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Evaluation of the R&D Tax Incentives in Sweden*

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Abstract

In 2014, the Swedish government introduced a specific kind of R&D tax relief, reducing firms' payroll tax liability for R&D staff. In comparison to traditional tax incentives where all qualified R&D expenditures can be deducted from taxable income or income taxes, the Swedish subsidy specifically benefits firms with labor-intensive R&D and loss-making firms. In addition, there is a monthly subsidy cap per firm, which benefits small firms. Exploiting the policy design, we perform a difference-in-difference analysis with firm-level panel data on R&D subsidies combined with data on employed scientists over the time period 2011–19. We find that the subsidy has positive effects on the number and share of scientists, with magnitudes of between 32 and 107 and 30 and 43 percent, respectively. Moreover, the treatment effect of the subsidy does not differ across firms by size or debt ratio but is somewhat higher for labor-intensive firms, although the last result is ambiguous.

Keywords: R&D payroll tax subsidy, direct subsidies, subsidy cap, scientists, employment, small firms, panel data

JEL classification: D22, G32, H25, L25, O32, O38

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1. Introduction

Several literature reviews have concluded that new knowledge and technology, created through research and development (R&D), are 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 less in R&D than is socially optimal. Due to imperfect appropriability, companies carrying out R&D cannot reap the full benefits of their efforts. Since companies solely consider 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 in the implications of these two causes of market failure—namely, imperfect appropriability and financial constraints—with respect to firm size. Whereas imperfect appropriability is an issue for R&D-performing firms of any size, financial constraints primarily affect new ventures and small firms working with high-tech projects in early phases (Lerner, 2009).

To address these market failures, governments have developed a toolkit of instruments to intervene in the market (Bloom et al., 2019). Through legislation, exclusive intellectual property rights (IPRs) are granted to inventors and artists in the form of patents and copyrights, which aim to stimulate R&D investment, the commercialization of inventions/artistic works and the standardization and dissemination of knowledge. Other types of intervention include government financing of R&D carried out at universities, government laboratories and in the business sector, and innovation support in the form of government loans or venture capital (VC) to entrepreneurs who want to commercialize new ideas. Governments can also provide a pool of trained scientists and improve market conditions for innovative companies. 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 of supporting R&D is lower than the positive effects.

In general, governments support R&D conducted at three different types of organizations:[1] 1) universities; 2) government laboratories; and 3) private companies. Funding should depend on the respective organization's goals in conducting R&D (see more in Archibugi and Filippetti, 2018). Here, we consider only public support in the business sector. Most OECD countries allocate 10–20 percent of their annual public R&D budget to the business sector (OECD, 2022). Such R&D support can be allocated through either direct subsidies or tax incentives. Recent statistics show that the distribution of this R&D support through direct subsidies and tax incentives varies substantially across countries (Appelt et al., 2019), but a clear trend is that more countries favor tax incentives (Güceri et al., 2020).

Tax incentives for R&D in various countries have taken the form of deductibility of R&D costs against either taxable income (tax allowances) or payable income tax (tax credits).

[1] There are also nonprofit organizations (NPOs), but they engage in low levels of R&D.

These R&D tax incentive programs have been rigorously evaluated in the literature (see, e.g., Becker 2015). In 2014, the Swedish government introduced a specific form of tax incentive program. R&D staff receive reduced payroll taxes corresponding to 10 percent of their gross salary. Compared to traditional tax allowances and tax credits, this payroll tax subsidy specifically targets firms with labor-intensive R&D and is, in addition, available to all companies, including unprofitable ones. Like the policies in some other countries (e.g., the United Kingdom and the Netherlands), the Swedish subsidy targets small companies since there is a subsidy cap per company and month (maximum SEK 230,000 per month).

The purpose of this study is to evaluate the effects of the Swedish R&D payroll tax subsidies for the period 2014–2019. To the best of our knowledge, this kind of tax support scheme for R&D has only been evaluated once before in in the literature for the Netherlands (Lokshin and Mohnen, 2012). As frequently argued in the economics literature, small firms are particularly constrained by market failures in financial markets. As this R&D tax relief scheme targets small and medium-sized enterprises (SMEs), it is of special interest to evaluate the effects of this policy. Since the design of the Swedish tax subsidy is linked to R&D staff, we test how the subsidy is related to the employment of scientists in firms. Exploiting the policy design, we perform a difference-in-difference (DiD) analysis with firm-level panel data on R&D subsidies combined with data on employed scientists over the period 2011–2019. We find that the subsidy has positive effects on the number and share of scientists, with magnitudes between 32 and 107 and 30 and 42 percent, respectively. Moreover, the treatment effect of the subsidy does not differ by firm size or debt ratio but is somewhat higher for labor-intensive firms, although the last result is ambiguous.

The study is structured as follows. Section 2 analyzes the theoretical pros and cons of direct R&D subsidies and tax incentives in the business sector. The empirical literature on tax subsidies is also reviewed. In section 3, the history of public R&D subsidies in the business sector in Sweden and the characteristics of the new Swedish R&D payroll tax subsidies are discussed. In section 4, the database, statistical method, and explanatory variables are presented. The empirical results are provided in section 5, and the main conclusions are summarized in section 6.

2. Theory and empirics of R&D tax incentives

When there is a private R&D project with a fairly high private return but still significant spillover effects, the government can subsidize R&D in the business sector (Archibugi and Filippetti, 2018).[2] Jaffe (1998) suggests that government R&D financing in the business sector should focus on projects with large spillover effects and a low risk of displacing private R&D. Government R&D support to the business sector can be allocated either through direct subsidies or tax incentives. When analyzing the consequences of these subsidies, one must consider the goal functions of firms. Private companies seek to maximize their profits in the long run. Thus, it is in their interest to avoid disseminating R&D results to competitors. Companies therefore try to protect the results of their R&D through secrecy, lead times or intellectual property rights (IPRs). However, in the case of patents, basic knowledge about R&D results is disseminated, as patent authorities are required to publish patent documents. With direct R&D subsidies, cooperation and spillovers can be induced by the financier. However, this cannot be done with tax incentives. In this section, we discuss the main different R&D tax incentive programs and their pros and cons compared to direct subsidies.

2.1 Different kinds of 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 as they are implemented.[3] 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 (more than 100 percent) 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, 2003). 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

[2] There are other reasons than imperfect appropriability and financial restrictions for why governments finance R&D in the business sector instead of at universities or 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. Finally, there is a reverse type of R&D subsidy for business R&D such that government laboratories (e.g., the Research Institutes of Sweden (RISE)) carry out R&D on behalf of companies at a subsidized price. In such cases, the company owns the results and usually demands that the results be kept secret.

[3] In Sweden, the following rules apply: According to the Income Tax Act, expenditure on R&D that has or can be expected to be significant for the main business activity must be deducted in the same year in which it arises. Since 2012, expenses for obtaining information about such R&D can also be deducted (SOU, 2012).

credits.[4] Since many unprofitable 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).

A third kind of tax incentive system is reduced wage or payroll taxes for R&D staff. Such a system (WBSO) has been applied in the Netherlands since 1994 and benefits labor-intensive R&D.[5] Furthermore, compared to traditional tax allowance and tax credit systems, unprofitable firms can benefit from the payroll tax subsidy directly.

Several EU countries have gone quite far with R&D tax incentives and have introduced patent or innovation boxes since the early 2000s. This means that the profit derived from patented products or other IPRs is subject to lower tax rates than the normal corporate tax. The idea is that these boxes will stimulate R&D investments and the commercialization of inventions and artistic works. We do not consider these patent or innovation boxes in the present paper.

2.2 Pros and cons of R&D tax incentives

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

One obvious advantage of tax subsidies is that they are more 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 innovation activity. Direct R&D subsidies distort competition, as the government decides which companies the support should be directed to. Only projects and companies that receive support can benefit from it.

Furthermore, tax subsidies have lower administrative costs than direct R&D subsidies. Politicians and bureaucrats do not need to select firms, sectors, and regions. In the case of direct subsidies, one must identify interesting sectors, announce projects, evaluate applications, and try to pick winners. Another advantage of tax incentives is that they are continuous and support companies' long-term R&D investments. Direct R&D subsidies are usually linked to individual projects and can be used for a project only until it has been completed. Finally, tax incentives prevent the emergence of so-called 'application' experts who specialize in winning most of the grants. Direct subsidies not only favor such application experts (Lerner 2009) but also can be influenced by political pressure, bureaucratic structures and lobbying from companies (Czarnitzki et al. 2010).

[4] Many OECD countries allow tax credits to be claimed against future income tax (OECD, 2003).
[5] WBSO has been changed several times since its introduction in 1994.

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

	Tax incentives of R&D	Direct R&D subsidies
Pros	• Competitively neutral, support irrespective of firm size, sector, and type of R&D • Low administrative costs • Continuity that is good for long-term R&D efforts • Suitable for applied R&D close to a finished product • Suitable for financing projects that are on the margin of being commercially profitable • The market and companies are efficient at selecting appropriate R&D projects • Avoids application experts and lobbying	• Suitable if there is consider-able uncertainty and a long time to a finished product • Suitable if spillovers can be identified • Suitable for R&D in specific public good sectors • Good budget control for the government • Government can enforce cooperation with other companies and universities
Cons	• Risk of financing R&D that would have been performed even without the support (volume-based subsidies) • Companies have incentives to relabel other costs as R&D costs to benefit from tax reduction • Poor budget control for the government	• Distorts competition and assists only selected companies • High administrative costs • Noncontinuous project-based support • Difficult for the government to identify suitable projects • Benefits application experts and lobbying

In general, direct 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 finished. Direct R&D support is also appropriate when large spillovers are expected and when the R&D is to be directed at specific public sectors, e.g., the environment and defense. 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.

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 (that is, the subsidies are characterized by non-additionality). 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. Finally, government budget control is reduced when direct support is provided, which is not the case with tax subsidies.

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. Another requirement may be that the company must hire a certain number of people or that the R&D results must be partially published (patent requirements). However, such requirements can be met only for direct R&D subsidies and seldom for tax incentives.

2.3 Efficiency of 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: structural and direct approaches (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 takes into account 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 percent, companies' R&D increases by 1 percent), but there is some variation across countries and time periods.

Bloom et al. (2002) estimate a long-run elasticity of R&D with respect to its user cost of approximately –1.0 for a panel study on the manufacturing sector in nine OECD countries in the period 1979–97. Parisi and Sembenelli (2003) report an elasticity between –1.5 and –1.8 for a panel of Italian firms during 1992–97. Koga (2003) estimates a lower elasticity of –0.4 for Japanese firms in the period 1989–98. Bernstein and Mamuneas (2005) estimate R&D price elasticities of –0.8 and –0.14 for the US and Canadian manufacturing sectors, respectively. Baghana and Mohnen (2009) confirm the long-run elasticity of –0.14 for firms in the Canadian province of Quebec. Harris et al. (2009) report an elasticity of –1.4 for a panel of manufacturing firms in Northern Ireland for the period 1998–2003. Lokshin and Mohnen (2012) estimate an elasticity of –0.8 for Dutch firms during 1996–2004. Mulkay and Mairesse (2013) obtain a long-run elasticity of –0.4 for French firms from 2000–07.

Direct approach. In studies using a direct approach, the tax subsidy is either measured as a dummy or measured 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.

Among early studies of the US tax credit system, Berger (1993), Billings and Fried (1999) and Billings et al. (2001) conclude that tax credits increased R&D spending or R&D intensity among US firms in the 1980s. However, Swenson (1992) finds positive effects only for certain types of firms: high-growth firms with current tax liabilities.

Paff (2005) applies a difference-in-difference analysis and concludes that state-level tax credits in California had a strong effect on firms' R&D spending in the period 1994–99. Yang et al. (2012), using a matching method, estimate that tax credits induce approximately 50 percent higher R&D activities in Taiwanese firms. The effect is stronger for firms in electronics than for firms in other sectors. However, the tax credit does not affect the growth rate of R&D in firms. Kobayashi (2014) uses a matching method to estimate the effects of tax credits on SMEs in Japan. He finds that the tax credits almost double the R&D expenditure of such firms and encourage many firms to conduct R&D. Furthermore, the effect is especially large for SMEs with liquidity constraints.

Crespi et al. (2016) estimate that a reduction in the user cost of R&D had an elasticity of at least –1 on Argentinian firms' R&D expenditures in the period 1998–2004. Güceri and Liu (2019) use a difference-in-difference approach and show that a UK tax credit reform from 2008 had positive effects on R&D spending among medium-sized firms. Agrawal et al. (2020) estimate that small Canadian firms increased their R&D spending by 17 percent as a result of a change in the rules of the tax credit system.

Notably, many of the direct approach studies 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 have better scores 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.

2.4 Time effects and firm size

Few studies have compared tax incentives with direct subsidies. However, Becker (2015) reviews the literature assessing how direct support and tax incentives affect private R&D in the short and long term. 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 above). 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. Similarly 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 that the government finances R&D activities that the companies would have performed even without government support. In such cases, it is better for the government to provide adequate R&D support to many companies rather than a large amount of R&D support 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 have more financial constraints (see the introduction). 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 R&D before receiving the support. Howell (2017) finds that one-time direct subsidies provided to small firms have a large 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). This phenomenon can be partly explained by the winner-picking[6] and application expert[7] theories.

3. Direct and indirect business R&D subsidies in Sweden

3.1 Comparison of Swedish and OECD R&D

In 2019, total R&D investment in Sweden accounted for 3.4 percent of GDP, in comparison to 2.5 percent in all OECD countries. Sweden thus provides funding at a significantly higher level than other OECD countries on average (OECD, 2022). The literature provides no obvious answer to the question of how large the public R&D budget should be or how it should be distributed to different recipients. Swedish public R&D financing was 0.84 percent of GDP in 2019, relative to 0.60 percent in the OECD. R&D financed by the business sector as a share of GDP is also higher in Sweden (2.1 percent) than in the OECD (1.6 percent) (OECD, 2022). According to the European Innovation Scoreboard index, Sweden is among the top-ranked countries with respect to R&D and innovation (European Commission, 2020). However, Edquist, C. & Zabala-Iturriagagoitia (2015) criticize this index, arguing that Sweden has high performance

[6] The 'picking-the-winner' theory (Stiglitz and Wallsten, 2000) implies that public R&D financiers prefer to finance R&D projects that have a high probability of success and a lower expected return over 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, with 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).

[7] The theory of application experts posits that 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.

mainly with respect to innovation input factors (patent applications, R&D expenditures, PhD graduates) but not for output factors (innovation sales, venture capital expenditures, productivity of R&D investment).

In 2019, approximately 72 percent of all R&D was carried out by the business sector in both Sweden and OECD countries (see Table 2). However, universities perform a significantly higher proportion of total R&D in Sweden (24 percent) than in the OECD average (16 percent). The opposite is true for government laboratories: the figure is 4 percent in Sweden in comparison to 10 percent in the OECD (OECD, 2022).

Table 2 Total R&D broken down by different performers, percent.

R&D by performer		1991	1995	1999	2003	2007	2011	2015	2019
Sweden	Business sector	68.4	74.6	74.4	74.3	73.0	69.1	69.7	71.7
	Universities	27.4	21.6	22.2	21.8	21.9	26.3	26.7	23.7
	Government laboratories	4.1	3.7	3.3	3.5	4.9	4.3	3.4	4.5
	NPOs	0.1	0.1	0.1	0.4	0.2	0.3	0.2	0.1
		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
OECD	Business sector	68.0	66.6	68.8	67.0	68.9	67.1	69.4	71.8
	Universities	15.1	16.4	16.2	18.0	17.2	18.5	17.6	16.3
	Government laboratories	14.5	14.4	12.3	12.3	11.4	11.9	10.6	9.5
	NPOs	2.4	2.6	2.7	2.7	2.5	2.5	2.4	2.4
		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

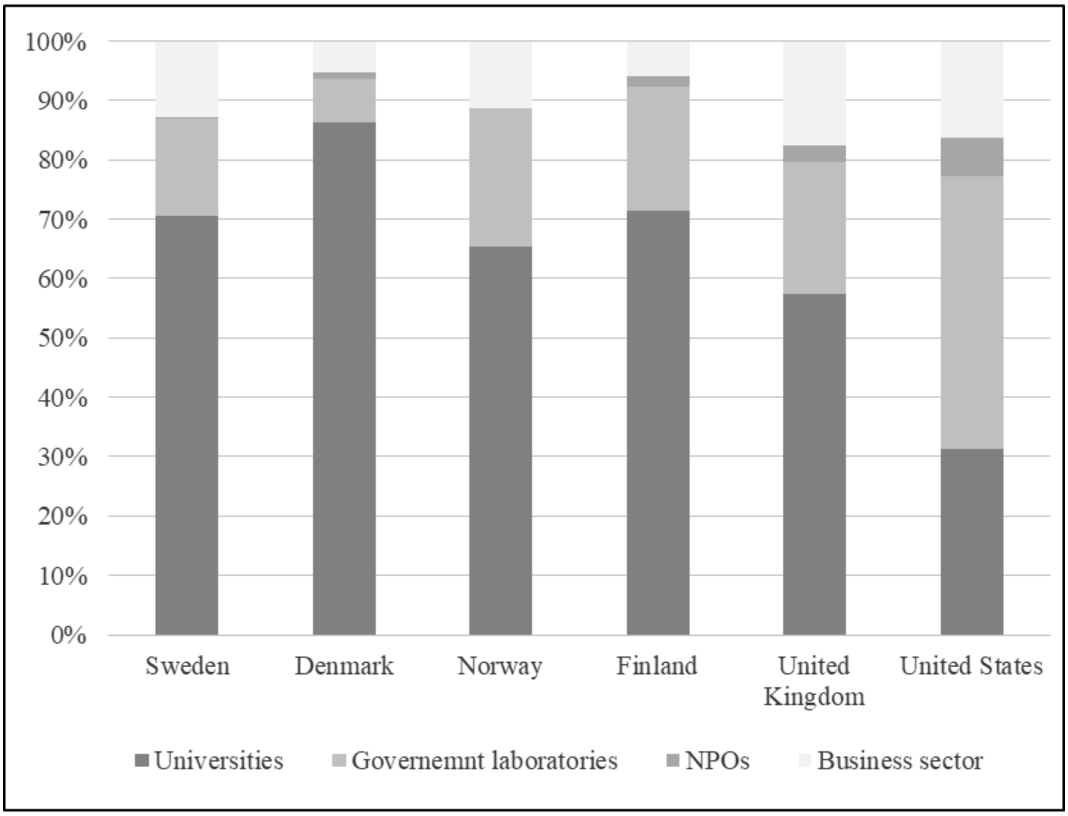
Source: OECD, Main Science and Technology Indicators (2022).

In 2019, 48 percent of the Swedish government's budget was directly allocated to universities through basic grants. The rest, i.e., 52 percent, was funneled through various energy and defense authorities and research councils, which then distribute the funds to different organizations (universities, government laboratories and firms)—often through competitions.[8]

The share of the total Swedish public budget for R&D that is allocated to universities was 71 percent in 2019, as shown in Figure 1. There are some countries (Denmark, Switzerland, Ireland, and the Netherlands) that provide an even larger share (75–85 percent) for universities, but in most OECD countries, the figure ranges between 35 and 65 percent. The share of total Swedish public R&D funding that is directed to the business sector was 13 percent in 2017. In Figure 1, it is obvious that the Swedish government, in an international comparison, prioritizes universities over government laboratories in terms of R&D investments.

[8] The research councils are the Swedish Research Council, VINNOVA, Formas, and Forte. Another funder is the Swedish Energy Agency. The Swedish defense authorities are the Swedish Armed Forces, the Swedish Armed Forces Materiel Administration, and the Swedish Defense Research Agency.

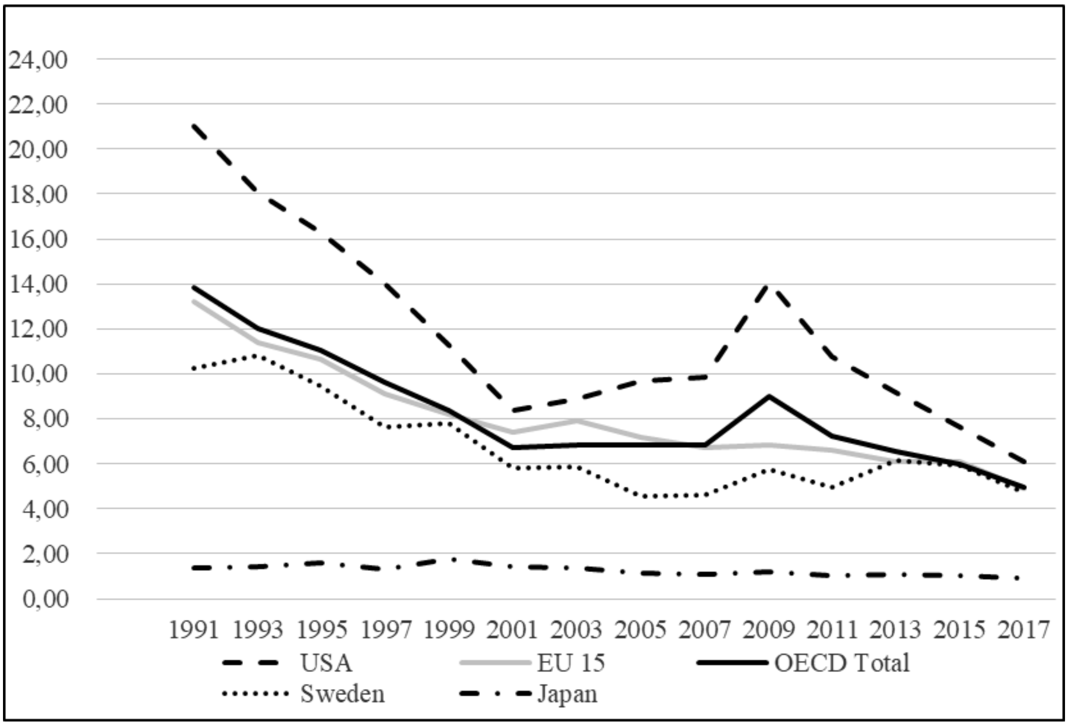
Figure 1 Government R&D budget by recipients in 2019, percent.



Source: OECD, Main Science and Technology Indicators (2022).

An interesting policy question arises: What level of business R&D financing is most appropriate for the government? Guellec and Van Pottelsberghe (2003) study the relationship between public R&D subsidies in the business sector and industry R&D at the macro level. They estimate that the effect of public R&D support on the business sector's R&D is strongest up to a level of approximately 10 percent of the business sector's R&D expenses; thereafter, the effect decreases. In other words, the effect of publicly funded R&D carried out by the business sector on private R&D is illustrated by an inverted U-shaped curve. Countries that invest too little or too much in the public funding of private R&D stimulate less private R&D than countries that finance at a reasonable level (approximately 10 percent). Figure 2 shows that most OECD countries currently provide support at levels of approximately 5–7 percent, which indicates that there is room to increase R&D support to the business sector without inducing crowding-out effects.

Figure 2 Percentage of business R&D financed by the government 1991–2017, percent.

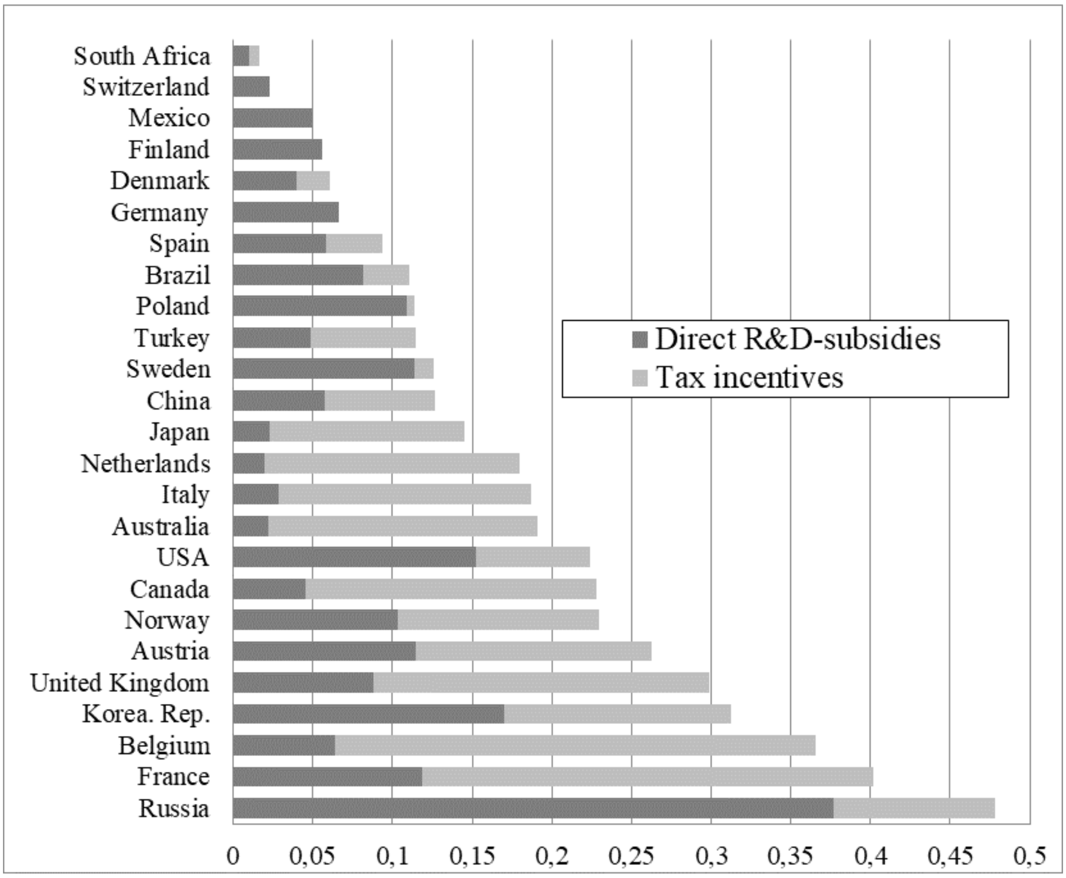


Source: OECD, Main Science and Technology Indicators (2022).

3.2 Direct and indirect R&D subsidies in Sweden

There is great variation among OECD countries in terms of the distribution of direct subsidies and tax subsidies to the business sector. Figure 3 shows a comparison of some OECD countries in 2017. At that time, Sweden was one of the few countries, together with Germany, Poland, Mexico, and Finland, among others, that provided a low level of R&D tax incentives. One major problem with public R&D subsidies is that countries often determine both the size and focus of their direct R&D subsidies and tax incentives. There is no coordination or international agreements to regulate the process, which often leads to a race between countries. The use of R&D subsidies contrasts greatly with the design of IPRs governed by international agreements. Güceri et al. (2020) show that there is an overall international trend in which government R&D subsidies in the business sector have shifted from direct subsidies to tax incentives in recent decades.

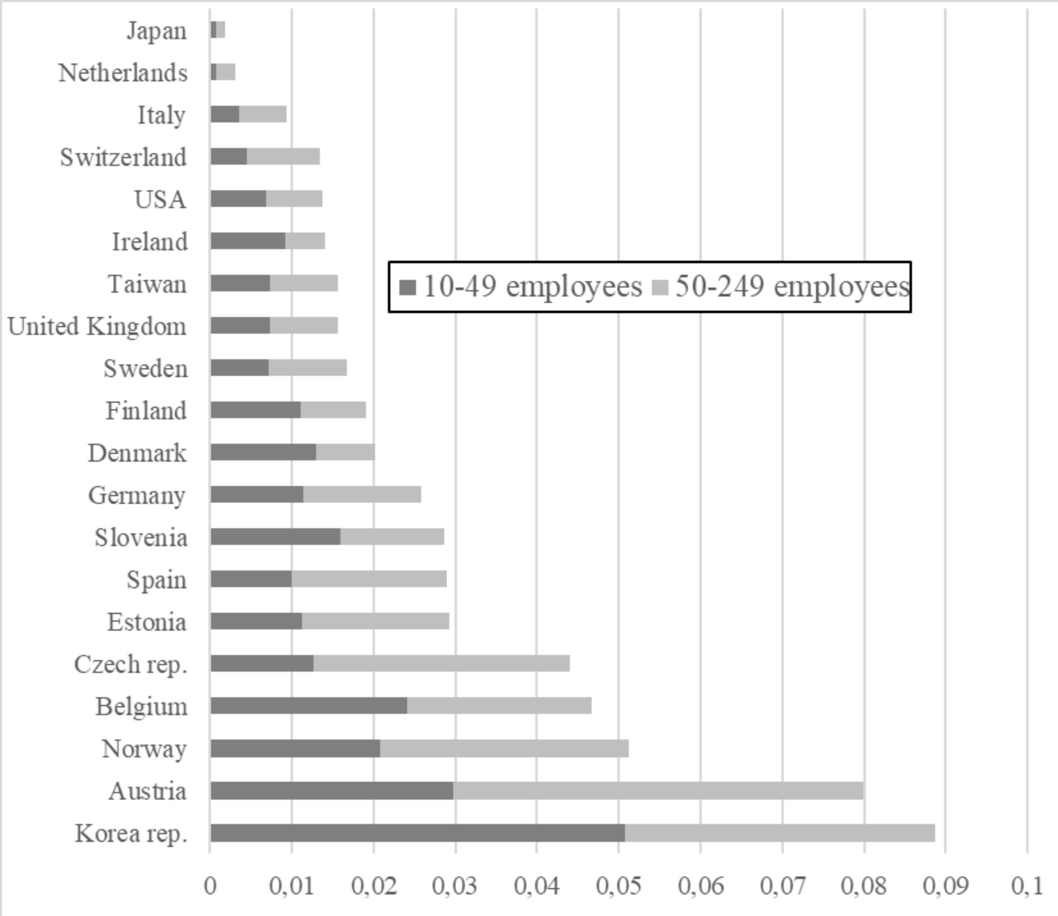
Figure 3 Government direct and indirect financing of business R&D 2017, percent of GDP.



Source: Countries selected from Appelt et. al. (2019). For USA, China and Spain regional tax deductions are missing, meaning that the total amount of tax incentives is underestimated for these countries.

In the periods before 1973 and between 1983 and 2013, the Swedish government offered only direct R&D subsidies to the business sector. Such subsidies have primarily gone to the defense, environment, and energy sectors. Large companies with more than 250 employees have long received most of these subsidies. In 2017, 85 percent of the public direct R&D subsidies (SEK 5.3 billion) provided to the Swedish business sector were allocated to large companies. This dominance of large companies depends mainly on the fact that Swedish defense authorities—which account for SEK 3.7 billion (72 percent) of the total subsidies of SEK 5.3 billion—allocate their subsidies to large companies (Vinnova, 2019).

Figure 4 Government direct R&D subsidies to SMEs as a percentage of GDP, 2017.



Source: Vinnova (2019).

Small (<50 employees) and medium-sized (50–250 employees) companies received only 6.2 and 8.4 percent of public direct R&D subsidies to the business sector, respectively, for a total of 763 million SEK. This is in stark contrast to recommendations based on economic theory and empirics, which indicate that many small firms face financial restrictions in carrying out uncertain R&D. From an international perspective, R&D subsidies provided to SMEs as a share of GDP are low in Sweden. This share was only 0.02 percent in 2017, while the shares of many other OECD countries were at 0.03 or 0.04 percent (Vinnova, 2019) (see Figure 4). This means that only 2.0 percent (763 million SEK of 36.7 billion SEK) of the total public R&D budget in Sweden went to SMEs in 2017.[9]

From 1973–83, there was a special tax allowance for R&D in Sweden. A percentage of total R&D costs (volume-based) and a slightly larger part of the increase in R&D costs (increase-based subsidy) since the previous year could be deducted from taxable income.[10] The subsidies were abolished in 1983 because they were not considered to have had the intended effect and because they were complicated. One major problem was that companies tried to reclassify other costs as R&D costs (SOU, 2012). Mansfield (1986)

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[9] Most government R&D subsidies were directed to universities (see Figure 3).

[10] During the periods 1973–83, 5–10 percent of the total R&D wage costs and 20–30 percent of the increase in these costs from the previous year were deductible from taxable income in Sweden.

evaluated tax incentive programs in the USA, Canada, and Sweden and concluded that the increased R&D expenditures were less than the revenue lost by the government in all three countries. He also noted that there was a reclassification of activities to R&D so that companies could benefit from the subsidies, which resulted in an increase in R&D investments on the books by as much as 13–14 percent in both Sweden and Canada. Between 1983 and 2013, Sweden did not provide any tax incentives for R&D.

3.3 The new R&D payroll tax subsidies

The Swedish Corporate Tax Committee (SOU, 2012) investigated how the introduction of tax incentives could spur economic growth. The committee rejected a proposal for patent boxes since it was too costly[11] and presented instead a proposal for tax incentives for R&D, which was introduced in 2014. Staff who work in R&D receive reduced payroll taxes corresponding to 10 percent of their gross salary but with limitations for each company (maximum SEK 230,000 per month).[12] In practice, the subsidy accounts for 1/13 of the total wage costs of R&D staff.[13] The Swedish tax incentive system is similar to that in the Netherlands (see section 2.1).

Given that firms already keep records on their R&D staff, the administrative costs to apply for the subsidy are low or negligible. The advantage of this subsidy is that it is available to all companies, applies to all types of R&D projects and is continuous. Unlike under traditional tax allowance and tax credit systems, unprofitable firms can benefit from the subsidy directly. Furthermore, the payroll tax subsidy is advantageous to firms with labor-intensive R&D since only R&D staff costs are subsidized. The cap of SEK 230,000 per company and month also implies that SMEs especially benefit from the support. Thus, this payroll provides a solution for both types of market failures (spillovers and incomplete capital markets for small businesses) mentioned in the introduction. However, companies with R&D payroll spending above the cap do not receive any incentives for increased employment of R&D staff. One general disadvantage is that the tax subsidy is volume based. The Swedish government provides subsidies for R&D staff beginning with the first SEK spent, i.e., R&D wage costs that the company may have already paid or would have been willing to pay even without the subsidies. Another disadvantage is that companies with spending below the cap will probably try to reclassify other staff as R&D staff to be able to utilize the subsidy.

The Corporate Tax Committee estimated that 2,500 companies would apply for the subsidy annually and that it would cost approximately SEK 1.1 billion annually in reduced payroll taxes (SOU, 2012). However, these figures turned out to be overestimated, at least for the first year 2014. In Table 3, statistics show that the number of companies using the support increased from 2,076 to 2,471 between 2014 and 2019, and

[11] It was estimated that if Sweden had introduced patent boxes corresponding to those in the United Kingdom, the annual cost would have been at least SEK 4.4–6.3 billion. By comparison, the current level of direct R&D subsidies to the business sector is approximately SEK 5.3 billion per year.

[12] The deduction can be made for both employees and contractors who have reached the age of 26 but not 65 years. The deduction may only be made for persons who work at least 75 percent and at least 15 hours of their actual working hours per month with R&D. The research must be conducted for commercial purposes. Thus, R&D conducted by universities, foundations, government authorities does not entitle to the deduction. Unused deductions for one month cannot be saved for later months.

[13] In Sweden, payroll taxes of approximately 30 percent are added to the gross salary.

the cost also increased from SEK 431 to 691 million per year. In 2016, the average deduction was SEK 27,400 per company per month (STD 2017).

These statistics imply that approximately 90 percent (SEK 5.3 of 5.9 billion) of the Swedish government R&D support for the business sector in 2017 consisted of direct R&D subsidies, which was still high from an international perspective, as shown in Figure 1.

Above, it is estimated that only 15 percent of Swedish direct R&D subsidies provided to the business sector are allocated to SMEs. However, the tax incentives introduced in 2014 have partly changed this skewed distribution. In the years 2014–19, as much as 76 percent of the tax deductions were made by companies with fewer than 250 employees (see the last row of Table 3). Thus, the R&D funding that SMEs receive from the government has increased by approximately 50 percent since the tax deduction was introduced in 2014.

Table 3 Swedish R&D tax subsidy 2014–19 across firm size. Number of firms (n), subsidy amount (MSEK) and percent.

No. of employees	2014		2015		2016		2017		2018		2019		Total
	No. of firms (n)	Sub-sidy (M-SEK)	n	MSEK	n	MSEK	n	MSEK	n	MSEK	n	MSEK	MSEK
Solo firms 0 or 1 employee	466	13	432	15	489	16	541	14	627	19	623	23	101
Micro firms 2–9 employees	771	53	747	63	795	71	837	75	829	77	838	80	419
Small firms 10–49 employees	439	125	432	137	451	144	488	170	506	188	564	206	970
Medium-sized firms 50–249 employees	210	127	205	151	202	148	209	165	221	189	241	206	995
Large firms 250–999 employees	58	59	55	63	57	71	58	75	64	79	73	84	433
Very large firms >1000 employees	25	42	27	52	28	50	29	54	31	54	39	71	324
Unknown	107	10	93	10	78	11	81	15	91	20	93	20	88
Total	2076	431	1991	491	2100	511	2243	567	2369	627	2471	691	3318
Percentage of SMEs [a]	96 %	76 %	96 %	76 %	96 %	76 %	96 %	76 %	96 %	78 %	95 %	77 %	77 %

[a] Firms with unknown firm size are excluded when calculating the percentage.
Source: Statistics Sweden (2022).

In March 2020, the Swedish Parliament approved a proposal by the government to extend the deductions on payroll taxes to 20 percent of the gross salary and raise the ceiling to SEK 450,000 per company per month. The extended subsidies were introduced in the second quarter of 2020. Thus, both the number of recipient firms and the amount of tax subsidies increased substantially in 2020.[14]

[14] Preliminary statistics show that the number of recipient firms increased to 2,806 and the subsidy amount to 1,367 million SEK.

The distribution of the R&D subsidies across sectors is shown in Table 4. The three sectors 'manufacturing', 'information and communication' and 'professional, scientific, and technical activities' dominate strongly with respect to both the number of recipient firms (20, 23 and 37 percent in 2017) and the amount of subsidy (32, 23 and 32 percent in 2017). The last two sectors consist of typical firms with labor-intensive R&D.

Table 4 Swedish R&D tax subsidy 2014–20 across sectors, number of firms (n) and subsidy amount (MSEK).

No. of employees	2014		2015		2016		2017		2018		2019		2020		Total
	n	M-SEK	n	M-SEK	n	M-SEK	n	M-SEK	n	M-SEK	n	M-SEK	n	M-SEK	MSEK
Agriculture, forestry, and fishing	21	0.1	17	0.2	22	0.3	27	0.4	21	0.3	10	0.7	6	1.0	3.1
Manufacturing, mining and quarrying	445	152.4	419	174.2	437	172.5	439	182.0	439	193.1	446	213.3	420	395.7	1483.2
Construction	48	0.7	30	0.7	29	0.8	36	0.8	39	0.7	28	0.7	8	0.5	4.9
Wholesale and retail trade	168	36.6	153	42.6	162	42.2	169	43.1	157	45.1	145	49.1	117	82.4	341.0
Information and communication	384	85.3	410	102.8	446	113.8	506	133.4	577	147.8	643	163.5	586	302.7	1049.4
Professional, scientific, and technical activities	721	131.5	735	146.5	770	156.3	819	176.7	890	203.2	950	218.8	855	407.1	1440.1
Education	14	1.1	17	1.1	19	1.4	15	1.4	15	1.5	12	2.0	12	2.8	11.3
Human health and social work	49	2.9	41	2.2	41	2.5	39	2.8	38	3.2	33	3.4	26	4.2	21.0
Other [a]	119	10	76	10.7	96	10.3	112	11.6	102	11.4	111	19.2	59	26.4	99.6
Unknown	107	10.3	93	10.4	78	11.2	81	14.8	91	20.5	93	20.0	717	144.3	231.5
Total	2076	430.9	1991	491.3	2100	511.2	2243	567.1	2369	626.9	2471	690.6	2806	1367.0	4685.1

[a] Industries with few observations
Source: Statistics Sweden (2022).

4. Empirical framework

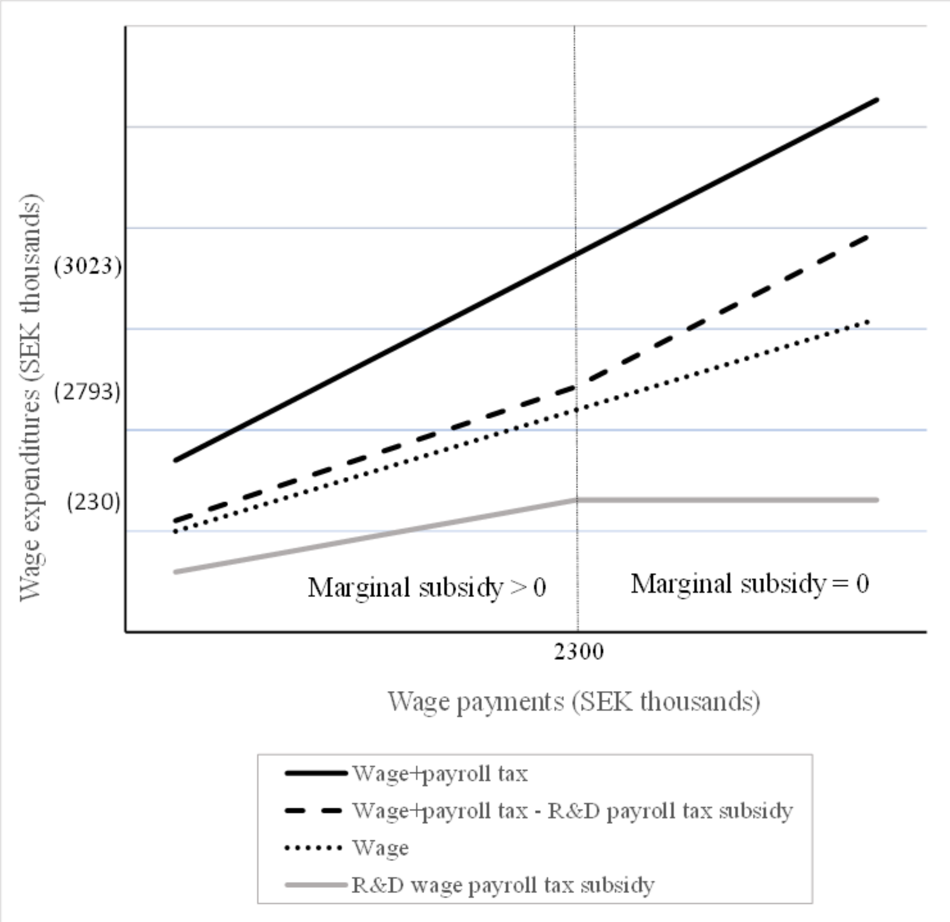
4.1 Empirical strategy

Most previous empirical studies test how R&D tax relief affects firm R&D investments and spending (see section 2.3). This would be the proper focus when R&D tax relief is intended to subsidize total R&D costs. In contrast, the Swedish R&D tax relief initiative is designed as a partial exemption of employers' social security contributions, thus specifically targeting R&D staff costs (see section 3.3). Accordingly, this study specifically explores the effects of this tax relief on variables related to R&D staff (see section 4.2).

If the R&D tax subsidy reform targeted a random sample of firms, evaluation of the impact would involve a straightforward comparison of R&D staff. The econometric problems facing researchers seeking to measure the impact of an R&D policy reform implemented across all business sectors are well known, with the main challenge among these problems being to find a counterfactual outcome for comparison. Since all R&D-performing firms are eligible for the tax relief, it is difficult to identify an appropriate control group of R&D-intensive firms. Although not all firms performing R&D apply for the introduced tax relief, the reason for this seemingly irrational management decision is nontransparent. It could reflect selection bias leading to underrepresentation of firms with little administrative capacity, lack of information or research costs in terms of capital and not wage costs for researchers. Unless there is information on the attributes of the R&D-performing firms that do not seek R&D payroll tax subsidies, there is a risk that the estimated effects of the R&D subsidy would be biased if these groups were compared.

Given the nature of the policy design, our empirical strategy instead exploits the R&D payroll tax subsidy cap, which is the maximum total tax credit for all employees working in R&D in the firm. Figure 5 graphs firm R&D wage expenditures with and without R&D payroll tax subsidies (not drawn to scale). The solid line represents total R&D wage expenditure, which is the sum of wage payments and payroll taxes (in Sweden 31.42 percent) before the policy reform. The dotted line depicts R&D wage payments, which are unaffected by policy. After the policy implementation, payroll taxes are reduced by ten percent of wage payments up to the limit of SEK 230,000 per month, represented by the dashed line in Figure 5. Because of this limit on total R&D wage subsidies, represented by the gray line, there is a kink in subsidized wage expenditures. More precisely, the marginal wage subsidy drops to zero after monthly wage payments for R&D staff exceed SEK 2,300,000.

Figure 5 Wage expenditures with and without the R&D payroll tax subsidy.



Therefore, upon crossing the payroll tax subsidy cap, firms have no incentive to employ more R&D staff, and we should expect no effect or a negative effect of the policy on R&D staff employment. Thus, in our estimations, we do not need to rely on a control group of firms that have not benefited from the tax subsidy. Instead, our identification strategy exploits the variation in the marginal benefit, as illustrated in Figure 5. Accordingly, firms exceeding or hitting the cap belong to the control group, while firms not hitting the cap belong to the treated group in our estimations. This policy design provides a quasi-experimental setting for us to identify the causal effect of the R&D payroll tax subsidy.

4.2 Data and key variables

The empirical analysis is based on several data sources from Statistics Sweden. All analyses are performed on annual and firm-level data. Our data on R&D tax incentives cover 3,078 firms based on information from employers' tax returns over the period 2014–2019.[15] During this period, the rules for the R&D payroll tax subsidy did not change. A narrow majority of the firms claimed the R&D tax credit in more than 70 percent of the quarters after the reform implementation, and 27 percent of the firms claimed the credit in each quarter. Not all firms claimed the R&D tax relief at the time of the policy introduction. In 2014, 2,076 companies applied, and this number gradually increased to

[15] The dataset includes information on the quarterly amount of the claimed tax deduction but lacks an explicit link to individual researchers within the firm.

2,471 by 2019. More specifically, slightly less than sixty percent of the firms in our sample applied for the first time when the policy was introduced in 2014, and in each of the following five years, approximately ten percent per year took up the subsidy.

Our main outcome variable, firm R&D staff, is measured as the number of employees with a PhD. These data were collected from Statistics Sweden's longitudinal database, LISA, which comprises detailed data at the individual level on residents' education and workplace.[16] Although far from all R&D staff in firms have a PhD and not all employees with a PhD are engaged in R&D activities, we argue that employees with a doctoral degree are a reasonable representation of the employees most likely to engage in research. In addition, this is the best measure of R&D staff that we can collect and use in the estimations. When we combine the subsidy dataset with the scientist dataset, the matching percent is 95 percent each year.

An alternative outcome variable is the firms' R&D expenditures. Statistics Sweden collects firm-level data on Swedish business R&D every year. However, the purpose of the collected data is to estimate total business R&D in Sweden at the macro level.[17] All micro firms and many SMEs are excluded, meaning that this R&D variable is unsuitable for microeconometric purposes.[18]

The control variables are derived from Statistics Sweden's balance sheet database. Firms' own capital ratio, age, size, and capital intensity have been included in previous studies estimating the effects of R&D tax incentives (Billings et al., 2001; Yang et al., 2012). In our sample, firms are divided into four age groups for our $AGECAT_{it}$ variable: those younger than 10 years, between 10 and 21 years old, between 21 and 30 years old and more than 30 years old. Firms' leverage is measured by the ratio of own capital to total capital, $OWNCAP_{it}$. Firm size is represented by net sales, $NETSALES_{it}$, measured in thousand SEK. Capital intensity, $CAP\text{-}INT_{it}$, is measured as the book value of current and fixed assets in SEK divided by the total number of employees.[19]

Due to the high share of micro firms in our sample of subsidized firms (see Table 3), some variables used in previous studies, e.g., export intensity, cannot be included. This would cause a very high omission of microfirm observations.

[16] Statistics Sweden's longitudinal database, LISA, was retrieved from various data sources, including the total population register (RTP), educational attainment statistics of the population, labor statistics based on administrative sources (RAMS) and structural business statistics.

[17] The R&D cost sample consists of all firms with more than 200 employees, all firms in industry 72 ('professional, scientific, and technical activities'), all research institutes and all firms that in the previous survey year reported earnings of more than 5 million SEK. All firms with less than 10 employees are excluded. For firms with 10–250 employees, only a sample is selected.

[18] We merge the data on the approximately 2,000–2,500 firms that annually received payroll tax subsidies in Sweden in the period 2014–19 (see Table 3) with data on annual internal R&D spending at the firm level from Statistics Sweden. For each year, only 300–400 firms (approximately 15 percent) matched. The dropout rate (85 percent) is significant and systematic for micro and small firms.

[19] All financial variables are deflated by the consumer price index to real 2010 SEK.

Table 5 Summary statistics of outcome and control variables across treated and control groups, unbalanced panel.

Variables		Treated group (n=2,948)				Control group (n=130)			
De-notation	Explanation	Mean	Std. dev.	Min	Max	Mean	Std. dev.	Min	Max
SC	No. of scientists	1.41	3.65	0	49	45.83	135.59	0	999
SC/EMP	Share of scientists of all employees	0.14	0.27	0	1	0.14	0.18	0	0.75
AGE-CAT	Age-category	12.5	9.7	0	34	20.0	9.2	0	34
OWNCAP	Own capital divided by total capital	0.39	0.69	<0	1	0.41	0.25	<0	1
NETSALES	Net sales (thousand SEK)	112,117	1,055,321	0	40,237,900	3,431,301	12,002,646	0	100,200,000
CAP-INT	Book value of current and fixed assets in SEK divided by the total number of employees	3,455	23,063	0	965,241	8,972	30,345	96	304,481

In Table 5, we present summary statistics for the key variables in the main unbalanced sample, which includes all firms with more than six years of observations. The treated firms have, on average, fewer scientists employed and are smaller, younger and more labor intensive than the control firms. The groups are similar in terms of leverage and share of scientists.

Figure 6 Number of scientists in treated and non-treated firms. Index 2011 = 1.

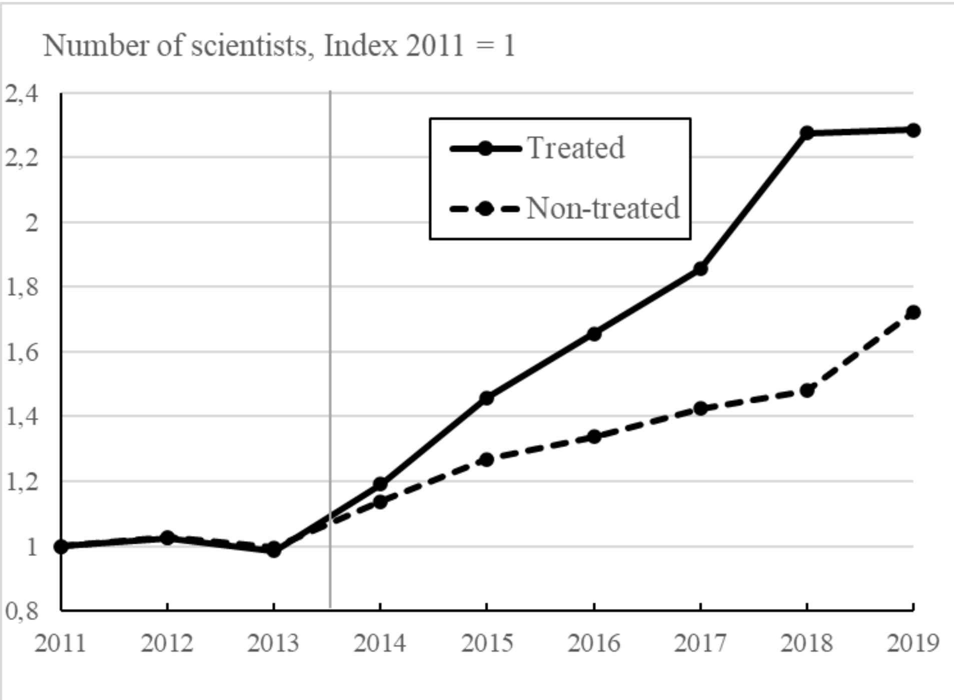
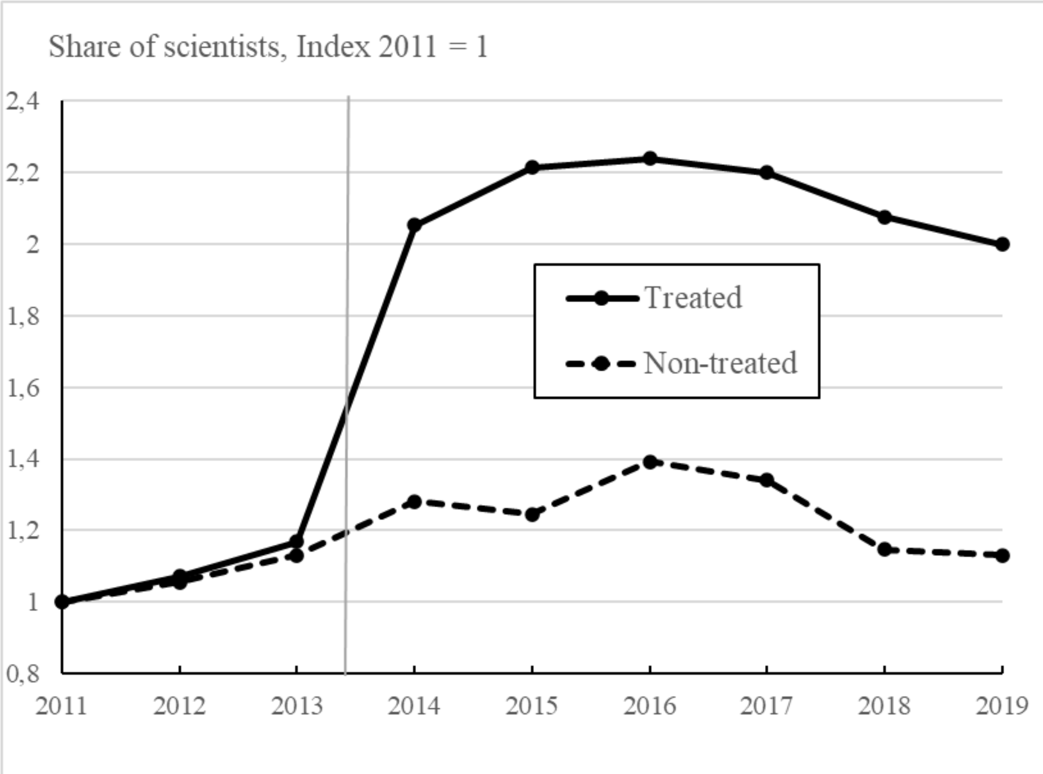


Figure 6 and Figure 7 compare the normalized means of the outcome variables for the treated and control groups for each year during 2011–2019. The normalization facilitates comparison between the two groups with different PhD employment levels. Graphically, we cannot see any evidence of diverging pre-policy trends in researchers' employment across the treated and control groups. This suggests that firms with expenditures above the cap are a reasonable choice for the counterfactual comparison. The parallel trends assumption is further discussed and tested in section 5.2.

Figure 7 Share of scientists in treated and non-treated firms. Index 2011 = 1.



4.3 Methodological approach

We employ a difference-in-difference approach with panel data to compare firms below (treated) versus above (control) the subsidy cap.

The dataset consists of firm-level data with annual observations before (2011–13) and after (2014–19) the subsidy was implemented.[20] We include fixed effects on two dimensions: firms and years. To test for robustness, we measure the outcome variable both as the number of scientists, *SC*, and as the share of scientists among all employees, *SC/EMP*. The estimations are undertaken on both balanced and unbalanced panel data.[21] Since our main dependent variable, the number of scientists, *SC*, has a large share of zeroes,[22] we estimate a Poisson pseudo-maximum likelihood (PPML) estimator with multilevel fixed effects (Correia et al 2020):

[20] Data are available up to 2019.

[21] In the balanced panel, the firm must be included in all 9 years. In the unbalanced panel, the firm must be included in at least 7 years, i.e., at least 1 year before 2014.

[22] In the dataset, 45 percent of the firms never employ researchers with a PhD, and 70 percent have at least one year in which they employ no PhDs.

$$E\ [Y_{it} |\ D_i, \mathbf{X_{it}}] = exp\{\beta_1 D_i T_t + \ \beta_2 D_i + \mathbf{X_{it}} \boldsymbol{\beta} + \mu_t + fe_i\} \qquad [1]$$

where Y_{it} is either SC_{it}, the number of scientists employed in firm i in year t, or SC_{it}/EMP_{it}, the share of scientists among all employees of firm i in year t. D_i is a dummy that takes value 1 for the treated observations and 0 for the control observations. T_t is a dummy that takes value 1 for the years after the first treatment year and 0 otherwise. $\mathbf{X_{it}}$ is a vector of control variables, and $\boldsymbol{\beta}$ is the corresponding vector of coefficients. Time-invariant unobserved firm heterogeneity is captured by firm fixed effects, fe_i, and annual aggregate shocks are controlled for by the set of annual fixed effects, μ_t. Standard errors of the coefficients are clustered at the firm level.

The coefficient β_2 measures the average difference in the outcome variables from the years before treatment. The coefficients β_1 on the interaction term capture the change in *SC* and *SC*/*EMP* between the pre- and posttreatment periods for the treatment group relative to the corresponding change in the control group. With a causal interpretation, β_1 is the change in R&D employment induced by the R&D payroll tax subsidy implementation. The key assumption required for a causal interpretation is that β_1 is a valid estimate of the relationship between the control and the treatment groups in the absence of a subsidy cap. To control for whether the treatment effect reflects a preexisting trend in researchers' employment that differs between the treatment and control groups, we estimate a version of [1] that replaces T_t in the interaction term with a set of year dummies. We present the regression and discuss the results in detail in section 5.2.

Although the subsidy has a direct financial effect on researchers' payroll tax, we expect a time lag on firm researcher employment decisions given the fixed costs associated with hiring new researchers, which are likely to hamper responsiveness (Agrawal et al 2020). Therefore, the posttreatment effect is measured from the year after the first tax subsidy application, which in turn can occur during a span of a maximum of six years, i.e., from 2014–2019. However, dropping firms that first claimed tax relief after the policy started does not qualitatively change the result.

5. Estimation results

Our baseline estimations are presented in section 5.1. In section 5.2, we estimate the leads and lags of the policy variable to test the pre-policy parallel trends and to explore how the treatment effect evolved in the post-policy period. Finally, in section 5.3, we analyze treatment effect heterogeneity across firms.

5.1 Baseline effects of the R&D payroll tax subsidy

Our baseline estimation results for the effect of the R&D payroll tax subsidy on the number of scientists, *SC*, are presented in Table 6. In general, the balanced (Models 1a–1f) and unbalanced (Models 2a–2f) panels give similar results. Since the unbalanced panel has more observations, we refer mainly to the results in Model 2.

Table 6 Empirical estimations of R&D payroll tax subsidy on number of scientists.

Statistical model	**Poisson (PPML), difference-in-difference, panel data**											
Outcome variable	*SC*											
Panel	Balanced panel						Unbalanced panel					
Explanatory variables	Model 1a	Model 1b	Model 1c	Model 1d	Model 1e	Model 1f	Model 2a	Model 2b	Model 2c	Model 2d	Model 2e	Model 2f
*Treated*Post-reform (D*T)*	0.31 *** (0.10)	0.30 *** (0.10)	0.39 *** (0.09)	0.53 *** (0.09)	0.62 *** (0.13)	0.68 *** (0.12)	0.29 *** (0.10)	0.28 *** (0.10)	0.39 *** (0.08)	0.55 *** (0.09)	0.63 *** (0.13)	0.73 *** (0.12)
Treated (D)	–3.44 *** (0.30)	–3.43 *** (0.29)	–3.50 *** (0.29)	–3.18 *** (0.24)	–3.10 *** (0.22)	–2.86 *** (0.20)	–3.48 *** (0.30)	–3.47 *** (0.29)	–3.55 *** (0.29)	–3.19 *** (0.24)	–3.16 *** (0.22)	–2.89 *** (0.20)
Post-reform (T)	0.38 *** (0.09)	0.36 (0.23)					0.37 *** (0.09)	0.40 * (0.22)				
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
AGE CAT	No	No	No	Yes	No	Yes	No	No	No	Yes	No	Yes
OWNCAP	No	No	No	Yes	No	Yes	No	No	No	Yes	No	Yes
NETSALES	No	No	No	No	Yes	Yes	No	No	No	No	Yes	Yes
CAP-INT	No	No	No	No	Yes	Yes	No	No	No	No	Yes	Yes
No. of obs.	14,852	14,852	14,852	14,718	14,395	14,384	17,356	17,356	17,356	17,133	16,699	16,686
No. of firms	2,480	2,480	2,480	2,472	2,444	2,443	3,078	3,078	3,078	3,064	3,022	3,020
Pseudo-R^2	0.43	0,43	0.43	0.49	0.62	0.64	0.43	0.43	0.43	0.49	0.62	0.64
DiD-effect	36 %	35 %	48 %	70 %	86 %	97 %	34 %	32 %	48 %	73 %	88 %	107 %

Note: Robust standard errors, clustered at the firm level, are in parentheses and ***, ** and * indicate significance at the 1, 5 and 10 percent level, respectively. Coefficients for control variables, intercepts and year dummies are available from the authors upon request.

Model 2a is a basic estimation that includes the dummies *Treated* (*D*), *Postreform* (*T*), their interaction term (*D*T*) and firm fixed effects. Recall that our treated group refers to the firms eligible for a positive marginal R&D subsidy, in contrast to our control group, which hits the subsidy cap and has a zero marginal R&D subsidy. Guided by economic theory, we expect a larger effect of the subsidy on the treatment group. Our main parameter of interest, β_1, has a value of 0.29 and is highly significant, confirming the hypothesis. This indicates that treated firms increased their number of scientists by 34 percent (see the last row of the table) in comparison to nontreated firms as a result of the policy reform.[23] By construction, the control group of firms hitting the subsidy cap most likely has more R&D staff than the treatment group of firms with expenditures below the cap. Therefore, we expect differences in the number of employed scientists between the two groups. The sign and size of the coefficient of *Treated (D)* show that the treated firms indeed had considerably fewer employed scientists than the firms in the control group before the policy reform. The positive and significant coefficient of *Postreform (T)* indicates that there was a trend toward more employed scientists for treated and nontreated firms after the policy reform. However, when we include year dummies in Model 2b, the significance of this trend weakens, and if we add control variables, the size of the *Postreform* trend coefficient is close to zero and insignificant (not shown in the table).

The inclusion of year dummies (Models 2b–2c) and the addition of control variables (Models 2d–2f) do not alter the significance of the DiD coefficient β_1 but increase the magnitude of the effect. Depending on the model specification, the introduction of the payroll tax subsidy increases the number of scientists in treated firms by 32–102 percent compared to nontreated firms in the unbalanced panel and by 35–97 percent in the balanced panel.

[23] The percentage change is calculated according to the formula $(e^{\beta_1} - 1)*100$.

Table 7 Empirical estimations of R&D payroll tax subsidy on share of scientists.

Statistical model	**Poisson (PPML), difference-in-difference, panel data**											
Outcome variable	*SC/EMP*											
Panel	Balanced panel						Unbalanced panel					
Explanatory variables	Model 3a	Model 3b	Model 3c	Model 3d	Model 3e	Model 3f	Model 4a	Model 4b	Model 4c	Model 4d	Model 4e	Model 4f
*Treated*Post-reform (D*T)*	0.36 *** (0.06)	0.36 *** (0.06)	0.27 *** (0.06)	0.24 *** (0.06)	0.34 *** (0.07)	0.33 *** (0.06)	0.35 *** (0.07)	0.36 *** (0.07)	0.26 *** (0.06)	0.26 *** (0.06)	0.33 *** (0.06)	0.34 *** (0.06)
Treated (D)	9.3 E-4 (0.13)	–2.0 E-3 (0.13)	0.046 (0.12)	–0.25 ** (0.12)	–0.18 (0.13)	–0.38 *** (0.12)	0.035 (0.12)	0.020 (0.12)	0.076 (0.12)	–0.24 ** (0.12)	–0.17 (0.13)	–0.37 *** (0.12)
Post-reform (T)	0.13 ** (0.05)	–0.10 (0.09)					0.16 ** (0.06)	–0.11 (0.08)				
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
AGE CAT	No	No	No	Yes	No	Yes	No	No	No	Yes	No	Yes
OWNCAP	No	No	No	Yes	No	Yes	No	No	No	Yes	No	Yes
NETSALES	No	No	No	No	Yes	Yes	No	No	No	No	Yes	Yes
CAP-INT	No	No	No	No	Yes	Yes	No	No	No	No	Yes	Yes
No. of obs.	14,852	14,852	14,852	14,718	14,395	14,384	17,356	17,356	17,356	17,133	16,699	16,686
No. of firms	2,480	2,480	2,480	2,472	2,444	2,443	3,078	3,078	3,078	3,064	3,022	3,020
Pseudo-R^2	0.01	0.01	0.02	0.04	0.02	0.04	0.01	0.02	0.02	0.04	0.02	0.04
DiD-effect	43 %	43 %	31 %	27 %	40 %	39 %	42 %	43 %	30 %	30 %	39 %	40 %

Note: Robust standard errors, clustered at the firm level, are in parentheses and ***, ** and * indicate significance at the 1, 5 and 10 percent level, respectively. Coefficients for control variables, intercepts and year dummies are available from the authors upon request.

In Table 7, we have undertaken similar estimations as in Table 6, but now the outcome variable is the share of scientists, *SC/EMP*. Once again, the balanced (Models 3a–3f) and unbalanced (Models 4a–4f) panels give similar results. The postreform trend, *T*, is positive and significant in Model 4a, but this trend disappears completely when we include year dummies in Model 4b. The dummy *Treated*, *D*, is negative and significant in only some of the estimations, indicating that the share of scientists is more similar between the treated and control groups. Our main parameter, β_1, is positive and significant in all specifications, i.e., the inclusion of year dummies and control variables does not alter the results. The size of the estimated coefficient is now more stable than in Table 6. The payroll tax subsidy increased the share of scientists in treated firms in comparison to the share in nontreated firms by 30–43 percent in the unbalanced panel and by 31–43 percent in the balanced panel.

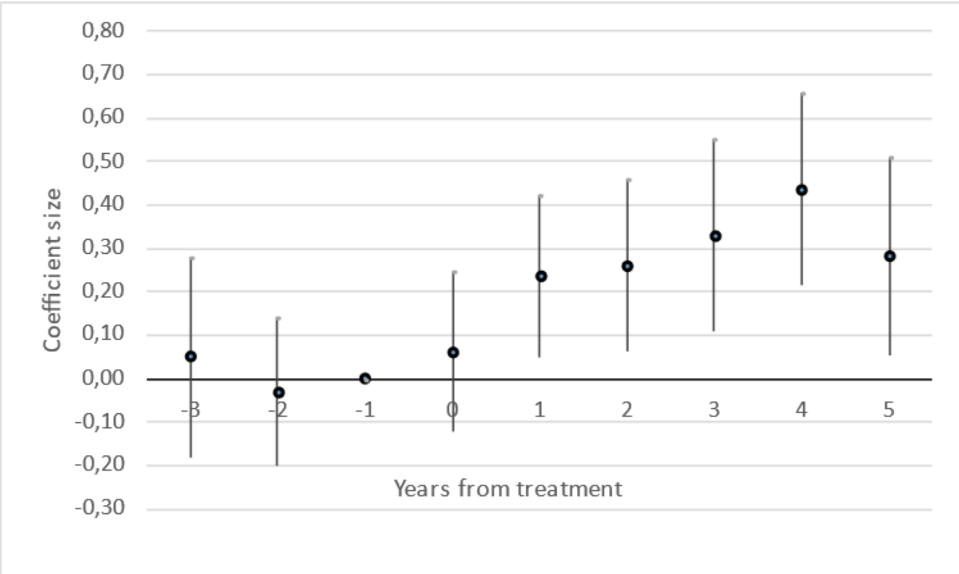
5.2 Trends and timing

One concern with our difference-in-difference research design is that our main coefficient of interest may capture a pre-reform trend between the treated and control groups prior to the policy reform. To rule out differential trends, we re-estimate our baseline model by letting our main parameter β_1 from [1] become year specific: β_{1t}.

$$E\,[Y_{it} \mid D_{it}, \mathbf{X_{it}}] = exp\{\beta_{1t}D_{it} + \mathbf{X_{it}\beta} + \mu_t + fe_i\} \qquad [2]$$

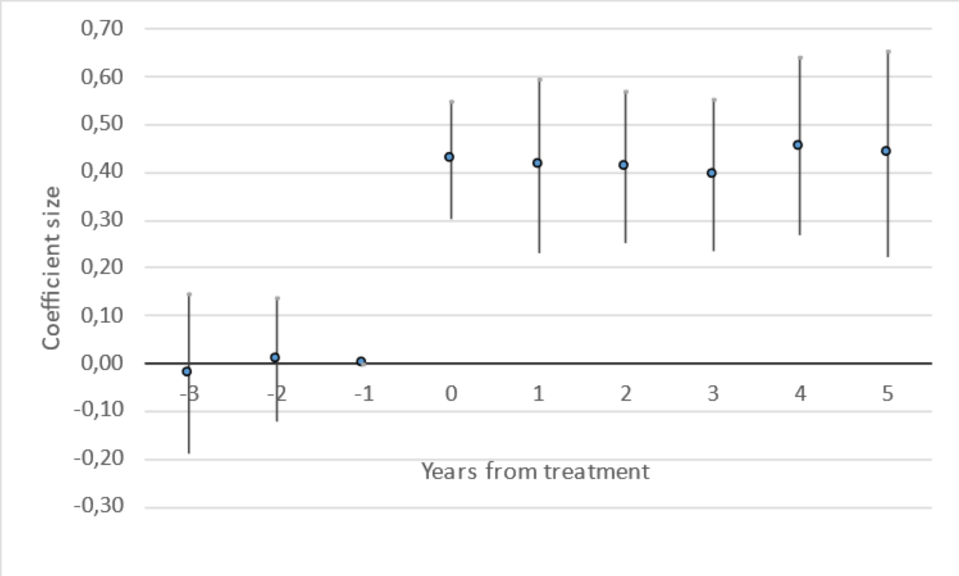
In Figure 8, the parameter β_{1t} is plotted for individual years. The effect of the payroll tax reform has a significant and positive effect on the number of scientists in treated firms in comparison to the number in control firms the year after policy introduction (‘year 1’) and onward. However, the impact is insignificant the first year of the reform, ‘year 0’.

Figure 8 Yearly effects on the number of scientists for treated firms.



A similar plot for the share of scientists is depicted in Figure 9. This time, the impact of the payroll tax reform is positive and significant in the first year in which a firm receives the subsidy and very stable over the following years.

Figure 9 Yearly effects on the share of scientists for treated firms.



Both Figure 8 and Figure 9 show that firms did not react to the policy reform in the years before the reform. As seen in the years (–3 to –1) before the treatment, there is no graphical evidence of any pre-policy trend in β_1. The pre-trend chi squared statistics for the null hypothesis that $\beta_{1,-3}$ through $\beta_{1,-1}$ are jointly equal to zero correspond to Chi2(2)=2.74 with p value 0.2545 for the number of scientists and Chi2(2)=0.28 with p value 0.8673 for the share of scientists. Thus, for both outcomes, we find no statistically significant evidence of a pre-policy trend.

5.3 Treatment heterogeneity: Firm size, debt ratio and labor intensity

Here, we test whether the impact of the payroll tax subsidy varies across different groups of firms. One of the main targets of the subsidy, according to the Swedish regulators (SOU 2012), is to promote R&D activities in small firms. To examine the treatment heterogeneity across firms of different sizes, we divide the firms into two subsamples—firms with fewer and more than 50 employees. The additive dummy *SMALL* equals 1 for firms with fewer than 50 employees and 0 otherwise.

A further aspect is whether financially constrained firms benefit more from the subsidy than firms without constraints. In the introduction, we argued that the design of the Swedish payroll tax subsidy is beneficial for loss-making firms and firms facing financial constraints. To explore the differences in impact of the policy reform across firms with various ex ante financial conditions, we divide the firms into two groups with a high and low own capital ratio. The additive dummy *DEBT* equals 1 for firms with an own capital ratio below the median in the sample of treated firms and 0 otherwise.

Finally, the Swedish tax subsidy is designed to favor firms with labor-intensive R&D. The R&D data for small firms are not sufficiently detailed or complete to allow the assessment of whether firm R&D is labor intensive or capital intensive. Instead, we divide the firms with respect to capital intensity in general, i.e., *CAP-INT*. The additive dummy *LABOR* equals 1 for firms with a capital–labor ratio below the median in the sample of firms in the dataset and 0 otherwise.

We estimate a set of triple-difference models to examine the treatment heterogeneity by firm size, debt ratio and labor intensity. The dummy H_i divides the firms into two groups based on their pre-policy firm size (*SMALL*), debt ratio (*DEBT*) and labor intensity (*LABOR*). We estimate the following model that contains a full set of two-way interactions:

$$E\,[Y_{it}|\,H_i, D_i, \mathbf{X_{it}}] = exp\,\{\beta_1 D_i T_t + \beta_2 D_i + \beta_3 H_i D_i T_t + \beta_4 H_i D_i + \beta_5 H_i T_t + \beta_6 H_i + \mathbf{X_{it}}\boldsymbol{\beta} + \mu_t + fe_i\}\ , \qquad [3]$$

where all other variables are defined as above.

The results of the treatment heterogeneity estimations are presented in Table 8. In Models 5a –5d, the effect of the subsidy reform (*D*T*SMALL*) on the number of scientists, *SC*, and the share of scientists, *SC/EMP*, is significantly higher for small firms than for larger ones in only one (Model 5c) out of the four runs. This result is not strong enough to reject the hypothesis of no difference in the effect of the subsidy reform between small and large firms. To test the sensitivity of the cutoff point, we rerun the estimations with the cutoff point for small firms at 10 and 25 employees instead of 50 employees. These runs show no systematic difference in the treatment effect between small and large companies.

Table 8 Heterogeneity: Firm size, debt ratio and labor-intensity. Interactions.

Statistical model	**Poisson (PPML), difference-in-difference, unbalanced panel data**											
Outcome variable	*SC*		*SC/EMP*		*SC*		*SC/EMP*		*SC*		*SC/EMP*	
Explanatory variables	Model 5a	Model 5b	Model 5c	Model 5d	Model 6a	Model 6b	Model 6c	Model 6d	Model 7a	Model 7b	Model 7c	Model 7d
*D*T*SMALL*	0.10	0.09	0.73 ***	0.17								
	(0.17)	(0.18)	(0.23)	(0.16)								
*D*SMALL*	0.19	0.03	0.37	0.63 ***								
	(0.42)	(0.35)	(0.30)	(0.25)								
*T*SMALL*	0.18	0.26 *	–0.16	0.01								
	(0.14)	(0.15)	(0.13)	(0.13)								
SMALL	–2.16 ***	–1.85 ***	0.81 ***	0.53 **								
	(0.40)	(0.33)	(0.23)	(0.22)								
*D*T*DEBT*					–0.31	0.20	0.10	–0.02				
					(0.19)	(0.23)	(0.13)	(0.13)				
*D*DEBT*					0.83	0.63 *	–0.14	–0.05				
					(0.52)	(0.37)	(0.24)	(0.23)				
*T*DEBT*					0.37 **	–0.27	–0.06	0.14				
					(0.16)	(0.21)	(0.11)	(0.12)				
DEBT					–0.66	–0.38	–0.26	–0.38 *				
					(0.51)	(0.35)	(0.23)	(0.22)				
*D*T*LABOR*									–0.18	–0.46 **	0.43 ***	0.29 *
									(0.21)	(0.22)	(0.16)	(0.16)
*D*LABOR*									0.11	–0.48	–0.73 ***	–0.45 *
									(0.50)	(0.45)	(0.25)	(0.24)
*T*LABOR*									0.55 ***	0.84 ***	–0.18	–0.07
									(0.17)	(0.19)	(0.15)	(0.15)
LABOR									–0.93 *	–0.17	0.35	–0.01
									(0.48)	(0.42)	(0.24)	(0.23)
*D*T*	0.23 **	0.38 ***	–0.28	0.19 *	0.48 ***	0.67 ***	0.25 ***	0.30 ***	0.29 ***	0.66 ***	0.15 **	0.15 **
	(0.11)	(0.12)	(0.20)	(0.10)	(0.12)	(0.16)	(0.07)	(0.07)	(0.09)	(0.12)	(0.06)	(0.06)
D	–2.43 ***	–1.98 ***	–0.77 ***	–1.17 ***	–3.92 ***	–3.21 ***	0.11	–0.33 ***	–3.36 ***	–2.64 ***	0.30 ***	–0.14
	(0.31)	(0.22)	(0.23)	(0.17)	(0.45)	(0.30)	(0.16)	(0.16)	(0.32)	(0.22)	(0.14)	(0.14)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control variables	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
No. of obs.	17,356	16,686	17,356	16,686	17,356	16,686	17,356	16,686	17,356	16,686	17,356	16,686
No. of firms	3,078	3,020	3,078	3,020	3,078	3,020	3,078	3,020	3,078	3,020	3,078	3,020
Pseudo-R^2	0.52	0.68	0.04	0.05	0.44	0.65	0.02	0.05	0.44	0.64	0.02	0.05

Note: Robust standard errors, clustered at the firm level, are in parentheses and ***, ** and * indicate significance at the 1, 5 and 10 percent level, respectively. Coefficients for control variables, intercepts and year dummies are available from the authors upon request

In Models 6a–6d, our main coefficient (*D*T*DEBT*) is never significant, indicating that we cannot reject the hypothesis of no difference in the treatment effect between firms with low and high debt ratios. Thus, there is no evidence that the R&D tax subsidy reform induces financially constrained firms to employ more scientists than financially unconstrained firms.

Finally, there is evidence that more labor-intensive firms obtain a higher share of scientists from the tax subsidy in Models 7c–7d. The key coefficient (*D*T*LABOR*) is positive and significant at the 1- and 10-percent levels, respectively. The introduction of the payroll tax subsidy increases the share of scientists in firms with high labor intensity by approximately 43 percent in comparison to that of firms with low labor intensity. On the other hand, the key coefficient is negative and significant in Model 5b when we test the impact on the number of scientists.

To summarize the results in Table 8, there is no evidence that the impact of the R&D payroll tax subsidy on the number and share of scientists differs by firm size or financial constraints. On the other hand, the treatment effect for labor-intensive firms is significantly higher for the share of scientists but somewhat lower for the number of scientists. Thus, the results for the treatment effect on labor intensity are somewhat ambiguous.

6. Discussion and conclusion

In this paper, we analyze the impact of a specific kind of R&D tax subsidy introduced in Sweden in 2014 to stimulate business R&D activities. Instead of allowing firms to deduct total R&D costs from their taxable income or payable income taxes, the policy subsidizes the payroll taxes of R&D staff. To the best of our knowledge, such an R&D tax subsidy has only been implemented in the Netherlands previously and has seldom been evaluated in the literature.[24] The specific characteristic of the Swedish subsidy is that R&D-performing loss-making firms can benefit from it directly. Furthermore, there is a subsidy cap per firm and month, which benefits small companies. In addition, firms with labor-intensive R&D gain the most from the subsidy, since R&D staff costs, but no other R&D costs, are subsidized.

To test the impact of the R&D payroll tax subsidy, we combine firm-level data on R&D subsidies with data on employed scientists over the 2011–2019 period. We perform a difference-in-difference analysis, using firms over or hitting the cap as a control group, and find that the treatment subsidy has positive and strongly significant effects on firms' employment of scientists. Treated firms increase their number of scientists by 32–102 percent and their share of scientists by 30–43 percent in comparison to levels in the control group. Finally, the impact of the subsidy does not differ much on the basis of firm characteristics. Neither firm size nor the debt ratio significantly alters the impact of the subsidy on the number and share of scientists. On the other hand, the treatment effect for labor-intensive firms is significantly higher with respect to the share of scientists but somewhat lower

[24] Lokshin and Mohnen (2012) evaluate the effects of the Dutch tax incentive scheme. However, there are some differences between their and our study. First, they use a structural approach, while we use a direct approach with a DiD-method (see section 2.3). Second, they evaluate the subsidy effects on firms' total R&D expenditures, whereas we estimate the effects on the number and share of scientists.

regarding the number of scientists. Thus, the results for the treatment effect on labor intensity are somewhat ambiguous.

Even if the marginal effect of the subsidy on the employment of scientists does not vary by firm size, there is no doubt that SMEs benefit greatly from the Swedish R&D tax subsidy. Whereas 85 percent of the direct R&D subsidies in Sweden are allocated to large firms, 76 percent of the new R&D tax subsidy is allocated to SMEs. Furthermore, labor-intensive sectors such as information and communication as well as professional, scientific, and technical activities receive 55 percent of the subsidies.

There is a risk that companies will try to relabel ordinary employees as R&D staff to benefit from the subsidy. This would have been a problem for the analysis if we had used reported R&D staff as an outcome variable in our model. However, we argue that the use of employees with a PhD as an outcome variable prevents relabeling bias in the analysis. It is unlikely that firms would hire high-wage scientists to benefit from the subsidy and then not employ them in R&D activities. In addition to relabeling effects, alternative outcome variables, such as R&D costs or researcher wage costs, would make it difficult to separate wage increases from direct employment effects. Although a R&D subsidy that enables a higher researcher salary could, of course, result in a more productive researcher being hired, which improves the firm's ability to conduct effective R&D.

Our results strongly support that the Swedish R&D tax subsidy has stimulated firms to employ more scientists. In the analyzed period between 2014 and 2019, the Swedish government’s funding of business R&D consisted of 90 percent direct subsidies and only 10 percent tax subsidies. In other OECD countries, the distribution between the policy tools is more even. The total cost of the reform is relatively small compared to other tax relief programs. Guided by our results, an expansion of the R&D payroll tax subsidy would be beneficial; either by increasing the magnitude of the R&D tax relief, or by rising the subsidy cap. Indeed, the Swedish government has now done so in two steps; in 2020 the R&D payroll tax deduction increased from 10 to 20 percent of wage payments, and the payroll tax subsidy cap increased from SEK 230,000 to SEK 450,000 per month. The year after, the cap was raised again to SEK 600,000 per month. It would be useful for future research to explore this policy change for further evaluation of the Swedish R&D payroll tax subsidy. Furthermore, it would be of great interest to evaluate wage effects in the firms and on the job markets for researchers, as well as the effects on skills supply and postgraduate education.

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Varmt välkommen att kontakta oss!

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