R&D Tax Incentives as an Alternative to Targeted R&D Subsidies

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Abstract Governments can provide targeted R&D subsidies and/or tax incentives to spur innovation and growth in the business sector. This chapter analyzes the theoretical pros and cons of these policy instruments and their practical implications according to the empirical literature. Tax incentives have low administrative costs, enable market agents to choose R&D projects, and can be provided to many firms. However, they entail the risk that governments might finance R&D that would have been undertaken anyway (deadweight loss) and that firms may relabel other costs as R&D costs. Targeted subsidies are preferable for projects with high uncertainty and those that require a long time to achieve a finished product and for contexts in which the government wishes to allocate resources to specific sectors. However, such subsidies have high bureaucratic costs, distort competition, and favor grant application experts. The greatest disadvantages of targeted R&D subsidies are that they are mainly allocated to large firms and are often used as covert industrial subsidies.

Keywords Targeted R&D subsidies · Tax incentives · Spillovers · Imperfect appropriability · Financial restrictions · Small business · Innovation · Government policy

JEL Codes O31 · O32 · O33 · O34 · O38

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Introduction

Several literature reviews have concluded that new knowledge and technology, created through research and development (R&D), are regarded as the main factors of growth and productivity in the economy (Wieser 2005; Hall et al. 2010). However, there is a consensus in the literature that in a free market, companies invest in R&D to a degree that is less than socially optimal. Due to imperfect appropriability, companies carrying out R&D cannot reap the full benefits of their efforts (Jaffe 1998). Since companies consider solely their own returns and ignore spillover effects to others when determining how much to invest in R&D, the socially optimal level is not reached (Arrow 1962). Underinvestment in R&D also occurs due to asymmetric information about the commercial prospects of projects, which leads to high transaction costs and imperfect capital markets. This can cause a financial gap, especially for small, early-stage, and risky R&D projects (Kaplan and Strömberg 2001; Carpenter and Petersen 2002). Thus, there is a crucial difference between these two reasons for market failure with respect to firm size. While imperfect appropriability applies for R&D-performing firms of any size, financial restrictions are a problem faced primarily by new ventures and small firms working in early phases of high-tech projects (Lerner 2009).

To address these market failures, governments have developed a toolkit of instruments for intervening in the market (Bloom et al. 2019).[1] Examples include exclusive intellectual property rights in the form of patents and copyright, innovation support in the form of government loans and venture capital, education of trained scientists, and improved market conditions for entrepreneurial firms.

While scholars are largely in agreement concerning the general importance of R&D to handle market failures as described above, the policy measures used to handle this issue have varied over time. Mission-oriented policies, such as those advocated by, e.g., Mazzucato (2021, 2022), have underscored the importance of a proactive government making targeted and bold efforts in certain sectors of the economy. Mazzucato (2022, p. 93) asserts that:

> Governments play a critical role in catalysing and coordinating both public and private investment around common goals, not least transitioning to a green economy. [...]
>
> Key here is to use the full range of levers available to governments—from supply-side interventions, with the state acting as an investor of first resort (rather than lender of last resort) and as a funder and regulator with clear direction, to demand-side interventions, with the use of dynamic procurement policy to incentivize innovative solutions in domains ranging from public transport to housing.

These statements and related innovation policy research point to the importance of directionality, i.e., that governments should set directions for technology

[1] These methods are designed to promote the dissemination of technology and create new and improved products that will benefit consumers. Thus, welfare is expected to increase, given that overall, the cost is lower than the positive effects.

development (e.g., Schot and Steinmueller 2016) rather than backing away from interventions in the economy.

Recent discussions concerning the effects of such mission-oriented policies would benefit from a thorough review of the various advantages and disadvantages of different policy measures. As policymakers throughout the Western world are implementing large-scale industrial policies aimed at leapfrogging the entire sectors into a more "sustainable" state through "green deals," there is a need for structured analysis of the effects that are associated with direct subsidies and tax subsidies.

In this chapter, one of the main policy instruments will be analyzed: government subsidies for business R&D.[2] Such subsidies can take the form of targeted R&D subsidies or R&D tax subsidies.[3] Targeted subsidies imply that the government subsidizes the R&D that is conducted by companies. R&D tax subsidies indicate that the government subsidizes the R&D performed by companies by lowering their taxes. The idea is that this incentivizes companies to increase their R&D investments.

Most OECD countries allocate 10–20% of their annual public R&D budget to the business sector (OECD 2022). Government support for business R&D increased from 0.14 to 0.22% of the total GDP between 2000 and 2020 in the OECD area (OECD 2023b). However, statistics show that the distribution of this R&D support through targeted subsidies and tax incentives varies substantially across countries (see Fig. 1). In 2020, approximately 55% of the total R&D support given to the business sector in OECD consisted of R&D tax subsidies (see Fig. 1).[4] Furthermore, there has been a clear shift from targeted subsidies toward tax subsidies in OECD countries in recent decades (Güceri et al. 2020; OECD 2023b). In 2022, 33 out of the 38 OECD countries provided R&D tax incentives for business R&D expenditures compared to only 19 OECD countries having done so in 2000 (OECD 2023b).

The current trend toward provisioning more R&D tax subsidies might depend not only on the economic factors that are analyzed in this chapter but also on political factors. Carvalho (2012) argues that the Lisbon Agenda and the Action Plan to fulfill the Barcelona objective have stimulated a growing interest in R&D tax incentives among politicians. The political goals of increasing the level of innovation and business R&D enhance the international competition for scarce R&D resources and can only be achieved when more companies are incentivized to undertake R&D and subsequently perform it. Therefore, the best instrument that governments have at hands is the provisioning of R&D tax subsidies.

The main purpose of this chapter is to examine the *economic* pros and cons of targeted R&D subsidies and tax incentives based on the theoretical and empirical

[2]Government R&D financing is also provided to universities and government laboratories. Archibugi and Filippetti (2018) have analyzed how public-funded R&D should be carried out among different recipients (universities, government laboratories, and firms in the business sector).

[3]The expression "targeted R&D subsidies" is used here because the government usually specifies in which sector the R&D project is to be carried out and specifies numerous other conditions for funding to be granted.

[4]In the OECD area, R&D tax subsidies surpassed targeted R&D subsidies in 2016.

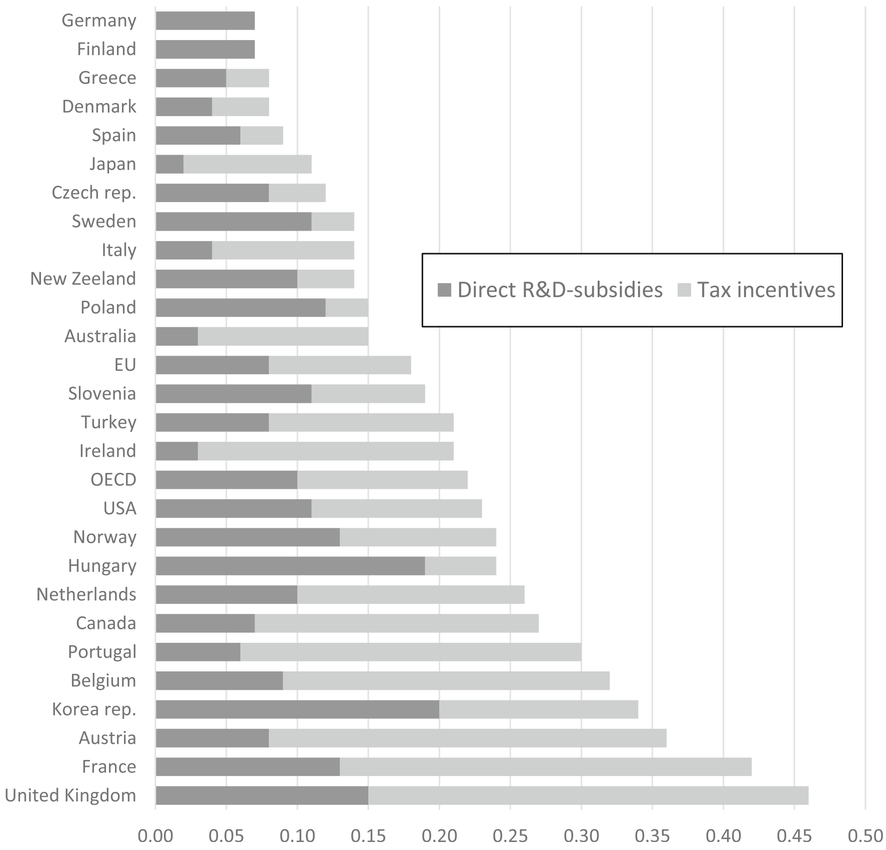

Fig. 1 Direct subsidies and tax subsidies for business R&D among high- and middle-income countries in 2020 as a percentage of GDP. *Source*: Countries selected from OECD (2023a)

scientific literature. Are these policy instruments substitutes or complements? How should they be designed to work efficiently?

The analysis shows that there are several pros and cons of both targeted R&D subsidies and tax incentives. Targeted subsidies are preferable for projects with high uncertainty, when it takes a long time to deliver a finished product and when the government wishes to allocate resources to specific sectors with high spillovers (e.g., the environment and energy sectors). However, targeted subsidies have high bureaucratic costs, distort competition, and favor organizations that are application experts. The greatest disadvantages of targeted R&D projects are that they are allocated mainly to large firms and that they are often used as covert industrial subsidies.

Tax incentives are mostly competition neutral, have low administrative costs, let market agents choose R&D projects, and provide continuous support. However, there is a risk of governments financing R&D that would have been undertaken anyway (generating dead-weight losses) and of firms relabeling other costs as R&D costs.

Furthermore, my analysis reveals that targeted R&D projects and tax subsidies are complementary in several senses: Targeted subsidies are often allocated to projects that require a lengthy period to reach a finished product, while firms choose short-term R&D projects when they are financed through R&D tax subsidies. Targeted subsidies should be used when the government aims to increase R&D efforts in specific sectors, while R&D tax subsidies are preferable when the aim is to increase total business R&D investments. However, increased efficiency can be achieved if the government uses a specific form of tax subsidies called "R&D payroll tax subsidies" that have a cap per firm. The subsidies can then be directed where they are most efficient—to small businesses and entrepreneurs. The reason for the increased efficiency is that market failures related to both imperfect appropriability and imperfect capital markets can then be considered.

The chapter is structured as follows. Section "Public Support of Private R&D" analyzes the theoretical pros and cons of direct R&D subsidies and R&D tax incentives in the business sector. The empirical literature is reviewed in Sect. "Empirical Research on the Efficiency of the Instruments". Section "Conclusions and Implications for Mission-Oriented Policy" spells out the main conclusions.

Public Support of Private R&D

Jaffe (1998) argued that government R&D financing in the business sector should be focused on projects with large spillover effects and a low risk of displacing private R&D. However, government financing of business R&D for the purpose of creating spillovers is problematic since profit-maximizing firms actively attempt to avoid disseminating R&D results to competitors. Companies therefore try to protect the results of their R&D through secrecy, lead times, or IPRs. However, in the case of patents, the basic knowledge about R&D results is disseminated, as patent authorities publish basic information about the inventions in patent documents. When there is a commercial potential with a fairly high private return but still significant spillover effects, the government can subsidize R&D in the business sector—either directly or indirectly.[5] The government may then set up appropriate dissemination criteria, such as requiring the company to cooperate with universities or other companies. Other requirements may be that the company hires a certain number of people or that the R&D results be partially published (patent requirements).

[5] There are other reasons than imperfect appropriability and financial restrictions why governments finance R&D in the business sector instead of at universities or government research laboratories. The business sector may have better R&D equipment than the public sector. The government may be interested in increasing the competitiveness of its own country's companies. There may also be expectations that an injection of government funding will stimulate companies to increase their own R&D.

Targeted R&D Subsidies

Direct R&D subsidies are usually allocated through a call for proposals by government agencies or research councils. Targeted calls are used almost exclusively for direct R&D subsidies to the business sector, while open calls are rare. Thus, the government authorities determine in which sectors R&D projects should be undertaken and also specify other conditions that must be fulfilled. Companies then compete for grants. As a rule, the grant applications are reviewed and evaluated by an audit committee consisting of internal and external experts from industry and academia. The government can try to estimate the quality and objectives of R&D projects in advance and select projects that promise a social return that significantly exceeds the private return. Examples include projects that promote the government's own public goals (defense, the environment, and health care) or early-stage projects in technology-intensive industries with no access to capital markets due to information asymmetries. Furthermore, targeted R&D subsidies can be tied to fulfilling certain obligations. Companies might, for example, be forced to patent their inventions, publish parts of their R&D results, create a certain number of new jobs, or collaborate with universities or other private companies.

R&D Tax Incentives

Most OECD countries allow R&D costs (including R&D capital expenditures) to be written off as current expenditures in the same year in which they are implemented. Thus, R&D expenditures are treated more generously than investments in plants and equipment, which must be written off over a longer period.

The most common R&D tax subsidies are tax allowances and tax credits, which are normally available for all firms performing R&D. Governments can allow an accelerated deduction (of more than 100%) of R&D costs from taxable income (tax allowance) or from payable income tax (tax credits). Tax deductions reduce companies' marginal cost of R&D and thus should stimulate more R&D (Hall and Van Reenen 2000).

Tax allowances imply that firms may deduct more R&D costs from their taxable income than they actually spend on R&D, while tax credits are a percentage of R&D expenditures that can be deducted from payable income tax (OECD 2023b). A difference between tax allowances and tax credits is that the value of a tax allowance depends on the corporate income tax rate, while a tax credit does not. Another difference is that unused tax allowances (for unprofitable firms) may be postponed, offsetting future taxes under normal loss carryforward provisions. However, the carryforward of unused tax credits requires a special pool to track unused credits; otherwise, unprofitable firms cannot use credits.[6] Since many unprofitable

[6]Many OECD countries allow tax credits to be claimed against future income tax (OECD 2023b).

companies are small firms or new ventures, a carryforward of unused tax credits increases the value of tax credits for such firms.

Most tax subsidies for R&D in OECD countries are volume-based, which means that all R&D carried out by companies is covered by subsidies. This generous system is easy to administer but means that the government subsidizes a large amount of R&D that companies would have undertaken without the subsidies. Some countries have incremental schedules of their tax incentives, i.e., companies receive more tax subsidies if they increase their R&D expenditures relative to those in a base year. This process avoids financing R&D that companies would have performed without the subsidies, but it is administratively demanding (OECD 2010a; SOU 2012). Many OECD countries have thresholds or upper ceilings for the eligible R&D volumes that qualify for R&D tax subsidies (OECD 2023b). This means that SMEs often are favored over large firms. For R&D tax credits/allowances, SMEs receive a 20% subsidy on eligible R&D expenses on average, as compared to 16% for large firms (OECD 2023b).

The third kind of tax incentive system is reduced wage or payroll taxes for R&D staff. Such a system (the WBSO system) has been applied in the Netherlands since 1994 and benefits labor-intensive R&D.[7] Furthermore, unlike under traditional tax allowance and tax credit systems, unprofitable firms can benefit from payroll tax subsidies directly. Three countries that had not previously had R&D tax subsidies—Sweden, Germany, and Finland—also introduced such payroll tax subsidies in 2014, 2020, and 2022, respectively.

The Pros and Cons of the Policy Instruments

There are several advantages and disadvantages associated with R&D tax incentives and targeted R&D subsidies (see Table 1).

One obvious advantage of tax subsidies is that they are mostly competition neutral and often available to all companies conducting R&D. Support is given irrespective of firm size, sector, type of R&D, and the objective of the innovation activity (van Pottelsberghe et al. 2003; CREST 2006). However, there might be thresholds or ceilings, as mentioned in the previous section, which favor SMEs. Furthermore, the design of the R&D subsidies might favor profitable firms (tax allowances and tax credits) since non-profitable firms must carry their subsidies forward until they become profitable (OECD 2023b). Targeted R&D subsidies obviously distort competition, as the government decides to which companies the support should be directed. Only projects and companies that receive support can benefit from it.

Furthermore, tax subsidies have lower administrative costs than targeted R&D subsidies (van Pottelsberghe et al. 2003; CREST 2004, 2006). Politicians and

[7] The WBSO has been changed several times since its introduction in 1994.

Table 1 Pros and cons of targeted R&D subsidies and tax incentives

	Targeted R&D subsidies	R&D tax incentives
Pros	• Suitable under considerable uncertainty and a lengthy time requirement for realizing a finished product • Suitable if spillovers can be identified • Suitable for R&D in specific public good sectors • Good budget control for the government • The government can stimulate spillovers by enforcing patenting and cooperation among other companies and universities	• Suitable for applied R&D that is close to realizing a finished product • Suitable for financing projects that are on the margin of being commercially profitable • Often competitively neutral since companies in all sectors can receive support • Low administrative costs • Suitable for stimulating business R&D in general • Both the market and companies are efficient at selecting appropriate R&D projects • Continuity that is good for long-term R&D efforts • Does not benefit application experts
Cons	• Distorts competition and assists only selected companies • High administrative costs • Impractical for stimulating business R&D in general • Difficult for the government to identify suitable projects • Non-continuous project-based support • Benefits application experts	• Poor budget control for the government • Entails the risk of financing R&D that would have been performed even without the support (volume-based subsidies) • Companies are incentivized to relabel other costs as R&D costs to benefit from tax reduction • Companies choose R&D projects with high private returns rather than a high social return • Patent boxes are available only for profitable companies

bureaucrats do not need to select firms, sectors, or regions. In the case of targeted subsidies, one must identify interesting sectors, announce projects, evaluate applications, and try to pick winners. This means that targeted R&D subsidies are impractical and costly to use when the government is aiming to increase business R&D investment in general (CREST 2006). In that context, R&D tax subsidies are the least costly option (Veltri et al. 2009; Carvalho 2012).

Another advantage of tax incentives is that they are continuous and support companies' long-term R&D investments. Targeted R&D subsidies are usually linked to individual projects and can be used for a project only until it has been completed (Carvalho 2012). Finally, tax incentives prevent the emergence of so-called application experts who specialize in winning most of the grants. Targeted subsidies not only favor such application experts (Freeman and Soete 1997; Hall and Van Reenen 2000; Lerner 2009) but can also be influenced by political pressure, bureaucratic structures, and lobbying from companies (Czarnitzki et al. 2011).

In general, targeted R&D support is considered appropriate if there is great uncertainty about R&D investment and if there is a long waiting time until a product's development is completed (CREST 2006; Veltri et al. 2009). Targeted R&D support is also appropriate when large spillovers are expected (van Pottelsberghe et al. 2003) and when R&D is to be directed at specific public sectors, e.g., the environment and defense (CREST 2006; Veltri et al. 2009). Tax subsidies are considered more suitable for applied R&D and for products that can be completed quickly (OECD 2010b) because tax subsidies stimulate R&D projects that are on the margin of being profitable for the private sector. Government authorities have problems selecting winners (van Pottelsberghe et al. 2003), while companies are more efficient in selecting appropriate and profitable R&D projects (Hall and Van Reenen 2000; CREST 2004, 2006; Atkinson 2007). In fact, one risk in regard to R&D tax subsidies is that companies might choose projects with a high private return rather than those with a social return (Hall and Van Reenen 2000; van Pottelsberghe et al. 2003).

There are some disadvantages of tax incentives. The subsidies may go to R&D that the companies would have carried out even without the subsidy (i.e., the subsidies are characterized by non-additionality) (CREST 2004). This is especially the case if the tax subsidies are volume based (R&D is subsidized from the first cent that is spent) (David et al. 2000). Furthermore, as all types of tax incentives in some ways are linked to the expenditure side, it may be problematic to classify which costs are actually related to R&D. There is a risk that companies will try to relabel other costs as R&D costs to benefit from the support (CREST 2004; Veltri et al. 2009). Finally, government budget control is reduced when direct R&D support is provided, which is not the case with R&D tax subsidies (van Pottelsberghe et al. 2003).

Because profit-maximizing companies do not want to disseminate their R&D results, the government may set up appropriate dissemination criteria, such as requiring the company to cooperate with universities or other companies (Veltri et al. 2009). Other requirements may be that the company hires a certain number of people or that the R&D results be partially published (patent requirements). However, such requirements can usually be met only under a targeted R&D subsidy system and seldom under an R&D tax incentive policy.

Empirical Research on the Efficiency of the Instruments

Several review studies have concluded that the social returns on private R&D are significantly higher than the private returns, i.e., the spillover effects are significant (Wieser 2005; Hall et al. 2010). Spillover effects can occur both within and between industries and between countries, which is particularly important from an economic-political perspective, as spillover effects primarily motivate public actors to finance R&D.

The research literature shows that publicly funded R&D carried out by companies has a positive effect on productivity and growth, but the effect is weaker than when companies finance their own R&D (Wieser 2005). This may occur because public authorities are not as skilled as market agents in terms of identifying promising R&D projects to finance, and the authorities do not invest their own money. Defense-related R&D that is implemented in the business sector and funded by the government has a negative effect on productivity and growth (Poole and Bernard 1992; Guellec and van Pottelsberghe 2004). There are two explanations for this negative effect. First, this type of R&D is sometimes accomplished through contracts where the financier (government) owns the result. Therefore, the company has a weaker incentive to carry out R&D efficiently. Second, the defense industry is hampered by export restrictions, which means that R&D has a smaller effect on productivity and growth. However, defense R&D can have desirable positive effects; for example, the well-being of society may improve because it has a stronger defense system in place.

Several studies have analyzed whether public subsidies have a positive effect on companies' self-financed R&D and create so-called additive effects (David et al. 2000). In this case, there is a risk that public R&D funding will create problems. First, publicly funded R&D can displace privately funded R&D by raising the cost of R&D—mainly the cost for scarce R&D staff. Second, publicly funded R&D can simply replace privately funded R&D. Companies may replace their own financing with public financing and maintain their current level of R&D. The third problem is that the government often does not allocate resources as efficiently as market participants, thereby creating distortions in the market.

Targeted R&D Subsidies

Early studies show that direct R&D subsidies have both positive effects and crowding-out effects on companies' R&D (see reviews by David et al. 2000 and Garcia-Quevedo 2004). However, David et al. (2000) criticized early studies due to biased sample selection; firms with no R&D were excluded from the samples. As R&D-intensive companies are more likely to apply for R&D support, it is probable that these companies would have made some of the R&D investments even without support. Therefore, these studies tend to find displacement effects.

More recent studies use econometric methods that account for this biased sample selection problem and have therefore found more positive effects on business R&D supported by direct R&D subsidies. This result is confirmed by studies that analyze R&D subsidies in numerous European countries (Aerts and Schmidt 2008; Czarnitzki and Hussinger 2004; Duguet 2004; Hussinger 2008; Özcelik and Taymaz 2008; Carboni 2011; Cerulli and Poti 2012; Bloch and Graversen 2012).

R&D Tax Incentives

There are two main groups of studies that analyze the effect of R&D tax subsidies on R&D investments at the firm level: studies using the structural approach and studies using the direct approach (Blandinières and Steinbrenner 2021):

Structural approach. In the studies using a structural method, the impact of the tax incentives is captured via an R&D user cost, which accounts for the reduction in R&D costs, and the dependent variable is the firm's R&D expenditures in a log-log specification. Thus, these studies estimate an elasticity, namely, how a percentage decrease in the R&D user cost affects the percentage change in R&D investments. According to a literature review by Becker (2015), recent studies have established that tax incentives have relatively stable effects on companies' R&D. The elasticity is approximately -1 (i.e., if the tax decreases by 1%, companies' R&D increases by 1%), but there is some variation across countries and periods (Bloom et al. 2002; Parisi and Sembenelli 2003; Koga 2003; Bernstein and Mamuneas 2005; Baghana and Mohnen 2009; Harris et al. 2009; Lokshin and Mohnen 2012; Mulkay and Mairesse 2013).

Direct approach. In studies using a direct approach, the tax subsidy is measured either as a dummy or in absolute terms, i.e., the amount of R&D subsidy received, and compared with firms' R&D expenditure. The dummy can be interpreted either as a treatment effect on the firm or as a reflection of whether the firm is eligible for the subsidy. Some recent studies using a direct approach rely on difference-in-difference or matching methods to correct for selection bias and to compare the effect across treatment and control groups. Most studies conclude that tax credits increase R&D spending or R&D intensity (Paff 2005; Yang et al. 2012; Kobayashi 2014; Crespi et al. 2016; Güceri and Liu 2019; Agrawal et al. 2020; Stavlöt and Svensson 2022). Notably, many of the studies taking the direct approach have found that small firms or firms with liquidity constraints respond more strongly to tax incentives (Kobayashi 2014; Güceri and Liu 2019; Agrawal et al. 2020).

Other approaches. Some studies use dependent variables other than firms' own R&D investment. This choice might arise from the fact that data on firm-level R&D expenditures are not available or that the authors wish to estimate the effects on other goal variables. One study in this vein worth emphasizing is that of Czarnitzki et al. (2011), who use a matching method to estimate the effects of Canadian tax credits on a series of innovation indicators (number of new products, sales of new products, originality of innovations, etc.). The authors conclude that recipients of subsidies score better on most indicators than a control group. Furthermore, they find that the tax credit has a positive impact on firms' decision to conduct any R&D at all.

Using data on Belgian R&D tax subsidies for R&D wages, Neicu et al. (2016) find that increasing the subsidies cause behavioral additionality effects among R&D conducting firms. Companies do not undertake similar R&D projects as they did before (scale), nor do they conduct projects with a higher speed, but they rather place greater focus on research than development and initiate new R&D projects. Since "research" is more intricately linked than "development" to market failures, the provisioning of additional volume-based R&D tax subsidies is therefore supported from a policy-perspective.

Targeted Subsidies vs. Tax Incentives

Few studies have empirically compared tax incentives with direct subsidies. However, Neicu et al. (2016) find that companies that also receive direct R&D subsidies are more strongly affected by the above-mentioned behavioral additionality effects that arise from R&D tax subsidies. Becker (2015) reviews the literature assessing how direct support and tax incentives affect private R&D in the short and long terms. In the short run, tax incentives have significant effects, which then diminish. Direct support, on the other hand, has small effects in the short run but greater long-term effects (see Table 1). These observations depend on the fact that companies are more likely to choose profitable projects that are relatively close to being finished and marketed. Furthermore, in the case of direct support, public authorities choose which R&D projects to carry out. These projects are often in the early R&D phases and focus on specific sectors (e.g., public needs). Such R&D projects can therefore create new opportunities and induce companies to start R&D projects in later phases. These results suggest that tax incentives and direct support should be coordinated.

Görg and Strobl (2007) conduct a firm-level investigation on how the amount of public R&D support to domestic and multinational manufacturing companies in Ireland affects firms' self-financed R&D. For domestic companies, low levels of R&D support for firms have positive effects on private R&D, but high levels of support crowd-out companies' own R&D. For multinational companies, government support has neither positive nor negative effects, regardless of the size of the support. Hsu and Hsueh (2009) examine the effectiveness of public R&D assistance provided to Taiwanese companies. They find that providing a high level of government R&D support for companies' R&D is ineffective. Similar to Guellec and van Pottelsberghe (2003) with respect to the macro-level, both Görg and Strobl (2007) and Hsu and Hsueh (2009) conclude that at the micro-level, the effects of public R&D support on companies' R&D correspond to an inverted U-shaped curve. Becker (2015) interprets this result to imply that a high level of R&D support increases the probability of the government financing R&D activities that companies would have performed even without government support. In such cases, it is better for the government to provide lower amounts of R&D support to many companies rather than large amounts to a few companies.

An increasing number of empirical studies show that public R&D support can increase private R&D more effectively in small firms than in large companies. The theoretical argument is that small and young companies are more financially constrained. Public R&D support acts as a signal to other financiers that the project is worth investing in and should thereby attract more external financing. Lach (2002), González et al. (2005), Hyytinen and Toivanen (2005), and Hall et al. (2009) find that R&D subsidies have a greater effect on R&D performed in small companies than on that performed in large companies, especially if the companies have not performed any R&D before receiving support. Howell (2017) finds that one-time direct subsidies provided to small firms have a significant impact on firm R&D/innovation since they fund prototype technologies and reduce uncertainty. However, multiple grants awarded to the same firms are not as efficient. Studies show that in practice, most public direct R&D subsidies go to larger companies (Czarnitzki and Ebersberger 2010). For example, it has been estimated that 85% of the public targeted R&D subsidies (SEK 5.3 billion) provided to the Swedish business sector are allocated to large companies (Vinnova 2019). The picking-the-winner and application expert theories (see the next section) can partly explain this phenomenon.

Theories about the Skewed Distribution of Direct R&D Subsidies

There are two theories used to explain why the allocation of targeted R&D subsidies is often skewed. The first theory is the "picking-the-winner" theory (Stiglitz and Wallsten 2000), which implies that public R&D financiers prefer to finance R&D projects that have a high probability of success and a lower expected return rather than projects with a low probability of success and a high expected return. There are several explanations for this phenomenon (Cantner and Kösters 2012; Antonelli and Crespi 2013). First, R&D projects are risky and have a high probability of failure. The public choice literature argues that strong political commitments are needed to justify the provision of subsidies for many failed projects. Second, direct support distorts competition. Subsidized companies have an advantage over nonsubsidized companies. By subsidizing good/efficient companies rather than bad/inefficient ones, the distortion is minimized (Shane 2009).

The second theory concerns application experts. Companies that have experience with previous support or applications seem to have an advantage over inexperienced companies (Lerner 2009). For each application submitted, companies gain insight into how the authority's selection of subsidized companies works. Experienced applicants should therefore be more likely to receive direct subsidies. The risk is that—in the end—some companies specialize in obtaining support from many different authorities. The "Matthew effect" can also explain why there is continuity in how direct R&D subsidies are allocated (Merton 1968; Antonelli and Crespi 2013). According to this principle, successful researchers receive a disproportionate amount of attention for their research and thus obtain more funding.

Conclusions and Implications for Mission-Oriented Policy

This chapter addresses the pros and cons of tax incentives and targeted subsidies, as the government finances R&D in the business sector. Targeted subsidies have certain advantages: the government can allocate support to specifically selected sectors, and this action works well under high risk, and it takes a long time to achieve a finished product. However, there are significant disadvantages in the form of distorted competition, and bureaucrats have difficulty knowing which R&D projects will be commercially viable in the long term. Targeted subsidies also favor application experts. In addition, bureaucrats do not distribute their own money but that of taxpayers and may therefore be less careful when choosing appropriate R&D projects. Above all, targeted subsidies are costly, as projects must be identified and announced, and applications must be evaluated. However, the largest disadvantages of targeted R&D projects are that they are allocated mainly to large firms and are often used as covert industrial subsidies.

Tax deductions also have disadvantages. There is a risk that the government finances R&D that companies would carry out even without support, and companies reclassify other costs as R&D costs to benefit from tax deductions. On the plus side, tax incentives are mostly competition neutral, and more companies can benefit from this type of support, especially innovative small companies and entrepreneurs. Tax deductions reduce the administrative cost for the government, and opportunists who specialize in applying for support do not overly benefit. Finally, companies are allowed, to a greater extent, to decide which R&D investments to carry out, as market participants are considered more efficient than bureaucrats in allocating the support where it is most useful, and companies must co-finance the R&D projects they choose.

The analysis shows that targeted R&D projects and tax subsidies are complementary: targeted subsidies are often allocated to projects where there is a long time to a finished product, while firms choose short-term R&D projects when financed through tax subsidies. Furthermore, targeted subsidies should be used when the government aims to increase R&D efforts in specific sectors, while R&D tax subsidies are preferable when the aim is to increase the total level of business R&D investments. However, increased efficiency can be achieved if the government uses a specific form of tax subsidies called "R&D payroll tax subsidies" that has a cap per firm. The subsidies can then be directed where they are the most efficient—to small businesses and entrepreneurs. The reason for the increased efficiency is that market failures related to both imperfect appropriability and imperfect capital markets can then be considered.

The findings in this literature review have implications concerning the efficiency and effectiveness of mission-oriented innovation policies. While the mission-oriented approach can be implemented in different ways, in many cases, it becomes a large-scale program aimed at a specific transformation of an entire sector of the economy, e.g., transitioning industries such as steel or cement into making use of hydrogen gas instead of previously dominant production methods (Sandström and

Alm 2022). These missions usually involve large sums of R&D subsidies that firms can apply for.

This literature review highlights a set of challenges that are related to mission-oriented innovation policies. First, large targeted R&D subsidies face an inherent risk of resulting in distorted competition, as only a few selected companies end up receiving support, an argument that has been previously applied to mission-oriented innovation policies (Bergkvist et al. 2022).

There is also an apparent risk that government officials end up supporting the wrong technology. Allocation of support does not happen in a vacuum; in contrast, such processes take place under the influence of various stakeholders. In Sweden, an attempt to transition cars into using ethanol instead of gasoline as fuel resulted in a spectacular failure. Ethanol was not a competitive fuel, neither for the environment nor for the economy, but nevertheless gained political support because a farmers' lobby association was historically a strong supporter of ethanol (Sandström and Björnemalm 2022).

The presence of large pools of public R&D support earmarked for specific technologies also results in considerable administrative costs. An industry for application experts emerges and results in a form of unproductive entrepreneurship aimed at writing and obtaining grants. Previous research has shown that firms that receive more R&D support tend to be less productive and pay higher wages, effectively becoming subsidy entrepreneurs (Gustafsson et al. 2020).

The review in this chapter suggests that targeted R&D subsidies may be warranted if large and long-term investments are required, if there is high uncertainty, and if the positive externalities are deemed to be substantial. However, there is an inherent risk that such subsidies could lead to misallocation of resources due to lobbying by interest groups and the pursuit of narrow self-interest among political decision-makers.

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