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Taxation and Innovation: How R&D Tax Credit Schemes Foster Innovation in the Private Sector

Innovations form the backbone of sustained economic growth and, as such, they play a key role in safeguarding prosperity. Governments, aware of this, invest heavily in public research at universities and research institutes, and strive to create ideal conditions for private sector research and development (R&D), usually through specific R&D tax credit schemes or direct funding.

THREE TYPES OF MARKET FAILURE

Public support of R&D activities in the private sector is economically warranted because the private sector's incentives to invest in R&D are typically too low. Three types of market failure lead to this underinvestment:

- 1) Spillover effects. If a company invests in R&D and generates new ideas, the ideas usually do not remain solely within that company but permeate the entire market, for instance through imitation by other companies, or by way of job-switching employees taking their knowledge and skills with them. Thus, many market participants end up benefiting from new ideas without having generated them themselves. The investing company, however, does not take such positive spillover effects into account. As a result, its investment into R&D is lower than would be desirable from an economic point of view.
- 2) Uncertainty. It is highly uncertain whether investments in R&D will pay off. In particular, it is unclear a priori whether such investments will lead to actual innovations, and even if they do, it is uncertain whether these innovations will be profitable for the company doing the investing.

- KEY MESSAGES
- **Research and Development (R&D) is crucial to secure continued economic growth and prosperity**
 - **Private sector investments in R&D are typically too low, which constitutes a market failure**
 - **Governments use R&D tax credit schemes to compensate for this failure**
 - **Input-based tax credit schemes and lenient corporate taxation are especially useful to stimulate private sector R&D activities**

Companies cannot insure themselves against this kind of uncertainty. Thus, especially for small and medium-sized enterprises (SMEs), whose financial leeway is more limited, investments in R&D represent a financial risk.

- 3) Public goods. Many important areas of our society depend on the provision of public goods, i.e., goods that are non-rival and non-excludable in consumption (e.g., health care). It is precisely these areas that often benefit from innovation, and the provision of important public goods suffers if innovation activities slacken off.

This article provides an overview of existing R&D tax credit schemes, documenting which ones are most effective. To that end, we summarize the results from an evidence review that systematically examines the existing literature. We conclude by discussing potential policy implications for Germany.



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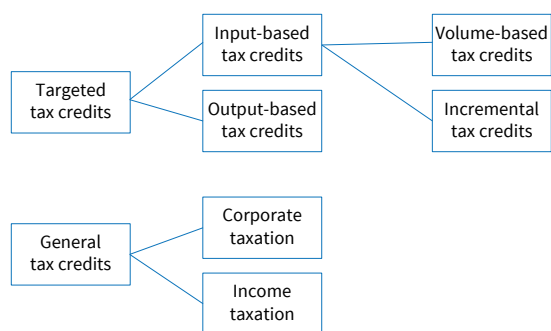


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Figure 1

Overview of Tax Credit Schemes



Source: Authors' compilation.

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R&D TAX CREDIT SCHEMES

R&D tax credit schemes can be broadly divided into targeted and general tax credit schemes (Figure 1). Targeted R&D tax credit schemes are tied directly to a company's R&D activities, for instance by basing them on actual R&D expenditures. General tax credit schemes, in turn, support private sector R&D activities more broadly, e.g., through lenient income and corporate taxation.

TARGETED TAX CREDIT SCHEMES

Targeted R&D tax credit schemes can be further divided into input-based and output-based schemes. Input-based schemes consider all expenses incurred in connection with companies' R&D activities, including, e.g., personnel and material costs. Based on that, the researching companies receive tax benefits in the form of tax breaks, tax allowances or special depreciation options.

Input-based tax credit schemes can be volume-based or incremental; mixed forms are also possible. In case of volume-based funding, a company's total eligible R&D expenditures are used to calculate the tax credit. Incremental tax credit schemes, on the other hand, take only those R&D expenditures into account that exceed a certain reference value (e.g., the expenditures from the previous year or the average expenditure over the last three years). Unsurprisingly, incremental tax credit schemes involve more administrative effort than the volume-based sort. On the other hand, incremental tax credit schemes can better avoid windfall effects, since the public does not fund any R&D expenditures that the company would have made anyway.

In contrast to input-based tax credit schemes, the output-based sort considers the actual innovative output of companies that invest in R&D. This means that researching companies can only benefit from output-based tax credits if their R&D activities are ultimately successful. Output-based tax credits are usually provided through so-called licensing or patent

box schemes, where corporate revenues generated through the company's innovations benefit from tax breaks.

GENERAL TAX CREDIT SCHEMES

A relatively new branch of the economic literature examines the relationship between general tax credit schemes—e.g., income and corporate taxation policies—and R&D activities in the private sector. Income taxation can affect the occupational decisions of R&D workers. For example, differences in income taxes can determine whether and where high-skilled workers locate. Moreover, income taxes have been shown to affect both motivation and performance of R&D personnel.

Analogous to income taxation, corporate taxes determine whether and where researching companies and self-employed researchers locate. In addition, corporate taxation plays a major role in determining companies' R&D intensity, such as through influencing how many high-skilled workers can be hired and how well they can be paid.

R&D TAX CREDIT SCHEMES IN GERMANY AND INTERNATIONALLY

Until the introduction of R&D tax credit schemes, Germany only supported selected R&D activities both in the private and the public sectors through a project-based scheme that is still in force. The volume of such project-related funding is based on the target group (such as universities, start-ups, companies), size (e.g., SMEs), and type of R&D activity (e.g., some corporate R&D). Most of the project-related funding is provided through grants that the supported companies do not have to repay. In addition, some R&D funding programs grant loans or involve participation, equity holding, or financial securities on behalf of the state.

Germany's first R&D tax credit scheme ("Forschungszulagengesetz," FZulG), introduced on January 1st, 2020, complements the above project-based R&D funding. Eligible are all companies that have their registered office in Germany, are subject to German taxation, and conduct R&D. In-house R&D, contractual research, as well as R&D that is carried out by individual entrepreneurs all qualify for the tax credit, which is input- and volume-based. It does not compete with existing R&D project-based funding, i.e., tax credits can generally be granted in addition to project-based funding (though not for the same expenditures). The assessment base for in-house R&D expenditures was initially limited to €2 million euros per year, which at a credit rate of 25 percent results in a maximum subsidy amount of €500,000 per year and company. The Second Covid Tax Assistance Act increased the maximum assessment base to €4 million for eligible expenses incurred after June 30, 2020, and before July 1, 2026.

Internationally, R&D tax credits and tax deductions are the most frequently used policy instruments to support private sector R&D activities. According to the *Worldwide R&D Incentives Reference Guide 2020*, published by the auditing firm EY, 60 percent of the 47 countries surveyed grant tax credits, while 64 percent offer the option of tax deduction. Accelerated depreciation of R&D-related assets and tax breaks also play an important role in 40 percent of the surveyed countries, whereas tax allowances are important in only 5 percent. Like Germany, most countries use volume-based tax credit schemes. Only Italy and Mexico pursue a purely incremental system, while some other countries combine both types of R&D tax credit schemes.

Outside Germany, patent boxes—i.e., output-based tax credit schemes—have also become a widespread instrument to promote private sector R&D activities. In recent years, for example, several European countries (including Belgium, France, Hungary, Portugal, Spain, the United Kingdom, and the Netherlands) as well as the United States have included patent boxes in their tax legislation.

Since the financial scope of SMEs is typically limited, some countries offer tax relief specifically for the R&D activities of such companies. For example, 12 of 28 OECD countries currently offer tax breaks for researching SMEs, with countries such as Italy and France specifically promoting young companies through tax credits or tax allowances.

Finally, some countries have created tax incentives for immigrating high-skilled (namely, R&D-oriented) workers. In Denmark, for example, immigrating workers whose income is above a certain threshold benefit from reduced income taxation for a period of three years; similar regulations exist in Belgium or Sweden (but not in Germany).

EVIDENCE ON THE EFFECTIVENESS OF R&D TAX CREDIT SCHEMES

We will now present the results of an evidence review that systematically examines the existing literature (Falck et al. 2021, ifo Forschungsbericht 123-2021) on R&D tax credit schemes. We start by summarizing studies on targeted tax credit schemes, which we further divide into studies on input-based and output-based sorts. In a second step, we review the existing literature on general tax incentives.

INPUT-BASED R&D TAX CREDIT SCHEMES

A total of fifteen studies provides credible causal evidence on the effectiveness of input-based tax credit schemes. Twelve of the studies examine the effect of volume-based tax credit schemes, eight of which consider European countries, with the remaining four examining Canada, Japan, the US, and Australia. All twelve studies use microdata at the firm level.

Three of the twelve studies on volume-based tax credits assess a 2008 tax reform in the UK, under which companies with up to 500 employees were declared SMEs, whereas the upper limit had previously been set at 250 employees.

Guceri (2018) exploits that reform to compare firms that unexpectedly benefited from SME-specific R&D tax credits (i.e., firms with more than 250 but less than 500 employees) with firms that were not rated as SMEs (> 500 employees). The author shows that the total R&D expenditures of the “sudden SMEs” increased by about 15-20 percent. In particular, the companies hired more R&D personnel, but refraining from increasing expenditures per R&D worker.

Guceri and Liu (2019) use the same reform to show that the eligible R&D expenditures of sudden SMEs—as opposed to their total R&D expenditures—increased by about 33 percent relative to firms not deemed SMEs.

Dechezlepretre et al. (2020) examine the tax reform’s impact on innovation outcomes in terms of the number of patents granted. The authors show that the number of patents granted to firms newly declared as SMEs increased by 60 percent relative to non-SME firms. They also demonstrate that R&D tax credit schemes led to spillover effects on technologically related firms.

Two further studies evaluate a tax reform in Italy, where a volume-based tax credit scheme to foster private sector R&D expenditures was introduced in 2006, temporarily abolished in 2009, and reintroduced a few months later with limited funds. Italian companies could apply for the funding on a “first come, first served” basis. The limit on state funding was quickly reached, leading to the rejection of around two-thirds of applications.

Cantabene and Nascia (2014) use this setting to make a comparison between supported and non-supported companies, regardless of whether the latter had applied for funding or not. They show that the tax credit had a positive effect on absolute R&D expenditures as well as on R&D intensity. Acconcia and Cantabene (2018) consider the same tax reform but compare supported companies exclusively to those that were not supported but applied for funding. Their results confirm the findings by Cantabene and Nascia (2014).

Acheson and Malone (2020) examine an Irish tax reform that, like the reform in the UK discussed above, caused a number of companies to unexpectedly become eligible for volume-based R&D tax credit schemes in 2009. In line with the results from the aforementioned studies, the authors find that tax credits have a positive impact on R&D expenditures of newly funded companies.

Agrawal et al. (2019) examine a change in the Canadian R&D tax credit scheme of 2004, whereby larger companies became eligible for public support. The authors show that the reform was followed by

17 percent higher R&D expenditures among the newly eligible companies.

Haegeland and Moen (2007) show that the introduction of a tax credit scheme in Norway in 2002 boosted the growth rates of R&D expenditures, with the effect primarily driven by companies that conducted little or no R&D before. By contrast, the R&D expenditures of companies that had already conducted R&D continuously before 2002 hardly changed at all.

Holt et al. (2016) analyze a tax credit scheme introduced in Australia in 2012. They show that subsidized companies have on average 14 percent higher R&D expenditures than non-subsidized ones.

Moretti and Wilson (2014) consider companies in the US biotech industry that benefit from volume-based tax credits. The authors document significant positive effects on the number of outstanding scientists in researching companies, but many of these gains occur at the expense of firms in adjacent states with lower levels of support.

Two further studies examine the shift from incremental to volume-based R&D tax credit schemes. Bozio et al. (2014) evaluate a tax reform in France from 2008. They find positive effects of the reform on R&D expenditures, but no effect on innovation outputs in terms of the number of patents granted up to two years after the reform. Kasahara et al. (2014) examine a similar reform from 2003 in Japan. They find that R&D expenditures would have been about 3 percent lower without the switch from incremental to volume-based funding, i.e., the tax reform had a positive effect on firms' R&D expenditures.

Three of the fifteen evaluation studies on input-based R&D tax credit schemes examine the impact of US incremental tax credit schemes, using firm-level microdata. The first one, Berger (1993), studies the effect of such a scheme introduced in the US in 1981 and documents a positive effect on the R&D expenditures. Hines (2007) investigates the period from 1986 to 1990, when R&D tax credits in the US were reduced at both the extensive and intensive margins, showing that affected firms spent less on R&D as a result. Rao (2016) examines the entire period from 1981 to 1991, confirming the findings of both studies above.

OUTPUT-BASED R&D TAX CREDIT SCHEMES

Three papers analyze the causal effect of output-based tax credit schemes on private sector R&D activities. Bornemann et al. (2020) examine the introduction of a patent box system in Belgium in 2008 and compare R&D activities from Belgian companies that benefited from the tax credits with companies from Germany, France, and Sweden. The authors consider four different outcomes: patent applications, patent grants, patent quality (measured by citations), and the number of R&D workers in the researching companies. Their analysis shows that the number of patent ap-

plications and grants increased after the tax reform in Belgium, while the quality of patents decreased. The number of R&D workers, in turn, almost doubled.

Schwab and Todtenhaupt (2019) study the impact of patent boxes in different countries. Their main finding is that such schemes tend to increase innovation output in terms of patent applications only when the physical presence of the company in the country where the application is filed is not necessary. In contrast, if physical presence is required, the effect of R&D support on the number of patents is much smaller and not statistically significant. The authors also find evidence for reallocation effects, i.e., patent boxes do not ensure that innovation output increases in aggregate, but that more patents simply tend to be filed where the tax credit is highest.

Köthenburger et al. (2019) reach a similar conclusion. The authors investigate whether patent boxes lead to intra-firm profit shifts of multinational enterprises (MNEs) across national borders. Their study reinforces what Schwab and Todtenhaupt (2019) also show: locations of MNEs where patent boxes exist report on average 8.5 percent higher profits than the same MNE locations where patent boxes do not exist.

GENERAL R&D TAX CREDIT SCHEMES

Ten studies examine the effect of general R&D tax credit schemes, eight of which analyze the impact of corporate taxation; of these, three examine the impact of income taxation on private sector R&D activities. The most comprehensive study comes from Akcigit et al. (2018), whose data cover taxation and innovation in the US over the entire 20th century. The authors show that higher corporate taxation reduces US companies' R&D activities in terms of the absolute number of R&D workers as well as both the quality and quantity of patents issued by companies.

Mukherjee et al. (2017) use firm-level data to study the effect of a gradual change in corporate taxation between 1990 and 2006 in the US. Their results are consistent with those of Akcigit et al. (2018). In particular, they show that higher corporate taxes negatively affect innovation inputs, outputs, and outcomes of private sector companies. Specifically, companies for which the corporate tax was increased reduce their R&D expenditures by about 4.3 percent, file about one fewer patent, record about 14.2 percent fewer patent citations in the two years following the tax increase, and register about 5.1 percent fewer new products in the year following the tax increase.

Atassanov and Liu (2020) study the effect of corporate tax increases and decreases in the US between 1988 and 2006. Like Mukherjee et al. (2017), they find that corporate tax cuts have a positive impact on the quality and quantity of companies' innovation outputs. More specifically, companies from states where corporate taxes were reduced file about 0.63 (0.79) more patents three (four) years later than comparable

companies in states where taxes were left unchanged; moreover, each patent received an average of 0.75 additional citations. Corporate tax increases have an opposite impact, but their overall effect is smaller. The authors also demonstrate that small and less liquid firms respond more strongly to corporate taxation changes than large and solvent firms.

Moretti and Wilson (2017), who examined the effect of corporate taxation on the location of high-skilled R&D workers in the US from 1976 to 2010, show that high corporate taxation reduces the number of high-skilled R&D workers who locate to a particular state. A plausible explanation for this is that corporate taxes reduce companies' demand for R&D personnel.

Looking outside the US, three papers examine the effect of corporate taxation on R&D activities of private sector firms in China. Howell (2016) shows that state-owned enterprises (SOEs) increased their R&D expenditures following a reduction in the corporate tax burden, while privately owned enterprises (POEs) decreased them. However, both types of companies recorded more new products and processes. The author explains the differing impact of the reform on the R&D expenditures of SOEs and POEs by the fact that POEs invested more in physical capital that was not declared as R&D - which was now relatively cheaper for them - and were thus also able to increase their innovation outcomes.

Cai et al. (2018) examine the effect of a tax reform that entailed a 10 percent reduction in the corporate taxation rate for manufacturing firms founded in January 2002 or later. The authors show that the reduction had a positive effect on both innovation inputs and outputs of the affected firms; in particular, their number of patent applications increased by 5.7 percent on average. Chen et al. (2020) use a Chinese tax reform from 2008 to determine the effect of general tax breaks on private sector R&D expenditures. Here, firms whose expenditures are above a certain threshold benefit from the tax breaks, while firms below do not. The authors show that tax breaks increase R&D expenditures by 25 percent for large firms, 17 percent for medium firms, and 10 percent for small firms.

Finally, Guceri and Albinowsky (2021) examine how economic uncertainty moderates the impact of corporate taxation on private sector R&D activities. They demonstrate that economic uncertainty counteracts the impact of tax credit schemes. In particular, companies hesitate to invest into R&D activities during times of financial stress, while economic certainty bolsters the will to invest.

A further three studies, focused on the US, examine the effect of income taxation on private sector R&D activities. Akcigit et al. (2020) demonstrate that higher income taxation has a negative effect on the quality and quantity of patents, as well as on the probability of generating a successful patent (with many citations). Moreover, R&D workers are less likely to locate to U.S. states with higher income taxation.

Akcigit et al. (2016) find that increases in the top income tax rates in the US, Europe, and Japan have had negative effects on the relocation of high-skilled R&D workers, and that the internal structure of companies also plays a major role in the migration of highly skilled R&D personnel: scientists who have worked for MNEs are more likely to move to take advantage of differences in income taxation. However, if the company is particularly strong in R&D within its industry, scientists are more willing to stay. Moretti and Wilson (2017) confirm these findings. The authors show that with larger differences in income taxation between two US states, the top R&D personnel are more likely to locate to the states with the lower taxation.

POLICY CONCLUSION

The evidence report paints a predominantly positive picture of the effectiveness of R&D tax credit schemes. In particular, the literature suggests that both targeted (input-based) and general tax credit schemes have a positive impact on private sector R&D activities.

What do these results imply for Germany? It is still too early to evaluate the effectiveness of the country's first R&D tax credit scheme, introduced in January 2020. However, a look at other countries suggests that the tax credit scheme is likely to have a positive impact on private sector R&D activities.

Two further lessons for Germany can be derived from the evidence report. First, with the introduction of R&D tax credits, the direct funding of private sector R&D projects will, and should, be put to the test. The literature mainly covers countries where direct funding of R&D does not play a major role. The fact that targeted tax credit schemes still have the desired effect in these countries suggests that Germany might no longer need its broad-based direct funding. One step forward could be to use direct project funding only to pursue specific goals, such as promoting certain R&D collaborations, regional projects, or selected technologies (e.g., in the area of environment and climate).

Second, the evidence report underlines the importance of general tax credit schemes for private sector R&D activities. The finding that lower corporate taxes tend to increase R&D activities is particularly important for Germany, a high-tax country in international comparisons, and should be considered in future debates on taxation.

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