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Tax incentives for R&D

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Summary

Today, many countries such as the US, UK, France, China and Korea provide generous tax incentives for research and development (R&D) to innovative firms. These incentives can be in the form of tax credits, tax deductions, cash refunds for companies without taxable profit, or other favourable means of treating expenditure on R&D that falls within a certain definition. Against the backdrop of the recent global

trend towards implementing generous tax incentive schemes, this paper reviews the economic literature on evaluating the effectiveness of tax policy for R&D.

Policy designs for R&D tax incentives differ across countries and over time. Broadly, the studies find a positive effect of R&D tax incentives on firm level and aggregate R&D spending for firms which are already engaged in such activity in a given jurisdiction. Estimates of the magnitude of the increase in R&D spending in response to a 10 percent reduction in the user cost of R&D usually range between 4 percent and 30 percent. The differences arise from country-specific aspects of each policy design and implementation, as well as firm characteristics such as size and age. There are statistical and data-related challenges related to evaluating the effects of policies on firm location and productivity.

1. Trends

Research and Development (R&D) is a type of investment, which the economics literature usually treats analogously to investment in physical capital. Relative to investment in physical capital, R&D spending typically has higher uncertainty of success in outcomes, takes longer to yield profitable outputs and the activity is more open to imitation by a large number of firms.

Perhaps the most important distinction between R&D and investment in physical capital is related to spillovers. Knowledge spillovers allow many to take advantage from one company's R&D efforts, preventing the main inventor from fully reaping the benefits of their investment in innovative activity. The theoretical basis for government support to R&D is built on the idea that in the market equilibrium, the private sector will underinvest in R&D relative to the socially desirable level because of R&D spillovers. There are also productivity gains from increasing the average skill level of the labour force.

Governments have devised a menu of policy responses to address the perceived problem of underinvestment in R&D by the private sector. These policy responses generally involve a mix of direct subsidies and fiscal incentives, which are complementary measures.

Direct subsidies are the appropriate response if the government's main aim is to increase the private sector's R&D efforts in a perfect market and where both the government and the private sector are fully informed about the market potential of innovations. In reality, governments are not knowledgeable to the same extent as the firms about the project costs or the commercial viability of the outputs of each R&D project. Bureaucratic difficulties such as the amount of paperwork required in applications, slow processing of disbursements for accepted projects and other institutional bottlenecks further complicate the process of direct support programs for R&D and innovation.

R&D tax credits give companies the flexibility to choose the most profitable R&D projects, while reducing the post-tax cost of spending in the marginal R&D project. In terms of paperwork, tax incentives usually involve filing the claim as part of a firm's regular tax return, alleviating the bureaucratic burden of R&D support, both from the government's and the beneficiaries' perspective.

Tax authorities are generally the responsible entity for implementation and monitoring compliance of tax incentives for R&D. The primary question regarding the effectiveness of tax incentives is whether the government is subsidising R&D that would be done even in the absence of such incentives. This is the major challenge of econometric exercises that aim to identify policy effects.

Another major issue regarding the efficacy of tax incentive policies from an operational perspective is the potential for companies to relabel ordinary spending as R&D. Tax authorities are then tasked with identifying what types of expenditures qualify for the R&D tax relief and inspecting the accuracy of the claims. For this purpose, the suitability of the institutional set up via the tax administration is sometimes seen as a disadvantage of fiscal incentives for R&D, given that tax authorities are not necessarily best equipped to assess the spending needs of projects in the fields of science and technology. This is not a criticism of tax authorities, but rather a question about institutional priorities.

Direct subsidies are useful measures especially for start-ups and smaller firms, which are likely to remain in a position of tax losses for lengthy periods of time, reducing the value of any fiscal benefits for such companies. Larger companies tend to find tax incentives to be more efficient and useful for their purposes, while smaller firms reportedly benefit more from direct subsidy programs and policies that provide mentorship assistance or consultancy services. This paper specifically focuses on the tax incentives for R&D.

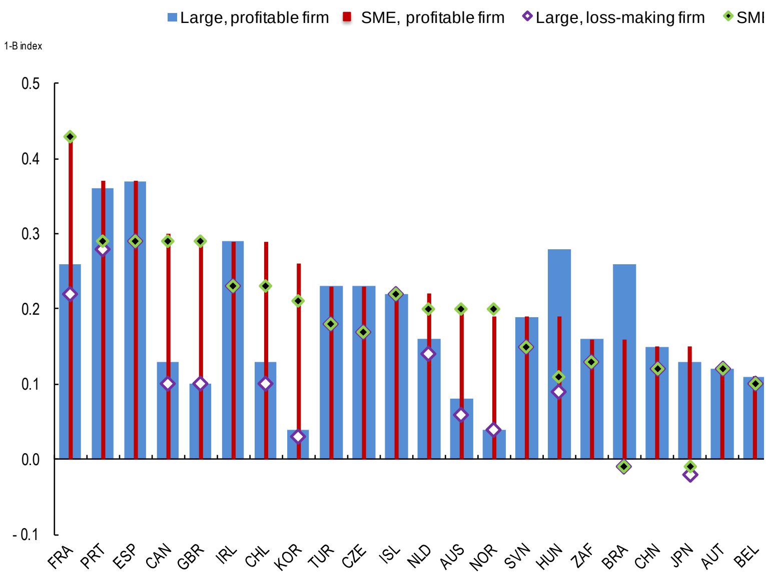
The last few decades have seen an unprecedented rise in the number of countries implementing tax incentive policies with the aim of boosting the innovation and R&D performance of the private sector. In the 2000s, countries which had existing R&D tax breaks such as France and Japan increased the generosity of available incentives, while others such as the United Kingdom and China introduced special tax deductions for current spending on R&D for the first time. There has been a shift towards providing volume-based schemes, which are incentives based on the total R&D carried out in a given year and away from only subsidising increases in R&D that took place during a reference period (incremental tax credits).

There are differences between countries on the generosity of R&D tax incentives. It is not easy to compare different policy designs. Even within the same country, rates and policy tools vary over time. In addition, the tax position of the company affects the form of the R&D tax incentive that they receive. Some countries allow for carry forwards or cash refunds, and some do not.

Figure 1 presents an OECD ranking of fiscal incentives for R&D across countries in 2015 based on the generosity of R&D tax incentives. The vertical axis in the figure is a scaled version of the B-index (1-B)[1], which tries to capture the cost of spending a unit of currency in R&D, at the point where the firm breaks even after paying taxes on the project's returns. A higher B-index means R&D is more costly, and the scale of Figure 1 is 1-B, with higher bars representing more generous schemes. For example, in 2015, for large UK companies, the B-index was 0.9, regardless of whether they made a profit or a loss. This is because the current form of the large company R&D tax incentive scheme in the UK is a refundable and taxable credit at 10 percent rate. For small companies, the R&D tax incentive is a deduction at 230 percent, meaning that the benefit over immediate expensing of £100 of R&D is £130, equivalent to a £26 gain after the 20 percent tax rate. Lossmaking companies may choose to receive a cash refund at 14.5 percent or carry forward their losses (which are calculated taking the enhanced deduction into account). These allowances translate to a B-index for small companies of 0.71. On this scale, France has a more generous system with a B-index of 0.57 for small companies, 0.78 for loss-making large companies and 0.74 for profit-making large companies.

[1] Details on the B-index formula can be found in Warda (2001).

FIGURE 1. A CROSS-COUNTRY COMPARISON OF THE GENEROSITY OF FISCAL INCENTIVES FOR R&D



Source: OECD R&D Tax Incentives Indicators; based on the 2015 OECD-NESTI data collection on tax incentives support for R&D expenditures. http://www.oecd.org/sti/rd-tax-stats.htm#design

2. Conceptual issues

Two main reasons drive governments to subsidise R&D. First, spillovers do not allow all of the return from innovative activity to be captured by the firm that is carrying out such activity. By subsidising R&D, governments aim to induce a higher level of private investment in R&D than the market equilibrium, with the belief that R&D stimulates productivity and economic growth.[2] Second, governments aim to generate high-skilled employment opportunities in the country which is again expected to boost productivity.

There are many factors that may interfere with the relationship between R&D subsidies, R&D and productivity. Tax incentives may reduce the cost of investing in R&D, but there are other aspects of the innovation ecosystem that may affect the attractiveness of the economy for private investment in R&D from abroad. These aspects of the innovation ecosystem may include the presence of good research universities, spinoff companies, investors, an industry that uses the knowledge input from innovators, and a consumer base that demands the products from that industry. Countries therefore compete both on the generosity of

[2] The relationship between innovation, productivity and growth has been studied in a number of seminal papers, including those of Aghion and Howitt, (1992) and Arrow, (1962).

R&D tax incentives and these other components of the innovation ecosystem that may attract innovative firms.

For an open economy that implements R&D support policies, the mobile nature of knowledge may limit the intended positive spillovers at the local level. A multinational firm may invest in R&D leading to a patentable invention in Country *X*, which it may then produce in Country *Y*, and register the intellectual property attached to the particular invention in Country *Z*. Inventors operating in technology fields close to the particular invention around the world may then advance on this discovery. If the intended spillover effects benefit firms and consumers around the world rather than those in Country *X*, then the spillovers argument for R&D policy in the open economy context becomes weaker.

Evidence for geographic spillovers would justify government support for R&D based on the spillovers argument even in an open economy. Adams and Jaffe (1996) give the example of inventors in Boston area (MIT and Harvard) interacting more frequently with each other than with the inventors in the California (Stanford). Even in today's globalised world, there are gains to researchers and innovative firms, albeit limited, to locating close to each other. Based on a carefully devised distance measure, Bloom et al. (2013) find evidence for geographic spillovers, which may justify support for innovative activity by the open economy governments.

By investing in R&D, the company builds an intangible asset. Expenditure on high skilled R&D labour, materials and capital goods related to innovative activities allow the firm to accumulate an intangible stock of knowledge capital in-house.

Each year, around 50 percent of private R&D is spent on labor, 40 percent is spent on supplies and less than 10 percent is spent on capital goods used in R&D-related activities.[3] Judging by this compositional breakdown, R&D spending and capital expenditures seem to be very different types of investment. R&D is mainly composed of labour and supplies, whereas capital expenditure mostly refers to spending on plant and machinery, land and buildings. We may nevertheless treat the accumulation of knowledge capital within a firm analogously to the accumulation of physical capital (Griliches, 1979). It is therefore possible to analyse the effects of tax incentives on R&D spending similarly to the analysis of the effects of tax incentives on investment in physical capital.

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[3] The precise statistics on the breakdown of aggregate R&D spending by industry can be found at http://stats.oecd.org under the heading 'Science, Technology and Patents', statistics on 'Business Enterprise R-D expenditure by industry and by type of cost (ISIC Rev.4).

Public intervention through special R&D tax incentives affects R&D through three channels: (i) a decrease in the effective average tax rate (EATR) induces firms to re-locate their R&D activity to lower tax jurisdictions, (ii) conditional on having located R&D activity in a given jurisdiction, a reduction in the user cost of R&D incentivises firms to undertake more R&D in that location, (iii) an increase in cash flow relaxes financing constraints and increases R&D by firms for which such constraints are binding.

The neoclassical theory of investment models the firm as an infinitely-lived entity that maximises its net present value. In this framework, the firm takes on R&D opportunities up to the 'marginal project' where it breaks even on the additional dollar invested, after having paid the tax on the return from this project.[4] The optimal level of investment is therefore determined by the user cost of capital, which takes into account various aspects of the tax system.

Governments may reduce the user cost of capital for the firm by providing special tax incentives (such as R&D tax credits, enhanced deductions, depreciation allowances on R&D capital, cash refunds, loss carry backs and carry forwards). Incentive schemes of this

[4] The neoclassical theory of optimal capital accumulation was developed by Jorgenson (1963) and Hall and Jorgenson (1967).

type are the primary focus of this paper. Another way to reduce the user cost of R&D is by lowering the tax rate on the rents that are accrued from intangible assets accumulated as a result of innovative activity. Multinational firms may choose to relocate their intangible assets in tax havens or jurisdictions which offer reduced rates for patents or other intellectual property income. These lower tax rates may also decrease the user cost of R&D.

Based on these ideas, an expression for the tax-adjusted user cost of capital can be derived and used to evaluate the possible effects of changes in the tax treatment of R&D on R&D spending at the firm level. In a nutshell, the user cost of R&D, or knowledge capital can be represented by the following expression:[5]

$$\rho = \frac{1 - A}{1 - \tau}[r + \delta]$$

where τ is the tax rate, A represents the net present value of tax incentives for R&D[6], r is the discount rate and δ is the depreciation rate for R&D capital. Special R&D tax incentives reduce the user cost by decreasing A, while a patent box regime or profit-shifting to a tax haven may reduce the user cost by decreasing τ. The B-

[5] A derivation for this expression can be found in Bloom et al. (2002).

[6] For example, if the country allows 100 percent expensing of all R&D, then $A = \tau$, or if there are enhanced deductions at rate d, then $A = (1 + d)\tau$.

index used in Figure 1 is a vastly simplified and standardised measure of the user cost of R&D capital.

Policymakers that consider changing the tax system in a direction that intends to favour private R&D spending then need to consider: first, the changes in the user cost of R&D capital induced by the tax incentive and second, the possible effects of the changes in the user cost of R&D capital on firms' R&D spending. For example, in a period of declining corporate tax rates, an increase in the rate of enhanced deduction for R&D may not necessarily induce higher R&D spending by firms, since the user cost may remain unaffected.

The policymaker may introduce either a tax credit or a deduction which could reduce A by the same amount, and *ceteris paribus* this should lead to the same equilibrium level of R&D. From an accounting perspective, on the other hand, the two policies may incentivise firms differently. An example of the importance of this distinction is the UK's transition from an enhanced deduction scheme to an above-the-line tax credit for large companies following consultations with businesses.

The discussion so far has abstracted away from the cash flow effects of R&D tax incentives on liquidity constrained firms. In the finance literature, a firm is defined as cash constrained if a windfall cash injection increases its investment. Young and innovative R&D firms typically face financing constraints, as they have limited access to bank financing and other debt channels and have to progress in their innovative efforts before attracting angel investors or venture capital funds.

The third channel through which subsidies affect the level of private R&D spending is the tax rate on profits from innovative activity in each location. The effective average tax rate (EATR), which is influenced by R&D tax incentives and the statutory tax rate, affects the location of both the R&D activity and the resulting intangible asset.[7] A firm may choose to perform R&D in a country with generous R&D tax incentives, and declare ownership in a country with a low tax rate.

The existing literature in the topic has largely focused on the impact of R&D tax incentives via the first channel, through the reduction in the user cost. Studies that explore the effects of patent box policies have investigated the location decision of the firms in response to the reduction in the EATR, but a comprehensive framework of R&D tax incentives and

[7] These ideas follow Devereux and Griffith (1998).

low tax rates on rents from intangible assets is yet to be developed.

3. Evidence

Estimates of firms' responses to fiscal incentives for R&D

Firms respond to R&D tax reliefs in diverse ways due to external factors, rendering evaluation difficult for policymakers. Economic shocks, general demand conditions or sectoral trends may influence the R&D performance of firms in the pre- and post-implementation periods of a newly introduced R&D tax relief scheme. In a country that was severely hit by the global economic crisis, a generous R&D tax credit scheme that was introduced in 2008 is less likely to result in increased R&D expenditure than a less generous scheme introduced in, say, 2004.

From the evaluators' perspective, an 'ideal' way to measure the impact of an R&D tax incentive policy would be to introduce such a policy, but only to a randomly assigned 'treated' group of companies. Obviously, this set up is impossible to achieve for many reasons. Even if implementation was somehow politically feasible, interactions between firms including competition, subcontracted R&D and supply chain relationships would blur the conclusions derived from comparing the innovation outcomes for treated and control group companies.

Since random assignment of an R&D tax relief scheme is not possible, researchers look for alternative ways to identify the effects of R&D tax incentives, trying to strip out the effect of the policy from other factors. If we can find a reform that benefited a certain group of firms and not others, we may find a natural control group against which the performance of a number of 'treated' firms has changed after the introduction of the policy.

We need a common metric to compare the results from a diverse set of studies, which examine the effects of tax relief policies implemented in different countries with different policy designs. The 'user cost elasticity' measures the percentage change in R&D spending in response to a 1 percent change in the user cost of R&D. Comparisons of estimates across different countries and over time are possible because the user cost framework incorporates various tax incentives such as tax credits, cash refunds, deductions, depreciation allowances and other reliefs, as described in the preceding section.

A cross-country study of nine OECD countries over the period 1979-1997 by Bloom et al. (2002) finds that a 10 percent reduction in the user cost of R&D triggers an increase in aggregate R&D spending of around 1 percent in the short run and around 10 percent in the long run. Cross-country studies have the drawback of not allowing a deeper analysis of the differences between smaller and larger firms, or any cross-sectoral differences. Recently, studies at the micro level have become more widely available.

Many of the frequently cited evaluation studies in the literature use micro level (firm) data and exploit the differences across companies in user cost of R&D capital to evaluate the policy impact.[8] Two factors contributed to the academic literature on evaluating the impact of R&D tax incentive schemes. First, with the increased popularity of R&D tax incentives, researchers found the opportunity to measure the R&D spending and other indicators of innovative activity following reforms in a number of countries and over time. Second, tax authorities, such as the US's Internal Revenue Service (IRS) and the UK's HM Revenue and Customs (HMRC) have made administrative tax returns data available for use by academic researchers under secure conditions.

There are a few recent studies which use firm-level administrative data to evaluate the effects of R&D tax

[8] Hall and van Reenen (2000) review the earlier literature on tax incentives for R&D and discuss methodological issues in detail.

incentives. Rao (2015) explores the effects of the US policy and identifies the policy impact by exploiting the tax changes in an instrumental variables strategy. The paper finds that a 10 percent drop in the user cost of R&D capital results in a long-run increase of around 10.4 percent in the firms' R&D intensity measured by total R&D spending as a share of sales. In addition, the paper points out that firms only gradually increase their R&D in response to the policy change, and therefore it takes time for the economy to adjust to the new long run equilibrium while firms gradually increase their R&D spending. In terms of the value for money, Rao (2015) estimates that $1 of tax credit generates around $1.80 of R&D.

Guceri and Liu (2015) use UK corporation tax returns data and exploit the definition change for SMEs to identify the effects of the policy on qualifying R&D spending. In 2008, the threshold defining an 'SME' for the purpose of the R&D tax relief increased from companies with fewer than 250 employees to companies with fewer than 500 employees.[9] Because the UK offers more generous tax incentives to SMEs relative to large companies, the 'new SMEs' that were reclassified after 2008 constituted a natural treatment group, and the companies that remained large

[9] There are also asset, turnover and ownership tests to define SMEs in the UK R&D Tax Relief, which also changed after the reform.

constituted a natural control group to study R&D outcomes in response to more generous tax incentives. Using this strategy, Guceri and Liu (2015) find that a 10 percent reduction in the user cost of R&D induces firms to increase R&D spending by around 23 percent, which is larger than the long-run estimates of Bloom et al. (2002) and Rao (2015). This may be due to the fact that Guceri and Liu (2015) focus on medium-sized firms, which may respond more strongly to R&D subsidies. The paper also estimates that £1 foregone in corporation tax revenue generates between £1.2 and £1.6 pounds of additional qualifying R&D.

Agrawal et al. (2014)'s impact evaluation study of the Canadian Research and Experimental Development tax credit uses firm level administrative data which covers the period 2000-2007. The paper finds that small companies respond to a 10 percent reduction in their R&D user cost by increasing their R&D spending by 15 percent, and the effect appears to be larger for subcontract R&D.

Czarnitzki et al. (2011) also uses data on Canadian firms and explores the effects of the tax credit on 'outputs' related to R&D such as the number of new products introduced to the market or the sales volume attached to these new products using data for the period (1997-1999). The treated group is composed of those firms that use tax credits and the control group is composed of firms that for some reason did not benefit from the scheme. They find some evidence for a positive effect on new products and sales based on new products for firms that benefit from the scheme.

France had a number of changes to its R&D tax incentive scheme, which had been in operation since 1983.[10] Mulkay and Mairesse (2013) examine the impact on R&D spending of the changes in the generosity of the earlier schemes that France implemented, and then simulate the effects of moving from an incremental to a volume-based scheme in 2008. Their estimates indicate that a 10 percent reduction in the user cost of R&D capital resulted in the companies increasing their R&D spending by around 4 percent, with a return of around €0.7 per €1 cost of the policy. The authors also argue that this is a sizeable effect of the policy, since the calculation of the estimate disregards any spillovers associated with innovation.[11]

There are other studies which use data from a wide range of countries, for example from the Netherlands and Norway, to list a few.[12] Based on the introduction of

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[10] Bozio et al., (2015).

[11] In their work currently in progress, Bozio et al. (2015) seek to evaluate the impact of the 2008 reform in France.

[12] For example, Lokshin and Mohnen (2011) use data from the Netherlands on and find a user cost elasticity estimate of around -0.8.

an R&D tax relief in Norway in 2002, Boler et al. (2015) find that the reduction of the cost of R&D induced by the R&D tax relief resulted in both an increase in R&D spending and also the imports of intermediate inputs. The authors highlight that this finding is consistent with the suggestion that R&D investment and imports of intermediate goods are complementary inputs.

Overall, many recent studies find a positive effect of R&D tax incentives on firm level R&D spending. The magnitude of the estimated impact on R&D spending in terms of the response to a 10 percent reduction in user cost usually ranges between 4 percent and 30 percent. This is a wide range of estimates, and the gap arises from factors such as firm size, policy design differences and institutional issues at the country or the firm level. The common finding is that tax incentives stimulate higher R&D on average for firms which are already engaged in such activity in a given jurisdiction. It is more challenging to evaluate the effects on other outcomes such as relocation, patenting and increases in productivity due to data availability. There are ongoing projects by researchers to explore such outcomes.

Caveats

An important policy question and a critique of the estimates found in the existing literature relates to the extent of potential relabelling of ordinary spending as R&D to benefit from the policy. Many studies have pointed this out as a potential caveat, but overall, the discussion about the incentives of firms in remains based on anecdotal evidence.[13] The ability of firms to exploit the policy in this manner depends on the characteristics of the firm as well as the tax administration's monitoring capacity in the particular country.

A critique of R&D support policies in general relates to the supply of researchers. Goolsbee (1998) argues that because of the inelastic supply of scientists and engineers, R&D support policies would increase the salaries of R&D employees, without generating new R&D headcount at firms. There is some empirical support for this suggestion in Lokshin and Mohnen (2013), who find that R&D salaries may have increased by around 0.24 percent in response to a percent increase in the fraction of salaries eligible for tax incentives. At the same time, findings of Guceri (2016) suggest that firms may also be increasing their R&D

[13] See, for example, US Government Accountability Office (2009).

headcount, which would indicate that the increase in R&D spending by firms is not simply a price effect.

The impact of R&D tax incentives on the location of R&D is a relatively under-explored aspect of tax incentive schemes for R&D. Given the current environment of tax competition, it is difficult to argue that the governments are only trying to increase R&D by firms within the country by reducing the cost of this activity for them. By introducing generous tax incentives, many countries hope to attract R&D operations of multinationals which are likely to bring know-how and their production operations of high value added goods and services. In a study of R&D location decisions based on tax incentive differentials using US state-level tax incentives, Wilson (2009) argues that tax incentives result in a zero-sum game of moving R&D across different jurisdictions without adding real value.[14]

Interaction with Patent Box policies

Patent Box policies offer lower corporate tax rates to revenues arising from ownership of intellectual property. R&D tax relief policies and patent boxes are highly interrelated, as they both appear to incentivise innovation and R&D. Due to the uncertain nature of

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[14] Wilson (2009) finds user cost elasticity estimates of around -2.5 in-state and around +2.5 out-of-state, resulting in a net effect of zero change.

innovative outputs and the long durations of R&D projects before arriving at a patentable product, R&D tax incentives seem to be a more direct way of incentivising innovative activity.

There are ongoing studies that aim to pin down the revenue, profit shifting and real R&D effects of patent box policies. These studies try to establish whether there have been substantial revenue and innovation effects of patent box regimes, and find some evidence for the profit shifting function. A paper by Griffith et al. (2014) has shown that patent boxes result in aggressive tax competition and a race to the bottom with substantial reductions in corporation tax revenue.

In addition to academic studies on R&D tax incentives, international organisations such as the OECD and the European Commission have produced a large number of rigorous research reports involving comparative studies of the different incentive schemes and benchmarking exercises based on descriptive statistics and other quantitative and qualitative evidence at the country level.[15] European Commission (2014) discusses the evidence on the impact of R&D tax incentives, and argues that patent box policies are unlikely to directly

[15] OECD cross-country comparisons can be found at http://www.oecd.org/sti/rd-tax-stats.htm. The European Commission report (2014) also analyses different regimes in 33 countries (all EU member states and Canada, Israel, Japan and Norway) and makes policy recommendations based on a number of good practices.

affect private R&D the same way as do R&D tax incentives.

The possible effects of the nexus approach within the OECD/G20's Base Erosion and Profit Shifting (BEPS) agenda may change the governments' incentives in offering patent box policies and may align these incentives more with attracting R&D and innovation. Possible effects of patent box policies on R&D and innovation outcomes offer areas for future research.

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