industry spillovers but not society-wide spillovers.
Payment structure	Always matching money but least generous.	Often matching money	Varies – can be in-kind matching resources.
Administrative costs	Low. No reporting, only random audits.	Expensive, 2-3 weeks spent by firms in application.	Costs born by industry

Recommendations in brief:

The best R&D scheme should engender lasting innovation capabilities and embody enough flexibility so that support can re-orientate itself towards changing opportunities and needs. A desirable scheme should:

- Be enduring enough to form a stable and predictable source of funding for industry;
- Embody clear and unambiguous rules that are easy for industry to discover and interpret;
- Explicitly acknowledge that some projects will be unsuccessful;
- Recognise that support should match one-to-one with external benefits so that separate R&D schemes are additive;
- Consider judicious targeting at a few technology areas in which Australia has a comparative advantage.
- Allow little or no scope for bureaucratic discretion and political interference in the selection process
- Not target additionality or otherwise over-engineer selection criteria with unachievable or unmeasurable goals.

In light of this, we recommend against competitive grant schemes that involve project selection by government or government appointed committees. Alternatively we recommend both entitlement schemes and supporting the establishment of industry R&D corporations.

1. Introduction

This paper assesses the design features of R&D support schemes for private sector firms.

R&D support include entitlement schemes (e.g., tax credits), competitive schemes (e.g., AusIndustry grants); industry R&D corporations (e.g., Grains R&D Corporation); and service provision schemes (e.g., Enterprise Connect). This paper does not consider programs which funds public sector research (e.g., Australian Research Council grants) or those aimed to facilitate the transfer of technology from the public to the private sector (e.g., technology transfer offices).

We discuss:

- How the different schemes operate;
- What are desirable design parameters of a scheme; and
- How the different schemes rate against these desirable parameters.

Our analysis focuses on major industry competitive grant programs, the R&D corporation model and the current R&D tax concession scheme. Our findings presented below are based on:

- A review of the literature[2]
- Interviews with employees from the Australian public service (10) and a state public service (1).
- Interviews with other industry people including consultants who assist firms in making grant applications (4).
- Interviews with grant managers at industry research and development corporations (3).
- A telephone survey of 171 R&D active firms.
- A telephone survey of 147 successful competitive grant recipients.

This research paper is organised as follows. In section 2 begin with some brief comments on innovation policy context. In section 3, four main types of R&D scheme are then introduced and key features, including differences and trade offs, are identified. Section 4

[2] We have not found any microeconomic evaluations in Australia of competitive grant schemes that follow the normal evaluation method which include the use of control groups; baseline data etc. Most are case studies or are descriptive tabulations of gross outcomes or are audits for internal budgeting purposes. There are a number of high quality evaluations of the R&D tax concession (BIE 1993; Thomson 2010).

discusses the 5 principal aspects of program design, identifying how these are manifest in different types of schemes. Section 5 presents concluding recommendations.

2. Policy rationale: spillovers and risk

Climate change is attributable to a negative consumption externality arising from greenhouse gas emissions. However, creating and deploying new low-carbon technologies are subject to two other market failures. These market failures are due to spillovers from the production of R&D and risk. Public policy intervention is justified on the basis of both theses failures.

Spillovers

There are two types of positive production externalities. The first is generically described as 'knowledge spillovers' though other benefits also arise from economies of scope, absorptive capacity and external economies. The second type is the gains that accrue to households from an increase in the efficiency of production. These are called 'rent spillovers'. A rent spillover is the additional consumer surplus created by a fall in the cost of producing a good (or the new consumer surplus gained from creating a new good). Over the long run, rent spillovers are only associated with investments into new knowledge and ideas. They are not generated by net investments into technology-constant capital goods.[3]

Actuarial and uncertain risk

The addition of risk to the public good setting means that conventional externality remedies do not necessarily apply in a straightforward way. While actuarial risk can be reduced via aggregation, in practice, this only covers a small range of activities (via institutions such as insurance agencies and stock markets). Uncertain risk, on the other hand, cannot be reduced through pooling since its occurrence does not have well-defined statistical properties.[4] Uncertain risk can only be transferred between parties – not reduced. However, if the marginal cost of bearing risk increases with the amount of risk held, the total *cost* of a given level of uncertain risk can be reduced by spreading it across the many parties (Arrow and Lind 1970). Both the prevalence of pooling institutions and the benefits from spreading uncertain risk can be used for using tax payer money to finance risky R&D.

Institutions, which both pool and spread risk, arise where information and transactions costs are low, usually because of the sheer accumulation of past transactions and associated learning-by-doing. The financial institutions which serve Australia's mining

[3] While there are short-term gains to consumer surplus from moving production units to the most efficient technique of production, once this has expired there are no benefits from adding additional technology-constant capital goods (in the absence of population growth). Of course, additional machinery which embodies new technologies will generate rent spillovers, but it is the embodied knowledge and ideas that are generating the spillovers, not the plant and equipment *per se*.

[4] See Frank Knight (1921) *Risk, Uncertainty and Profit*

sector and the information technology industry in Silicon Valley are examples of these pooling and spreading institutions.

Innovation policies designed to overcome both externality and risk market failures include competitive grants given to firms and universities, procurement, intramural R&D (such as funding to CSIRO), and the state enforcement of monopoly intellectual property rights. In isolation each of these are imperfect and involve fundamental tradeoffs. IP rights, such as patents, are imperfect since they create dead weight loss. Competitive grants impose large information costs on administrators, are subject to political interference, and potential bias toward low risk projects. Due to these enduring imperfections, arbitraging between policy instruments is common practice in OECD countries, including Australia.

2.1 The adequacy of pre-existing policy measures

In light of the climate change challenge we must ask:

- Do existing policies effectively solve market failures in innovation?
- Are they responsive enough to continue to do so following a dramatic increase in marginal productivity of mitigation innovation?

It is outside the terms of reference of this study to comprehensively address these questions, or to comment on the desirable rate of support but some preliminary discussion is outlined below.

As regards to the first part of this question, a substantial volume of international evidence indicates that the social rate of return to R&D is still considerably higher than the social discount rate, even after taking these policies into account (for a recent review see Hall, Mairesse and Mohnen 2010). This finding suggests that we are still producing below the optimal level of R&D in general. Therefore investment in climate-change related R&D will be suboptimal even after a carbon price is introduced.[5]

If we require large and fast structural change – because of a large shift in the demand curve (due to the imposition of the carbon price) – and marginal adjustment costs rise with the rate of adjustment, then it may be more efficient to approach the adjustment with both the demand-pull (via the carbon price) and supply-push. That is, in a choice between a carbon (CO_2e) price of $60 per tonne on the one hand, and, a carbon price of $30 plus carbon-focussed R&D support on the other, the latter may be more efficient.

[5] Of course, even in the unlikely possibility that that existing policies do effectively address innovation externalities, evolving R&D opportunities mean support must be re-directed and increased in accordance with shift in private sector R&D investment. Ad valorem entitlement schemes, such as the R&D tax concession, 'automatically' provide greater support to areas with the highest private investment. Similarly, competitive grants should follow the shift in private R&D.

Targeted R&D schemes have a long historical precedent.[6] Famous US examples of targeted supply push-demand pull policies include Defense Advanced Research Projects Agency (DARPA); ARPA-E (Advanced Research Projects Agency-Energy); the Advanced Technology Program and SEMATECH; in Israel the BIRD and MAGNET programs; in the developing world, the Green Revolution.[7] These programs were enacted either in response to national 'crises' over war, including the cold war, fear of losing competitive edge or fear of running out of food. Such programs are credited with tremendous technological advances, including the internet and computers. The Green Revolution seems an apt analogy, particularly with respect to the plurality of inputs, technologies, producers and intermediaries which constitute the global crop industry. In a recent paper Acemoglu *et al.* (2009) argue theoretically that optimal policy involves both carbon taxes and research subsidies.

Considerable research has focused on identifying the impact of government grants on private sector R&D. Results indicate some variation, though the prevailing consensus is that full crowding out is unlikely. That is, businesses do not reduce their own spending by one dollar for each dollar given to them by the government. However, overwhelming empirical evidence indicates that demand conditions are among the most important determinant of private sector investment in R&D. That is, the most effective way to drive private sector resources to climate change innovation is via a carbon price – R&D support should be seen as a compliment.

2.2 Policy effect varies across innovators and technology

As mentioned, R&D market failures arise from the presence of spillovers and uncertain risk. In practice, these failures are compounded by stumbling blocks along commercialisation channels.[8] A typical path to market involves a series of different firms each contributing according to their comparative advantage. This is probably efficient. Passing through several legal and economic entities allows risk spreading and gains from specialisation. However, there is reasonable evidence that junctures in the commercialisation channel do not always operate well. If commercialisation pathways operated effectively, inventions which originate from different institutions should have the same likelihood of reaching market commercialization. We know that this is not so (Webster and Jensen forthcoming).

R&D support schemes need to be mindful that the costs and inefficiencies in commercialisation channels will vary. There are several features that can complicate commercialisation channels, and should be borne in mind.

- Whether the basic research emanates from the public or private sector. Survey data on over 4000 Australian inventions supports anecdotal views that public sector science

[6] Indeed, some commentators have advocated a "climate change Manhattan project", i.e., a government-sponsored, mission-oriented technology programme (see Mowery et al 2010 for discussion).
[7] Feldman and Kelley (2003); Feldman and Kelley (2002); Nagano (2006); Feldman, Kelley, Schaff and Farkas (2000); Link and Scott (2005); Breznitz (2007).
[8] We use the term 'commercialisation' in an inclusive sense to include extension services and non-commercial technology transfer.

incurs greater difficulties transferring to the private sector than private sector firms (Webster and Jensen, forthcoming).

- The size of the firm. There is evidence that SMEs have more difficulty financing the commercialisation process (Hall 2005). In large part, this is due to the lack of retained earnings and mortgagable assets. It is partly for this reason that the smaller is the firm, the more likely it is to need to sell or buy-in specialised capabilities.

- The internationalisation of the industry and technology. Face-to-face contact matters for transactions involving tacit knowledge and intuitive communications. Novel and frontier knowledge tends to be more tacit and less codified. The further afield one has to go to find suitable partners or buyers, the more fraught the channel, *ceteris paribus*.

- Indivisibilities of investment. Technologies that require large minimum investments – perhaps because they are more radical or require the establishment of industry standards – will involve more parties.

- The existing organisation of the industry or technology group. Some industries are more organised and offer well worn paths for commercialisation than others.

Climate change innovation policy should also be mindful of the inherent trade-off between supporting existing firms and encouraging the entry of new firms. Supporting an existing industry in technological upgrading makes it more difficult for market entrants with the potential to erode the market share of the incumbent firms. While in theory such a question is best left to the market, in practice many government policies work with existing industries which tends to favour incumbents.

3. Types of R&D schemes

There are four main types of R&D support to the private sector: service provision, entitlement schemes, competitive grant schemes and industry R&D corporations. These are introduced below.

1. **SERVICE PROVISION SCHEMES:** These schemes typically offer information or advice to firms on a walk-in-the-door basis. Extended advice involving firm visits can sometimes be rationed. Examples include the Australian Institute for Commercialisation, Innovic, C21, Enterprise Connect and ASEA. We do not focus on service based schemes in this report.

2. **ENTITLEMENT SCHEMES**: Once the rules for entitlement are established, all units that meet the threshold test qualify for the subsidy. The most common R&D entitlement is a taxation concession. The Australian Tax Office (ATO) defines what qualifies as eligible R&D and firms can claim an additional rate (above 100%). Loan entitlements are less common but R&D examples include programs run out of the Office of Chief Scientist in Israeli and for education costs, the Australian HECS

scheme. Entitlement grants, such as tax concessions, are given *ex post* (after the money has been invested) but others, such as HECS, are given *ex ante*.

3. **COMPETITIVE SCHEMES:** Competitive schemes only award money to a sub-set of eligible firms. The rules for qualification are determined at the policy level, although administrators and selection committees generally have some degree of discretion in determining qualification. Ranking is usually determined by a committee. Most competitive schemes are for grants but some loans are also allocated this way.

4. **INDUSTRY R&D CORPORATIONS:** R&D corporations are co-operative industry owned groups that fund R&D for the benefit of the industry (members). In this report we use the term to describe the general type of organisation, not to refer specifically to *rural* research and development corporations, though we do use examples from these.

   In Australia, R&D corporations are generally (but not always) funded from a mix industry levies, membership fees and government funds.[9] Strategic research priorities are identified by the industry through a range of consultative activities and the research is targeted at specific industry needs. People consulted described their approach is fundamentally one of problem solving – identifying key challenges facing the industry, isolating sub components and funding projects which address those which have the best likelihood of making the biggest impact on the nominated problem.

   Industry R&D corporations are individually crafted to suit the specific industry structure. Many are composed of small independent operators (such as primary producers), for whom technology is not a usual nexus of competition. However, there are several examples of industry R&D groups comprised of a small numbers of technologically sophisticated manufacturers and miners who are otherwise in direct competition with one another.[10] These tend to only fund R&D that is common to all members, such as basic research or research focused on industry-wide issues (like health and safety). For such organisations to work, members must have similar technological needs and be able to find areas of common technological interest, where the benefits of cooperation outweigh competitive considerations. A priori, the most suitable industries are those not dominated by one main player; those with many price takers; those able to levy members in a way that is perceived as fair and equitable; and, those where technology is not the primary nexus of competition.

   Our consultations indicated that there is widespread acknowledgement of fundamental trade off between doing incremental research which may generate modest returns in the short term versus pursuing more strategic radical innovation. Some industry R&D groups also acknowledged the inherent tension between common benefit and the reality of ongoing competition between members. For instance sometimes a firm which is leading in a particular field may not want to work

[9] Rural RDCs are funded 1:1.Funding arrangements. Other industry groups differ.

[10] Such as Dairy Innovation Australia, the Australian Coal Association Research Program and the Australian Mineral Industries Research Association Limited. These operate in a range of ways but each with the general objective of investing in intangibles, largely technology, for the good of the industry.

on a given issue. By funding more fundamental or basic research and leaving applied or commercial research for the individual firms, R&D corporation can support projects with industry-wide benefit.

Entitlement and competitive schemes

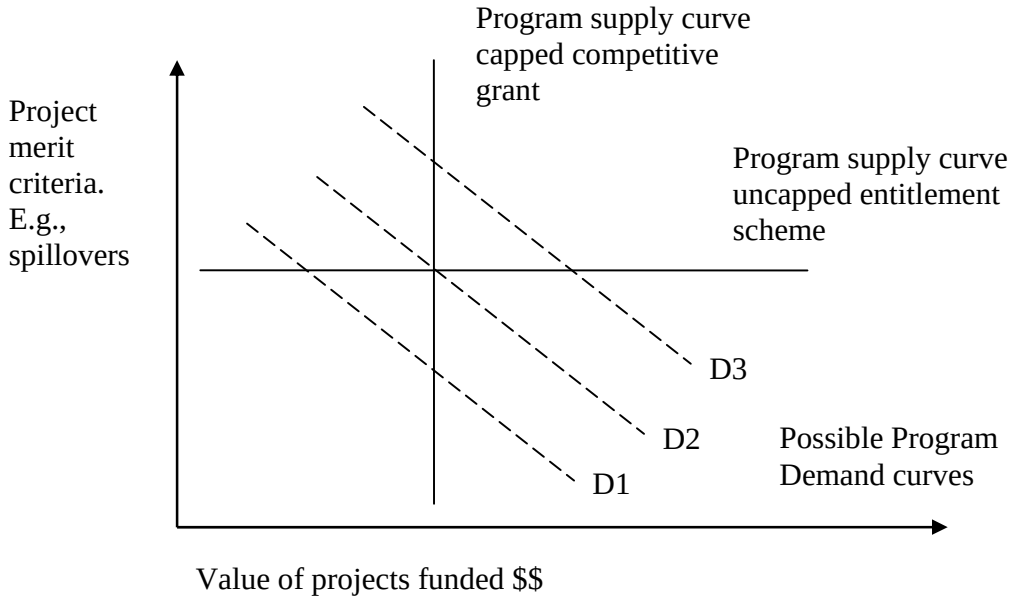
Since tax entitlement and competitive grant schemes are the most common forms of R&D subsidy in Australia, it is worth to pause and consider their differences. It is common to describe entitlement schemes as being advantaged for being 'market mediated'[11] thereby reducing the risk of government failure.

In practice the Australian R&D tax concession applies neutrally across all technology types and industrial sectors. One implication of this is that it automatically flows toward the research deemed most valuable by the private sector. However, this is not a feature restricted to entitlement schemes. Both entitlements and competitive grant programs can be targeted and in principle can include exactly the same criteria. The generalisable differences between entitlement schemes and competitive grants stem from the differences regarding *who* evaluates projects merit against program eligibility criteria and the commercial confidentially of the R&D.

Entitlements are uncapped whereas, competitive grants are typically capped. These have a number of implications in theory and in practice. The first difference relates to a trade-off between the quantity of project funding and the average quality of projects funded. *Ex ante* the government does not know, with certainty, what the demand for a program will be (or equivalently the quality of the projects that will be put forward). The lower the merit threshold, the more projects will be eligible (greater demand). In principal, with a capped grant scheme, the quantity of expenditure is set and the quality of projects funded is determined by the market. In the case of an uncapped entitlement scheme, the reverse is true, a quality threshold is defined *ex ante*, and all the uncertainty manifests in the rate of uptake (demand for the scheme).

Figure 1 illustrates this trade off. Project merit criteria is the rationing device and is increasing along the vertical axis. In practice, projects are evaluated against multiple criteria, but for illustrative purposes we only depict one. Total value of projects funded is increasing along the horizontal axis. The diagonal lines indicate possible demand for the scheme (that is the $$ value of applications for the merit level required by the scheme), which is unknown ex ante. If market demand turns out to be D1 a capped competitive grant will provide more funding and projects with a lower level of merit will be funded. If demand is represented as D3, the reverse is true. If market demand for the scheme is D2, the thresholds are set such that each scheme design will result in the same volume of expenditure for projects of identical quality.

[11] See for example Productivity Commission (2007).



An implication for government is that capped competitive grants risk under-subscription[12] or 'excess' demand with many applicants being denied funding; while in the case of entitlement schemes, risk is manifest as uncapped liabilities. For a range of reasons governments may put more weight on one or the other of these program design risks.

This also has implications for program applicants. Entitlement schemes are generally self assessed with compliance monitored via (random) auditing. Merit criteria must be a codified, consistent, and universally understood, threshold of the desired project attribute. Alternatively, in the case of competitive grants, projects are ranked and funds awarded to the best projects such that available funds are used up. The threshold is ultimately determined by the quality, and number, of program applicants. Grant applicants are competing against each other rather than against a set of fixed criteria. From the applicant perspective, this significantly increases the uncertainty regarding the availability of funds.

Note that if a competitive program is 'undersubscribed', funds are being rationed by a pre-determined quality threshold – 'competition' is not driving quality. In this regard, rounds-based competitive grants are thought to have the advantage over ongoing grants that a bigger pool of projects is received at one time, thereby increasing competition and raising project quality. On the negative side, a rounds-based system is not seen as being as responsive to applicant needs.

[12] or excessive lowering of project quality

DIFFERENCE BETWEEN GENERAL ACCEPTED ACCOUNTING PRINCIPLES (GAAP) AND TAX CONCESSION R&D

Measured R&D depends on the accounting and measurement policies of individual firms as firms can decide how to organise their internal accounts and whether to supplement these with ad hoc additions. However, most firms are guided either by national accounting standards or national taxation rules – the two are not the same.

The Generally Agreed Accounting Principles (GAAP) defines R&D investment according to whether it meets the definition of an "asset" and can thus be said to contribute towards intangible assets. GAAP requires asset expenditures to be separable (i.e., implying contractual or property rights); have the power to obtain future economic benefits; have the power to restrict the access of others to the benefits; have a 0.5 or higher probability that future benefits will eventuate; and have been a cost from an external party. Research costs generally fail this test and are therefore normally expensed. This means that they are not separately accounted for and cannot be distinguished from production wages and administrative costs. Only downstream portions of the commercialisation process which have high probability of generating future income will be included as an R&D asset.

The ABS by contrast follows the Frascati manual definition and includes risky, unsecured upstream research but not downstream activities in their definition of R&D. The former comprise basic research, applied research and experimental development. The ATO typically follows the ABS definition. The upshot is that the differences in standards make it unclear which guidelines firms are following in their own internal accounting and what they include when they complete company reports and ABS surveys. In addition, changes over time to ATO rules, including the financial incentive to claim tax rebates, has meant that data based on this measure will not necessarily give a consistent series of data over time. The table below gives a potted summary of the different measures of R&D.

R&D Measure	*Research*	*Development*	*Commercialisation*
Accounting principles (GAAP)	X	X (unless certain) √ (external patent costs)	√
ABS (Frascati)	√	√ (prototypes, design, tests if part of further research)	X
ATO	√	√	X

4. Design parameters

There are four design parameters common to any form of government support for R&D:

(a) Firm engagement — How does the scheme recruit business interest?

(b) Project selection — What criteria are used and who selects the projects?

(c) Payment structure — How is financial support structured?

(d) Administrative costs — How to minimise the burden.

Based *inter alia* on our consultations and stakeholder surveys, these parameters are reviewed below in the context of entitlement schemes, competitive schemes and industry R&D corporations.

(a) Firm engagement

Our interviews and surveys revealed that the cost of knowing about industry grant schemes is larger than most people imagine. R&D managers in large firms are often not aware of large R&D grant programs. SMEs are even less informed. The problem is especially acute for programs that change often. While 6-8 years may represent a long-lived program, this is not long enough to become well-known in industry (many recent programs exist for only 3-4 years). Even through the R&D tax concession has existed for 25 years, anecdotally it is believed that many smaller firms are not aware of it.[13]

Public service administrators appear aware of this issue, noting that clarifying program requirements is a key request from potential applicants. Similarly there is recognition that it takes time to build interest in a new scheme via educating the population of potential applicants. In sectors with a high degree of foreign ownership, such as automotive manufacturing, any R&D scheme ultimately must influence the behaviour of parent firms whose attention may be harder to grab.

Our surveys of firms found that people believe that selection 'rules' change without warning or are opaque. In the words of one respondent:

> *Changes in the administration & administrators mean a vast amount of money is spent on adapting applications & recalibrating arguments, to fit the changing priorities of funding boards*

Even though State and Commonwealth governments have run R&D grant programs for many decades, new programs still have program specification and administration teething problems. We speculate a number of possible reasons why this might be the case. First, there may be issues to do with the public service retaining corporate memory. Alternatively it may be that each new scheme is 'over-engineered' to meet unreasonable specific program objectives. Finally, a consistent underestimate of the high costs to

[13] see Thomson (2010) for a history of the R&D tax concession scheme

industry in understanding the rules of the game for each new iteration of R&D grant schemes might provide some explanation.

As part of our industry survey, we also asked grant applicants how they heard of the grant programme. Forty per cent of firms found out about R&D grant programmes through their industry association. Other important sources of information about relevant schemes are government referral services (29 per cent) and consultants (19 per cent).

Firm engagement in Entitlement schemes

Large firms are advised by large accounting firms and have the greatest awareness and engagement in the R&D tax concession scheme. The situation for SMEs is less sanguine. There are reports that many SMEs are not aware of the scheme and are not advised appropriately by their accountants. On the plus side, entitlement schemes are suitable for commercially sensitive projects where proprietary IP is important. Entitlement schemes do not tend to arbitrarily exclude good projects that were not anticipated at the time the program was set up. It is relatively easy to make entitlement schemes flexible with respect to unknown future issues and technologies.

Firm engagement in Competitive schemes

Survey evidence reveals that many firms had either not thought of applying for existing grant (1/5 of respondents in our sample of large firms who are R&D active had not thought of applying for a grant) and many cite that they did not understand the selection criteria.

We spoke to eight firms who had considered applying for a grant, but ultimately did not do so. The most common reason why firms in our survey did not apply for a grant was because the grant was too small. Other reasons include commercial sensitivity, not wanting to disclose details of their R&D programs and also not wanting to share IP (especially in the case of R&D linkage grants). Availability of matched funding was not seen as a barrier to application, in fact, this was the least most common reason nominated.

Firm engagement in Industry R&D corporations

Because the R&D corporation is owned by industry, there is good engagement between firms and the executive. The corporations and the committees know the researchers well and there is an enduring relationship with the relevant research community. The committee that determines funding allocations are in the industry (the parties contributing the levies) and have an intimate knowledge of the technologies and applications. The committee has an active role in shaping the research, so it is not a ‘one-hit game’. Because the funds are coming from industry, probity concerns are less and there is limited oversight from government.

However, based on our discussions with stakeholders we believe identifying and negotiating projects with shared benefits is costly (in terms of time and resources). For this reason, a considerable incentive maybe required to ‘bring firms to the table’ (see also

discussion below regarding subsidy amount). In practice, government influence appears to have been critical in establishing existing industry groups.[14] However, governments should avoid defining industry grouping. As noted previously, directing resources to a given government defined industry (say coal fired electricity) can be to the detriment of others (i.e. renewable energy). By providing general incentives for groups of firms to find common ground, negative consequences of this issue can be minimised. It might be useful to make funding available to support the establishment of groups.

(b) Project Selection

Project section involves two elements: what are the selection criteria and who judges projects against these criteria. Four selection criteria are commonly used:[15]

1. Technological feasibility and capabilities of the applicant
2. Private benefits i.e. commercial viability
3. Additionality i.e. will it lead to more R&D?
4. External benefits i.e. spillovers

Selection personnel are usually:

1. Program recipient (entitlement schemes)
2. Government-appointed committees (competitive schemes)
3. Industry committees (R&D corporations)

Selection criteria

The design of the structure of payments can make many of the selection criteria redundant. For example, co-contribution – matching funds – aligns the incentives of grant applicants and the selection committee/unit with respect to technological feasibility and private benefits. If the selection committee/unit cannot claim better knowledge than the applicant, these criteria should be omitted from the decision. The relative skills and access to information between applicant and committee is likely to vary. Sophisticated firms are likely to have better information on the technology and market than independent award committees, whereas this may not be the case regarding backyard inventors.

However, applicants have different incentives to selection committee with regard to project additionality and spillovers. A common objective of competitive R&D grant schemes is to avoid subsidising projects which would proceed in the absence of

[14] Rural RDCs were established by an act of parliament (*Primary Industries and Energy Research and Development Act 19*89). Anecdotally, Government also played an important role in the other industry R&D corporations we identified.

[15] E.g., the Commercial Ready Program criteria are: (1) Management capability of the applicant (2) Commercial potential of the project; (3) Technical strength of the project, and the technical capability and resources available to the applicant (4) Extent to which the project is likely to provide National Benefits (5) Need for funding.

government support – that is, to target 'additionality.'[16] In practice, applicants are asked to show evidence that they were unable to acquire funding from other sources. We argue that using selection criteria to target marginal projects are unlikely to be successful, and will introduce considerable inefficiencies. We first note that project level additionality is not a requisite for program additionality. That is, if a firm's best project is awarded a grant, this frees up resources to fund other more marginal projects (i.e., lowers the average cost of capital). There is a cascading effect. Hence, trying to second guess whether the project will or will not go ahead without the grant is not going to identify additionality.[17] Furthermore, all government programs – for education, the labour market, health – involve displacement (i.e. crowding out). A goal of zero displacement is not reasonable. We note however that about half of unsuccessful grant applications (in our survey) reported that the project did eventually go ahead, albeit in reduced form.

There has been a lot of academic and government research, especially overseas, measuring additionality in general.[18] The consensus is that each $1 of government subsidy does not affect the private contribution so there is neither crowding out nor additionality – though specific estimates vary considerably. On average, European studies are more likely to find additionality and US studies are more likely to find crowding out. These differences could be due to the program mix or the prejudices of the researcher. There is no evidence that schemes designed to induce additionality increased R&D activity by more that schemes not designed in this way.

Selecting R&D projects based on industry consensus, as is the case in of R&D corporations, provides a unique solution to the additionality issue. Members will resist funding research projects they are performing anyway and should focus on projects with maximum intra-industry spillovers.

So far we have argued that the design of the structure of payments can avoid the need for technological feasibility and private benefits to be part of the selection criteria. To avoid over engineering schemes, 'additionality' should not included either. The only remaining 'valid' assessment criterion therefore relates to external benefits or spillovers. In the case of climate change innovation, this may amount to nominating specific industrial outcomes. However, a case must still be made that a given selection committee/unit has the relevant expertise.

Project selection in Entitlement schemes: Entitlement programs, such as a tax concession scheme, avoid the use of selection committees and instead use bureaucratic units (i.e. the ATO). The implications are that the administration cost is lower and

[16] For example, both the R&D Start Program and Commercial Ready include merit criteria related to the need for funding.

[17] Fellner (1992) found that most program administrators have difficulty predicting additionality in proposals. See also Lach (2002).

[18] Hall and Van Reenan (2000); Wallensten (2000); Klette and Moen (2010); Lach (2002); Conzalez, Jaumandreu and Pazo (2005); Almus and Czarnitzki (2003); Blanes & Busom (2004); Aerts and Schmidt (2008); Clausen (2009); Ebersberger (2005); Bayona-Saez and Garcia-Marco (2010); David, Hall and Toole (2000); Lindstrom and Heshmati (2005).

uncertainty (for the firm) reduced. However, it would be awkward, but not impossible, to use an entitlement scheme to target projects with spillovers above a certain threshold.

Internationally, tax-based entitlement schemes are often structured such that only expenditure over and above some pre-defined base is eligible. The idea is to target the subsidy to marginal expenditure and thereby targe additionality. A bonus rate on incremental expenditure has been a feature of the Australian scheme since 2001. *A priori* we would expect this to encourage industry to inefficiently oscillate their R&D programs (see Richardson and Wilkie 1995). The net predicted effect is no long term additionality.

Project selection in Competitive schemes: Government appointed selection panels, in the current form, are unlikely to possess a sufficient level of expertise in all the technology, industry and market areas they are required to cover. This problem may be a function of Australia's small size and thus we should be cautious about copying schemes from US or Europe without accounting for this handicap. Lack of selection committee expertise was cited by survey respondents as the main reason why people though their application had been unsuccessful. Typical comments given by survey recipients include:

> *Grant administrators need some sort of technical expertise or industry knowledge*
>
> *There is some naivety regarding restrictions on what businesses can achieve when in partnership with overseas companies*
>
> *Too much executive time is taken up pandering to government. Grant itself places restraints on sensible commercial exploitation…*
>
> *Less emphasis on unrealistic commercial stipulations in the application, as these are the hardest to prove*

Many schemes are designed to try to second guess what the company would do if the grant was not awarded. We expect that this will give firms an incentive to 'play the game'. There is no evidence that these rules lead to more R&D investment by the firm.

Project selection in Industry R&D corporations: For the three industry R&D corporations we spoke to, a considerable share of research funding is awarded in response to competitive tenders. Expertise on selection committees appears to be the strength of this model. Similarly, a range of governance structures are possible which align the incentive of the award committee and the industry members (eg committees can comprise member representatives, or allocation can be made by direct ballot). The collaborative nature of decision making means funding will be targeted to R&D not being undertaken by individual member firms. That is, funding is implicitly directed toward projects with the most intra-industry spillovers.

Because R&D projects are based on industry consensus, there is an internal check to exclude projects that a member would otherwise perform. This does not however guarantee additionality across the whole industry. In terms of knowledge spillovers, project proposals are sometimes modified to ensure a sufficient number of members benefit.

Ostensibly, it would appear that industry groups are in a unique position to allocate R&D activities to develop technology for application in their industry even if the benefits do not accrue to them. However, industry groups do not have an incentive to fund research that has significant extra-industry knowledge spillovers. Although it should be remembered that similar to all forms of R&D, we expect to achieve rent spillovers. Superficially, might be considered straight forward to motivate industry groups to undertake extra-industry spillover research. However some stakeholders advocated that independence and operating strictly in the industries interest represent key advantages of industry R&D groups. Identifying common ground between participants is complex enough without also trying to meet government funding criteria. The introduction of a carbon tax makes research toward mitigation technology consistent with the objectives of industry, therefore no additional stipulation or incentive should be required to undertake mitigation research.

(c) Payment structure

Payments can vary according to the minimum and maximum amounts offered; whether payments are made as a grant, a loan or equity; and whether matching funds are required.

As noted previously, co-contribution is an important mechanism for aligning the incentives of grant applicants and recipients. Matching formulas ensure that the firm has 'skin in the game'; minimises rent seeking; and improves the quality of proposals. The higher the co-contribution requirement, the more closely funded projects are to market driven projects (except that more projects should be funded). This probably means less risky, less novel investments than a 100 percent grant situation. One grant recipient noted this fundamental trade off:

> *The assessment of the scheme can be contradictory, on one hand you must prove that the project is very risky, while at the same time that it is immediately commercial.*

Some stakeholders considered that the size of the grants determined how much behavioural change the grant program can be expected to 'buy'. The 61 grant recipients surveyed for this study, nominated the rate of financial support was the second most important factor in deciding to apply (after project fitting the program criteria).

Matching funds only assists firms which have the baseline level of liquidity. Firms who are unable to access capital markets, other forms of credit (e.g., trade credit) and don't have retained earnings will be unable to benefit from support paid in arrears. The international literature provides some support for the hypothesis that firms are often liquidity constrained in their R&D investments (see Hall 2005). However, the evidence that large Australian firms are generally liquidity constrained in R&D is not strong (Thomson 2010). Generally, smaller firms, firms with less cash flow and firms investing in upstream technologies, are more likely to be capital constrained.

As part of our survey, we asked grant recipients for their opinion about different forms of support with specific reference to: guaranteed loans, government-sponsored venture capital and repayable grants. Responses from firms, which are summarised in table 1 below, suggest that the respondents are, on balance, positive about these other modes of support.

Table 1 Perceptions of grant recipients of different types of government support

Support type	View Positively	View negatively	Unsure
Government guaranteed loans	17	8	5
Government sponsored venture capital	17	11	7
Repayable grants	16	10	7

Payment structures in Entitlement Schemes: Tax-based entitlement schemes are typically far lower than grants. Historically in Australia the R&D tax concession has provided a subsidy in the order of 10 cents per dollar[19] of R&D expenditure, compared to the standard 50:50 funding rules for grants. Most of these involve *ex post* benefit (that is, tax returns), however there is no reason why an entitlement loan scheme cannot exist (an example from the higher education sector is HECS).

Payment structures in Competitive Schemes: Most competitive grant programs around the world give $1 for each $1 of the firm's money. The payment structure for competitive loans and grants is usually set at the commencement of the program. There are cases where payment rules change within a program (such as ACIS), but these changes are most successful if done with the agreement of all firms in scope (in the case of ACIS there were only four car manufacturing companies). Otherwise, changes cause confusion and grief among firms who feel that the rules change capriciously and to their cost. The R&D Start program had a competitive loan scheme component. There were some 'issues' with R&D Start and interviewees felt it was problematic to recoup monies from firms who had failed, or firms which had not competed their R&D project.

Payment structures in Industry R&D Corporations: In many cases project proposals include some contribution from the researcher (applicant), be it in-kind or cash. Generally, the contribution made by each party reflects their desire to own resultant IP (which is also dependent on background IP bought to the project).

(d) Administrative costs

Entitlement schemes and competitive grants also have obvious differences in regards to administrative costs, both to government and to applicants. The cost to government is lower in the case of entitlement schemes. For example, in 1998-99 the ratio of administration costs to program expenditure was three times higher for R&D Start (6%) than for the R&D tax concession (2%).[20] Evidence also suggests firm compliance cost for R&D Start was also higher for the R&D tax concession. Our 'Grant Recipient Survey' found that firms typically devote 2-3 weeks of staff time, with about 20-30 percent of firms engaging an external consultant.

[19] This low rate is one reason that it is statistically very difficult to observe any aggregate affect of the Australian tax incentive (as in Thomson 2010).
[20] Evaluation of the R&D Start Program, the Allens Consulting Group.

Another reoccurring theme in our consultations was that requirements for the application does not reflect the magnitude of the grant. Many applicants were annoyed by the fact that small grants required the same amount of paper work as large grants. Administrators we spoke to were aware of this potential problem. Best practice policy should equate the evidentiary requirement per government dollar spent. That is, lower requirements for small amounts of money and higher requirements as the magnitude of the grant increases. A typical comment was:

Administrative costs of Entitlement Schemes: Administrative costs are about 1/3 the cost of competitive schemes.

Administrative costs of Competitive Schemes: Administrative costs are about 3 times the cost of entitlement schemes. Firms typically devote 2-3 weeks of staff time to the preparation of the proposal. For respondents from the 'R&D active firm survey', excessive 'paperwork' associated with grant schemes was not ranked as an important reason for not applying for a grant and was not the main factor mentioned by applicants as a issue to be improved (see detailed tables in Appendix A). However, respondents from the 'Grant recipient survey', indicated that reducing the paperwork associated with final and progress reports as the main way the scheme that could be improved (Table 10). A representative comment was:

> *Lots of bureaucracy surrounding grant schemes, which limits cost-effectiveness.*
>
> *The evaluation process needs to be much quicker/more efficient.*

That the scrutiny of a $85,000 grant is the same as a $5,000,000 was widely seen problematic.

Administrative costs of Industry R&D Corporations: We have no comparative evidence on the cost of running R&D corporations. The decision regarding the optimal ratio of administrative to administered funds is left to industry members to determine on a case by case basis.

5. Recommendations

The best R&D scheme should engender lasting innovation capabilities and embody enough flexibility so that support can re-orientate itself towards changing opportunities and needs. A desirable scheme should:

- Be enduring enough to form a stable and predictable source of funding for industry;
- Embody clear and unambiguous rules that are easy for industry to discover and interpret;
- Explicitly acknowledge that some projects will be unsuccessful;

- Recognise that support should match one-to-one with external benefits so that separate R&D schemes are additive (i.e., no penalty should apply if firms qualify for multiple schemes);

- Allow little or no scope for bureaucratic discretion and political interference in the selection process;

- Not target additionality or otherwise over-engineer selection criteria with unachievable or unmeasurable goals; and

- Consider judicious targeting at a few technology areas in which Australia has a comparative advantage.

In light of these goals we recommend against competitive grant schemes that involve project selection by government or government-appointed committees. Alternatively we recommend both entitlement schemes and supporting the establishment of relevant industry R&D corporations.

It is possible to target entitlement support by defining expenditures that fall within designated low-carbon technology areas. Benefits may be through an extension to the R&D tax incentive, or relief from carbon tax liabilities. To minimise confusion for industry, the definition of R&D should conform to the existing R&D tax definition. This not only lowers auditing costs, it reinforces industries understanding of a standard definition of R&D, lowering communication costs and the need for firms to understand a new set of rules. However, the rate of benefit should reflect the degree of behavioural change desired. We speculate this will be considerably higher than the average historical R&D tax concession.

The second proposal is to provide incentives for industries to develop ongoing shared research programs, analogous to existing R&D corporations. Resources could be made available to support the administrative costs of establishing such a body.

Table 1: Recommended R&D subsidy schemes

Feature	Entitlement Scheme based on R&D tax concession – higher rate for designated low carbon technologies	RDC-style body in selected technologies
Operation	Tax credit or rebate; possible 12 month advance for SMEs with funding shortfall.	Corporation
Administered by	ATO	Corporation
Marketing to industry	Tax agents; accountants; grant brokers	Owned by industry
Selection	None, entitlement	Expert industry people – retired experts. Can use R&D corporation staff as 'technology scouts'.
Funded by	Tax forgone	Taxation and industry levy (in lieu of carbon permit?)
Matching funds	To be determined	Can vary by how commercial-ready the project. Might be a loan; procurement; matched funds.
Stability and ambiguity	Less if cannot be cut by cabinet. Codified transparent eligibility criteria.	Less than programs that can be cut by cabinet.
Application process	None, tax form.	Standard R&D corporation process. Needs to be faster than ARC which is too slow and bureaucratic.
Reporting requirement	None, normal random tax audit only.	Standard R&D corporation process.
Commercialisation potential	'Level playing field' – no selection by committees, no delay in approval, no reporting, commercialisation the firms' responsibility.	Strategic, problem-focussed research. Determined by the industry that pays the levy. The corporation is also responsible for ensuring uptake / extension – that is penetration to members.
Confidentiality	Confidential, firm has clear IP title	Not confidential. IP title subject to negotiation.

Appendix A. Survey results

R&D active firm survey.

To inform our study, we undertook two telephone surveys of businesses in Australia. The first covered a sample of 171 large R&D-active firms

Table 2: R&D active firm survey responses, 2011

Response	Number	%
Completed survey	59	34.5
Applied for a grant in the past	38	22.2
Only considered applying for a grant	8	4.7
Never considered applying for a grant	13	7.6
Did not want to participate	64	37.4
Dead record	9	5.3
Contacted but not completed survey due to timetabling problems	39	22.8
TOTAL	171	100.0

Note: Population of firms derived from IBISWorld Business Information

For those who thought about applying for a grant, but did not, the biggest reason was the grant was too small. Commercial sensitivity and not wanting to share IP were the next most important reasons.

Table 3: Reasons for not applying for a grant, n=8

Reasons	Importance
Your R&D projects are too small to be eligible	0.429
Not able to get the internal matching funds required	0.143
Project didn't fit the criteria	1.142
Too much paper work involved in application	0.571
Too much paper work involved in progress reports	0.571
Grant too small	1.714
Commercial sensitivity – don't want to disclose R&D information.	1.429
Those administering the scheme have the skills to evaluate projects.	0.333
Didn't want to share project IP	1.429

Note: Importance is the mean of responses to the question "Why didn't your company apply?" Responses were weighted "yes" but the answer was unprompted = 3; "major problem" after prompting by the interviewer= 2; "minor problem" after prompting by the interviewer= 1; "no problem" after prompting by the interviewer=0. Population of firms derived from IBISWorld Business Information.

Respondents who were not successful in their grant applicaton did not think they missed out because their project was too risky or had low commercial returns. The main reason given was that the selectors did not understand the project. Low community benefit was also nominated, though this was not seen as important. There was no clear message from this group about what could be improved.

Table 4: Perceived reasons for being unsuccessful, n=8

Project too risky	0.000
Low commercial returns	0.125
Limited community benefit	0.875
Selectors didn't understand	1.625

Note: Importance is the mean of responses to the question "Why do you think you were unsuccessful?" Responses were weighted: "yes" but the answer was unprompted = 3; "major problem" after prompting by the interviewer= 2; "minor problem" after prompting by the interviewer= 1; "no problem" after prompting by the interviewer=0. Population of firms derived from IBISWorld Business Information.

For all applicants, there is no obvious lessons about improving the scheme, although there is evidence again that commercial sensitivities may be an issue.

Table 5: Grant scheme/admin improvements, n=36

Commercial sensitivity	0.861
Paperwork- application	0.722
Paperwork - reporting	0.600
Grants too small	0.639

Note: Importance is the mean of responses to the question "Are there any elements of the grant scheme or administration could be improved?" Responses were weighted: "yes" but the answer was unprompted = 3; "major problem" after prompting by the interviewer= 2; "minor problem" after prompting by the interviewer= 1; "no problem" after prompting by the interviewer=0. Population of firms derived from IBISWorld Business Information.

We scored common themes from respondent open-ended comments. Table 6 indicates how many times each was nominated (out of 27 responses). Collectively, communication and understanding the rules of the game are nominated 12 times. IP sensitivities are also nominated frequently.

Table 6: Improvements and general comments.

Open-ended comments	# mentions
Finding what is available	4
Understanding selection criteria	5
Online communication and IT	3
Uncertainty of receiving grant	4
Time for application process	2
IP issues – commercial sensitivity and allocation	6
Matching requirements	1

Note: Population of firms derived from IBISWorld Business Information

Grant recipient survey

The second telephone survey comprise 147 past recipients of an R&D grant – about half of whom agreed to complete the survey (Table 7). About half of recipients heard about the grant through industry groups but about one in three heard about them from government referral services. Print advertising was the most infrequent source of information.

The main reason applicants applied for the particular scheme was that the selection criteria fitted their project and the view that it offered a high rate of financial support. Reducing the amount of paper work in both the application process and the reports to government are the main ways applicants believed that grant schemes could be improved.

Table 7: Grant recipient survey responses, 2011

Response	Number	%
Completed survey	61	51.3
Did not want to participate	28	23.5
Dead record	30	25.2
TOTAL	147	100.0

Note: Population of firms derived from AusIndustry web site.

Table 8: How did you hear about this grant?

Source	mean
Internet search	0.159
Industry group	0.413
Print advertising	0.032
Government referral service	0.286
Word of mouth	0.190
Consultant	0.190
Other – mainly relating to the unrealistic selction criteria and the bureaucratic demands.	0.016

Note: Mean of responses to the question "How did you hear about this grant?" yes=1, no=0. Population of firms derived from AusIndustry web site.

Table 9: Why did you choose to apply for this particular grant scheme?

Stats	mean
Criteria fit my project	0.825
Easiest application process/lowest cost	0.032
High rate of financial support	0.333
Belief that the applications would be evaluated by experts	0.032
No need to pay it back	0.063
Requirement for co-funding was not a problem	0.016
Low IP stipulations.	0.048
High probability of success	0.079
Other	0.111

Note: Importance is the mean of responses to the question "Are there any elements of the grant scheme or administration could be improved?" Responses were weighted: "yes" but the answer was unprompted = 3; "major problem" after prompting by the interviewer= 2; "minor problem" after prompting by the interviewer= 1; "no problem" after prompting by the interviewer=0. Population of firms derived from AusIndustry web site.

Respondents were also asked about the evidence requirements within the application, regarding the technological feasibility of your project; the commercial viability of the project. (market demand and benefits) and financial issues surrounding your project. (ability to get co-funding, inability to self finance). Over 80 per cent believed that the requirement for technological feasibility and financial issues were reasonable. However, only three quarters felt that the commercial viability requirements were reasonable.

Table 10: Element of grant scheme that could be improved.

Decrease paper work involved in application	0.541
Decrease paper work involved in reporting to the government, progress reports etc.	0.746
Increase grants size	0.540
Increased success rate	0.254
Commercial sensitivity	0.254
Ownership of IP	0.338
Other (specify)	0.460

Note: Importance is the mean of responses to the question “Are there any elements of the grant scheme or administration could be improved?” Responses were weighted: ”yes” but the answer was unprompted = 3; “major problem” after prompting by the interviewer= 2; “minor problem” after prompting by the interviewer= 1; “no problem” after prompting by the interviewer=0. Population of firms derived from AusIndustry web site.

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