Enhanced Tax Incentives for R&D Would Make Americans Richer

JOHN LESTER AND JACEK WARDA | SEPTEMBER 2020

The United States continues to fall far behind comparable countries in the level of tax support it provides to spur research and development. Increasing the R&D credit would boost Americans' real incomes through innovation, productivity, and competitiveness.

KEY TAKEAWAYS

- Federal and state tax support accounts for 9.5 percent of R&D spending in the U.S. economy. This is quite low by international standards—ranking America 24th out of 34 comparable OECD and BRIC countries, considerably behind China.
- Due to a provision in the Tax Cuts and Job Creation Act of 2017 will shift in 2022 from current expensing to five-year amortization of R&D expenditures, the United States is on track to slide even further off the pace.
- Congress should lift the overall R&D subsidy rate to at least 15.5 percent—the benefits would still far outweigh the costs—by eliminating the 2017 expensing repeal and slightly more than doubling the effective rates for federal R&D credits.
- Congress also should expand the favorable tax treatment of foreign-derived intangible income—which indirectly supports R&D by reducing taxes on income from exports of commercialized R&D products—to cover income from domestic sales, too.
- Achieving an overall R&D subsidy target of 15.5 percent still would only put America near the median level among comparable counties. But it would help improve our competitive advantage in innovation industries.
- More importantly, enhancing tax incentives for R&D would boost Americans' incomes by bolstering innovation, productivity, and competitiveness.

INTRODUCTION

Virtually all nations want more innovation, and the increased income that comes with it. As a result, many nations provide tax incentives to companies for performing research and development (R&D). The U.S. federal government has two main investment tax credits (ITCs) for R&D: the Regular Credit (RC) and the Alternative Simplified Credit (ASC). Almost three-quarters of U.S. states accounting for over 80 percent of R&D performed also provide tax incentives. In addition, R&D benefits from other tax advantages, notably immediate deductibility of spending on equipment, wages, and other current expenditures along with a special low tax rate on net income derived from exports of commercialized R&D. Altogether, federal and state tax support accounts for 9.5 percent of R&D spending.

This is, however, quite low relative to tax-support levels in other countries. The United States ranks 24th out of 34 in a comparison group consisting of all Organization for Economic Cooperation and Development (OECD) member countries with a population of more than four million, plus Brazil, Russia, India, and China (BRIC). China's R&D tax subsidy, for example, is 2.7 times more generous than the United States'. Slightly more than doubling the federal credit rates would raise the federal-state subsidy rate to 15.5 percent, which would be slightly below the median for the comparison group (excluding the United States), and still well below China.

The international comparison, coupled with a benefit-cost analysis, suggests U.S. tax support for R&D is too low.

Moreover, starting in 2022, because of provisions in the Tax Cuts and Job Creation Act of 2017, the United States is on track to be one of the few countries not to allow expensing of current R&D costs. Letting this change go ahead, and assuming state governments follow the federal lead, would reduce the subsidy rate to 2.8 percent from 9.5 percent and bring the U.S. ranking down to 32nd. In addition, eliminating the favorable tax treatment of net exports of commercialized R&D, as some have proposed, would drop the subsidy rate to 1.8 percent, while leaving the United States' international ranking at 32nd.

The international comparison, coupled with a benefit-cost analysis, suggests U.S. tax support for R&D is too low. The analysis in this paper confirms that substantial increases in U.S. tax support for R&D would improve overall economic performance, including innovation, productivity, and international competitiveness. A fiscally responsible target would be to increase the overall subsidy rate to 15.5 percent from 9.5 percent. This could be done by eliminating the 2017 repeal of the expensing of R&D costs, while slightly more than doubling the effective rates for the ASC and the RC through some combination of higher statutory rates and design changes. In addition, there is an advantage in using more than one instrument to achieve the target support level. As a result, the favorable tax treatment of foreign-derived intangible income (FDII), which indirectly supports R&D by reducing the tax rate on income from commercialized R&D products that are exported, should be expanded to cover income derived from commercialized R&D products sold domestically. Such a change would raise the R&D subsidy rate by about 2 percentage points while encouraging the retention in America of commercialization activity and the associated taxable income.

U.S. TAX SUPPORT FOR BUSINESS R&D

In the U.S. federal system, both the federal and state governments tax business and provide R&D tax incentives.

Federal Research Credits

The federal government offers two main ITCs for R&D.[1] The RC is available to firms that increase their R&D intensity (R&D spending divided by revenue) relative to a fixed base period. Base spending on R&D for the current year is determined by multiplying R&D intensity in the period from 1984 to 1988 (the fixed-base percentage) by the average level of sales in the preceding four years. Special rules for calculating the base period R&D intensity apply to firms not in existence over the entire 1984–1988 period.[2] If current R&D spending exceeds the base amount, firms may claim a 20 percent tax credit on the additional increment of spending. However, the base amount must be at least 50 percent of current-year spending on R&D. Firms subject to this constraint have an effective marginal credit rate of 10 percent because an additional dollar spent on R&D raises the minimum base by 50 cents, so only 50 cents of the additional dollar is eligible for the 20 percent credit.

Firms may choose the ASC instead of the RC. Under the ASC, firms claim a 14 percent credit on the excess of current R&D spending over 50 percent of the average level of spending in the preceding 3 years. Firms that have not undertaken any R&D in the preceding three years can use current-period spending as the base, but must use a 6 percent credit rate. The ASC therefore consists of an incremental component for most firms, but a volume or level-based component available to "start-ups."

The statutory credit rates are not a reliable guide to how the measures affect the incentive to invest in R&D because not all R&D is eligible for a credit. The RC and ASC apply to wages, selected elements of intermediate materials, and rental or lease costs of computers. These qualified research expenditures (QRE) of claimants account for almost two-thirds of total business spending on R&D.

In addition, the ASC provides a smaller incentive to increase R&D than implied by the 14 percent statutory rate because an increase in spending in one year raises the base for calculating incremental spending in subsequent years. If a firm spends an extra dollar on R&D in the current year, it will receive an additional credit of 14 cents, but will lose 2.33 cents (=0.5*14/3) in credits in each of the following three years because of the increase in the base for calculating the credit. With a discount rate of 7.7 percent, the present value of the forgone credits is approximately 6 cents, which implies an 8 percent effective credit rate. While the RC also targets incremental spending, the use of a fixed intensity ratio means that, for most firms, the base effect is small enough to be ignored.[3]

The credits are deducted from corporate income taxes payable, but can be carried back one year or forward for up to 20 years if they cannot be used in the year they are earned. However, interest is not paid on unclaimed credits, making them less valuable when carried forward. Delays in claiming the credits reduce their present values by 18 percent.[4] Small businesses with sales under $5 million in the current tax year and no sales in the preceding four years may use up to $250,000 of the research credit to reduce the employer portion of Social Security liabilities. As a result, the research credit will be partially or fully refundable for qualifying small businesses depending on how much R&D the firms perform relative to their number of employees.

The RC and ASC reduce the acquisition cost of R&D to firms, which may claim the reduced amount as a business expense. This treatment lowers the value of the credits to the claimant by the business income tax rate. However, even with this base adjustment, the percentage reduction in the user cost of capital still equals the credit rate—the effective subsidy rate is not affected.[5] A more intuitive explanation for this result is the base adjustment prevents firms from claiming all spending on R&D as a deductible expense when their cost has been reduced by the subsidy.

Data available from the Internal Revenue Service (IRS), along with certain assumptions, can be used to calculate the effective subsidy rates for the RC and ASC.[6] The calculations presented in table 1 indicate that, on average, from 2011 to 2014, the effective RC credit rate was 11.5 percent, reflecting the fact that most claimants were constrained by the minimum base, which implies an effective subsidy rate of 10 percent. Since RC claims account for about 30 percent of qualified R&D spending, the effective rate on QRE is 3.5 percent. With respect to the ASC, the effective rate is 5.5 percent on QRE. The weighted average marginal subsidy rate for both credits is 9 percent on QRE and 5.8 percent on total R&D spending.[7]

Table 1: Calculation of U.S. federal weighted average marginal effective investment tax credit rates

	Share[1]	Marginal Rate	Weighted Marginal Rate
Qualified Research Expenditure (QRE) that is:			
Eligible for the Regular Credit			
Not constrained by minimum base[2]	4.5%	20.0%	0.9%
Constrained by minimum base[2]	26.3%	10.0%	2.6%
All	30.9%	11.5%	3.5%
Eligible for the Alternative Simplified Credit[3]	69.1%	8.0%	5.5%
Weighted average federal credit rate on QRE			9.0%
Effective rate on total R&D spending[4]			5.8%

1. 2011–2014 averages calculated from IRS statistical tables (www.irs.gov/uac/SOI-Tax-Stats-Corporation-Research-Credit).

2. The base amount used to determine eligibility for the credit cannot be less than 50% of current year QRE.

3. The effective rate for the ASC is calculated as the credit available for the current year less the present value of the credits forgone as a result of the increase in the average expenditure base in future years.

4. QRE excludes overhead and most capital expenses. On average from 2011 to 2014, it accounted for 63.7% of domestic R&D spending by firms as reported by the National Science Foundation.

State Research Credits

In 2019, 36 states accounting for 82 percent of business R&D performed in the United States provided general R&D ITCs. All states except five currently use the federal definition of spending that is eligible for a credit. Details on these credits are provided in annex 1. The weighted average state credit is 2.3 percent on QRE and 1.5 percent on total R&D expenditures, which are about a quarter of the corresponding federal subsidy rates. The low average state rate is the result of the absence of credits in states accounting for 18 percent of national R&D, statutory rates that are almost always lower than federal rates and low caps on the total fiscal cost of the credits in 7 states accounting for almost 8 percent of national R&D spending.

Tax Preference for Income From Intellectual Property

Under the Tax Cuts and Jobs Act of 2017, the United States adopted (among many other measures) a dual rate structure for corporate income: The top federal rate is 21 percent, while FDII is taxed at 13.125 percent, rising to 16.4 percent after 2025. With some simplification, FDII is income from exports less an imputed return of 10 percent on the tangible assets that generate the export income.[8] R&D capital is one of the assets that generates FDII, so the dual rate provides a tax preference for the income arising from the commercialization of R&D, which is similar to innovation boxes in other countries.

Since the preferential rate applies to income derived from foreign sources, the effective tax rate on overall net income from R&D is determined by multiplying the statutory rate by 1 minus the export intensity of commercialized R&D, estimated at 24 percent.[9] The reduction in the federal corporate income tax rate on income generated from R&D assets is approximately 1.75 percentage points.[10] Based on work by De Jong and Lapsiwala, we estimated that states accounting for about 20 percent of R&D spending have followed the federal lead on FDII.[11] The reduction in the combined federal-state tax rate on income from R&D is approximately 2 percentage points.

Tax Depreciation Allowances

The federal and state governments allow firms to deduct current expenditures (e.g., wages and supplies) on R&D as they are incurred. Under the Tax Cuts and Jobs Act of 2017, equipment used in the performance of R&D can also be expensed.[12] The knowledge created by R&D creates income over a period of years in the same way as tangible capital, so spending on R&D should also be depreciated over time rather than be deducted immediately. The appropriate depreciation rate for knowledge capital is determined by the decline in its capacity to generate income from products brought to market, or made cheaper to produce because of performing R&D. Empirical estimation of the depreciation rate for R&D raises some difficult issues that have not yet been resolved. As a result, a 15 percent depreciation rate is typically assumed in analytical work, although the evidence is accumulating in favor of a higher rate.[13] Relative to a 15 percent declining balance depreciation rate, expensing of non-capital expenditures provides a substantial tax benefit by allowing firms to defer tax payments to later years.

Measuring Tax Support

The benefit arising from R&D tax incentives is measured in the user cost of capital framework. This is a broader measure than the B-Index framework commonly used to assess tax support for R&D.[14] (See box 1.) In contrast to the B-Index, the user cost framework captures the tax advantage conferred by immediate deductibility of current R&D expenses. Another difference with the B-Index is the inclusion of the tax on the net income generated by R&D, which makes it possible to model income-based measures such as the tax preference for FDII or innovation boxes in the cost of capital framework.

In the user cost framework, immediate deductibility of expenditures that should be capitalized makes the biggest contribution to the subsidy (see table 2). However, the impact of the federal tax credits is only slightly smaller.[15] The favorable treatment of FDII reduces the pretax cost of

R&D by less than 1 percentage point. The tax payable on income generated by R&D, net of interest deductibility, provides a substantial offset to these incentives, resulting in a net federal subsidy of 7.6 percent. When state tax systems are included, the overall net subsidy rises to 9.5 percent.

The subsidy as measured by the B-Index, which consists of the tax credit and a tax penalty for not allowing the expensing of expenditures on buildings, is about two-thirds as large as the user cost subsidy rate including the FDII preference.

Box 1: Modeling R&D Tax Incentives

Tax incentives for R&D can be classified into expenditure and income-based measures. Expenditure-based measures encourage investment in R&D by reducing its after-tax cost to firms. They consist of ITCs, accelerated depreciation of tangible assets, and the "super-deduction" of current costs incurred to perform R&D. Income-based measures, generally described as patent or innovation boxes, encourage investment in R&D by reducing the tax burden on the income it generates. If there is a link or "nexus" between the income taxed at a preferential rate and the expenditures undertaken to generate that income, as recommended by the OECD, innovation boxes become a method of subsidizing R&D that encourages retention of commercialization activity and the associated taxable income in the implementing jurisdiction, without encouraging profit shifting from other jurisdictions.[16]

We model these two forms of tax support in a user cost of capital framework. The subsidy rate arising from tax incentives is calculated as the percentage change in the pretax user cost of capital caused by taxes. The pretax user cost of capital is the sum of the financial cost of capital and the economic depreciation rate of the knowledge created by performing R&D, which represents the rate at which the ability of the knowledge to generate revenue declines. In addition to the ITCs and super-deductions previously referenced, the after-tax user cost captures the impact of gaps between baseline tax allowances and economic depreciation, interest deductibility, and the corporate income tax payable on the net income generated by R&D.[17]

Tax support for R&D is more commonly measured using the B-Index, pioneered by McFetridge and Warda.[18] The B-Index—more precisely, one minus the B-Index—measures the percentage reduction in the cost of performing R&D arising from ITCs and super-deductions. The exclusion of the tax on net income and interest deductibility means the B-Index framework cannot be used to assess the subsidy arising from innovation boxes. The treatment of tax depreciation allowances also differs in the two frameworks. The B-Index is calculated assuming the baseline treatment of costs is immediate deductibility; as a result, failure to allow expensing raises the after-tax cost of performing R&D. In contrast, if tax depreciation allowances exceed economic depreciation, there would be a tax incentive in the user cost framework.

As shown in annex 2, excluding the impact of innovation boxes, the 2 approaches result in similar subsidy rates, although the estimates for the B-Index are about 1.75 percentage points lower.

Under forthcoming rules, current expenditures on R&D will be deducted from taxable income in equal installments over five years, beginning in the midpoint of the year when the expenditure was made.

The large contribution of expensing to the user cost subsidy rate draws attention to the impact of the scheduled switch to five-year amortization beginning in 2022. Under the forthcoming rules, current expenditures on R&D will be deducted from taxable income in equal installments over five years, beginning in the midpoint of the year when the expenditure was made. In addition, the depreciation allowance that would normally be claimed for tangible capital must be amortized over five years. If implemented at the federal level only, these changes would reduce the R&D subsidy by about 5 percentage points. If all states were to follow the federal lead, the subsidy rate would fall by about 7 percentage points. These declines are smaller than the total contribution of depreciation allowances to the subsidy rate because tax depreciation allowances still exceed economic depreciation under the upcoming changes.

Table 2: Decomposition of subsidy rates calculated using the user cost and B-index formulas

	Tax on Net Income	Tax Reduction on FDII[1]	Tax credit	Depreciation Allowances	Subsidy rate	
					Without FDII Preference	With FDII Preference
User cost						
Federal	-4.7%	0.7%	5.3%	6.2%	6.9%	7.6%
Federal plus state	-6.6%	0.9%	6.7%	8.5%	8.6%	9.5%
B-Index						
Federal	0	0	5.7%	-0.5%	5.2%	
Federal plus state	0	0	7.2%	-1.1%	6.1%	

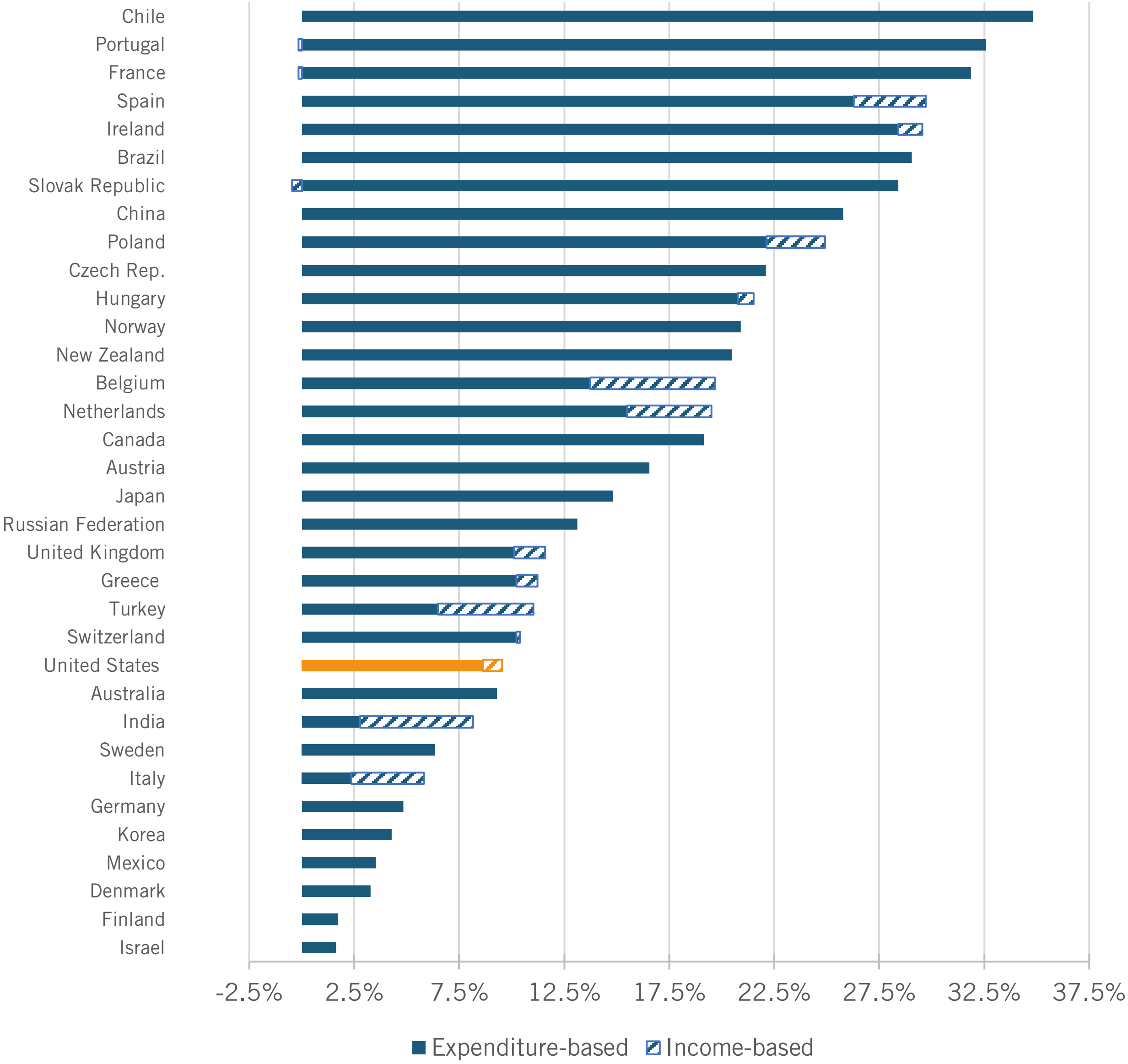
1. Foreign-derived intangible income. See text for an explanation.

U.S. Tax Support for R&D in International Context

Federal and state tax support for R&D is low relative to other countries. In a comparison group consisting of 30 OECD countries with a population exceeding 4 million, along with BRIC, the United States ranks 24th with a subsidy rate of 9.5 percent (see figure 1 and annex 2).[19] The United States is 1 of 16 countries in the comparison group that provides a tax preference for the income derived from investment in R&D. (These provisions are usually described as patent or innovation boxes). The United States measure stands out in that only income derived from export sales is eligible for the preference. As a result, the effective U.S. income-based subsidy rate is the second-lowest in the comparison group. The United States ranks 26th when only expenditure-based measures are included in the comparison.

All countries in the comparison group except Finland and Israel provide expenditure-based tax incentives for R&D in the form of ITCs or tax allowances that exceed the costs incurred (super-deductions).[20] Twenty-two countries provide ITCs and another ten provide super-deductions. One country, Hungary, provides both. Super-deductions have a key disadvantage over tax credits: The value of a super-deduction varies with the corporate income tax rate.[21] As a result, as countries raise or lower corporate tax rates, or if they offer special low tax rates to small firms, subsidy rates may deviate from their target value. All countries except Australia allow current expenditures on R&D to be deducted as they are incurred.[22] Ten countries provide accelerated tax depreciation allowances for the tangible capital used to perform R&D. Almost all these countries, including the United States, allow expensing of machinery and equipment along with baseline treatment of the structures used when performing R&D. Machinery and equipment accounts for about 6 percent of R&D costs, so the accelerated depreciation provisions have only a minor impact on the subsidy rates.

Figure 1: R&D tax subsidy rates for large taxable firms



R&D expenditures that are qualified or eligible to receive a tax incentive are defined relatively narrowly in the United States to include, roughly speaking, wages and supplies, which account for about two-thirds of R&D spending. Six countries in the comparison group, like the United States, include all current spending, and also other spending such as overhead costs, which boosts coverage to about 90 percent of R&D spending. Eleven countries include all current spending and some or all capital expenditures.

The United States is one of eight countries in the comparison group that make use of incremental incentives (see table 3). The U.S. RC is, however, the only measure that uses increases in R&D intensity to determine incremental spending. The RC is more complicated to administer and comply with than both volume and incremental credits, in part because calculating the amount of R&D spending eligible for the credit requires data on sales as well as R&D spending, whereas the other credits require only R&D spending.

The ASC and the measures in the other seven countries determine incremental spending as current spending less an average of past spending. The ASC effective incremental incentive on overall R&D is by far the most generous in the group, despite having the lowest statutory rate. A key factor in this outcome is the United States defines the base for incremental spending as 50 percent of the average of spending in the prior three years; it is the only country to reduce the average of past spending when calculating the base. In addition, all countries except one use a shorter averaging period to calculate base spending than the United States; the shorter period puts downward pressure on the effective rate. For example, Portugal provides a 50 percent credit on R&D spending that exceeds the average level in the preceding 2 years. As discussed, "base effects" reduce the effective U.S. rate on incremental spending from 14 percent to 8 percent and the effective rate is further reduced because less than half of R&D is performed by firms that are eligible for the credit.[23]

The U.S. practice of requiring firms to reduce the base for depreciation allowances by the amount of the R&D tax incentive received is unusual in the comparison group. Among the 18 countries offering business income tax credits, only Australia, Canada, Chile, and the United Kingdom adopt the same approach as the United States, which is often described as making the credit taxable. Nontaxable credits allow firms to deduct expenses they have not incurred, which raises the subsidy delivered through the tax system. If the federal credits were nontaxable, the overall subsidy rate would rise almost 1 percentage point, to 10.4 percent. The fiscal cost of the credits would rise about a quarter.[24]

The U.S. practice of requiring firms to reduce the base for depreciation allowances by the amount of the R&D tax incentive received is unusual in the comparison group of countries.

Of the 22 countries offering ITCs, 6 allow them to be claimed against payroll taxes or social security contributions instead of corporate income tax liabilities, making them effectively refundable in whole or part (table 3).[25] In another eight countries, ITCs claimed against income tax liabilities are refundable for all firms, and refundable for only small firms in another three countries. Overall, R&D tax incentives are refundable for all firms in 13 out of 22 countries, and in 4 small firms only. In the United States, recent legislation allowed small start-ups to claim up to $250,000 in R&D credits against their Social Security contributions, although current legislation is proposing to increase this.[26] Four other countries in the comparison group also limit the amount of the ITC that is refundable.[27]

There is a particularly strong case for providing refundability to young firms, which are unlikely to have taxable income while they undertake the first round of R&D. Failure to provide refundability reduces the effective subsidy rate for young firms relative to established firms, which can typically use tax credits to reduce taxes payable; this creates a barrier to entry that can hurt economic performance.[28]

Table 3: Summary of expenditure-based tax incentives, 2019–2020

Corporate Income Tax			Payroll / Social Security Withholdings
Tax Credits		Super Deductions	Tax Credits
Level	Incremental/Hybrid		
Taxable: Australia, Canada, Chile, United Kingdom (large) Nontaxable: Austria, Belgium (M&E only), France, Germany (wages), Ireland, Korea, New Zealand, Norway	Taxable: United States Nontaxable: Italy, Korea, Mexico, Portugal, Spain	Brazil, China, Czech Republic, Denmark, Greece, Hungary, Netherlands, Poland, Russian Federation, Slovakia (hybrid), Switzerland, Turkey (incremental), United Kingdom (small)	Taxable: Belgium, Hungary, Netherlands, Sweden, Turkey, United States (small)
Refundability			
Australia (small), Austria, Belgium (M&E after 5 years), Canada (small), France (small), Italy (offset regional taxes and SS contributions), New Zealand, Norway, United Kingdom	Hungary, Italy	United Kingdom	Belgium, Hungary, Netherlands, Sweden, Turkey, United States (small)
Preferential rates for small companies or young firms			
Australia, Canada, Norway	Japan, Korea, Portugal (start-ups)	United Kingdom	Belgium (young innovative firms) France (young innovative firms) Netherlands (small firms and start-ups), Spain (Innovative SMEs)
Two-level incentive rates			
France			Netherlands, Russian Federation
Caps on benefits			
Australia (small), Canada (small), Austria, Chile, Germany, Hungary, Japan, New Zealand, Norway.	Italy, Japan, Korea, Mexico, Spain, United States	United Kingdom (small)	Belgium, Hungary, Netherlands, Spain, Sweden

The disadvantage of refundability for large established firms is that the tax-minimizing amount of international income shifting increases because less taxable income is required to claim credits and deductions. On the other hand, refundability has the advantage of increasing the effective subsidy rate on R&D to its target level for firms that are nontaxable for reasons other than income shifting between jurisdictions, such as a cyclical downturn, unusual investment spending, or other firm-specific events. Refundability for large established firms may improve outcomes if it is implemented as part of a shift in support from expenditure to income-based measures, such as an innovation box. If a national nexus requirement is imposed, the impact on international profit shifting would be mitigated, while also spurring more domestic production.

Small or young firms receive enhanced incentives in 11 countries. The preference is substantial in four of these countries (Australia, Canada, Korea, and the United Kingdom), but the subsidy rate gap with large firms is less than 4 percentage points in the other countries. Benefit caps, particularly in Germany, and threshold effects for incentive rates (two-level rates that apply to all firms) also favor small firms. On the other hand, as noted earlier, countries that provide uniform super-deductions along with lower corporate income tax rates for smaller firms (Brazil, China, and Poland) end up providing a lower level of support for smaller firms, which may not be the intended outcome.[29]

Almost half the countries in the comparison group impose caps on benefits for all firms, and another three cap the benefits available to small firms, where size is determined by assets or employment. While most countries impose dollar caps on benefits, Hungary, Japan, Mexico, and Spain limit benefits to a percentage of tax liabilities.

The U.S. federal-state subsidy rate is 9.5 percent, compared with a median rate of 16.6 percent in the comparison group (excluding the United States). The top five countries (Chile, Portugal, France, Spain, and Ireland) have tax subsidy rates ranging from 30 to 35 percent. Within the G7 countries, Italy and Germany have lower subsidy rates than the United States.[30] Subsidy rates in the United Kingdom and Japan are higher than in the United States but below the median for the comparison group. Canada, at 19.1 percent, is above the median. Subsidy rates in Brazil and China are 29.1 percent and 25.8 percent respectively, and 13.1 percent in Russia and 8.2 percent in India, which is slightly lower than in the United States.[31]

The international comparisons strongly suggest U.S. tax support for R&D is too low. However, since subsidizing R&D has costs as well as benefits, it is possible for tax support to be too high. A benefit-cost analysis can help set a subsidy rate that is neither too low nor too high, as is discussed in the next section.

BENEFIT-COST ANALYSIS OF FEDERAL RESEARCH CREDITS

Overview of the Benefit-Cost Framework

This section provides a brief overview of the benefit-cost methodology and assumptions. Additional detail is provided in annex 5.

When firms perform R&D, they create knowledge that allows them to introduce new products or services, improve existing goods and services, and reduce production costs. However, on average, a sizeable portion of the knowledge created leaks out or spills over to other firms, thereby allowing them to reap benefits from R&D without performing it themselves. On the other hand, when firms bring new products to market and develop new production processes, the increases in sales can be at the expense of other firms. This output loss represents a social cost that has to be balanced against the gain from knowledge spillovers. The empirical evidence, discussed in annex 5, indicates the positive knowledge spillovers are larger than the negative "business-stealing" effect.

Since firms rightly do not take the positive spillover benefits into consideration when making investment decisions, there is a prima facie case for subsidizing business investment in R&D to correct this market failure. Indeed, this has been the main reason most economists have long supported R&D tax incentives. However, it is important to consider the social costs as well as the benefits of subsidizing R&D to ensure intervening in the market improves economic performance. Abstracting from spillover benefits, we assume that overriding the market distribution of the labor and capital used to perform R&D with a subsidy imposes a cost by reducing economic efficiency. A loss occurs because, if markets are functioning properly, capital and labor are being used as efficiently as possible prior to the subsidy-induced shift in resources. In making this assumption, we are not ruling out the possibility that, due to a market failure, capital and labor are used more efficiently in the R&D-intensive sector than in other sectors so that shifting resources into it would raise overall efficiency.

Since firms rightly do not take the positive spillover benefits into consideration when making investment decisions, there is a prima facie case for subsidizing business investment in R&D to correct this market failure.

The loss in efficiency can be illustrated by considering how the subsidy affects the commercial rate of return on the additional R&D performed. The subsidy lowers the hurdle rate for a profitable investment, so firms undertake R&D projects with less commercial value, which reduces the market value of output. Firms performing the R&D receive their required returns on investment, but part of the returns comes from the subsidy.

Raising taxes, or cutting spending, to finance an R&D subsidy does not directly affect the overall income of Americans if all the subsidy remains in the country. In other words, the first-round effect on national income of increasing taxes on one group of Americans and giving the proceeds to another is approximately zero. However, some of the R&D subsidy will be transferred to foreigners, which reduces income in the United States. This transfer could occur in two ways. First, since some firms eligible for the subsidy are owned by foreigners, profits derived from subsidized investment in R&D will benefit foreigners as well as Americans. Second, some of the subsidy will be passed on to the consumers of the products and services developed from the subsidized R&D in the form of lower prices. These products will be sold in domestic and world markets, so some of the subsidy will be transferred to foreigners in the form of lower prices for R&D-intensive products.

Finally, expenses incurred by governments to administer the credits, and by firms to apply for and comply with their eligibility requirements, represent a social cost. Resources devoted to these activities can be used productively elsewhere.

Table 4: Key parameter values in the benefit-cost analysis (percentage, except as noted)

	Parameters	Notes on sources and methods (See annex 5 for a detailed explanation)
Federal marginal effective credit rates		Credit rates on total business R&D spending. See table 1. The impact of delays in using credits is not included.
Alternative Simplified Credit (ASC)	3.4	
Regular Credit	2.2	
Price responsiveness of R&D[1]	-1.05	Median value of 31 empirical estimates prepared since 1993.
Spillover rate[2]	34.0	Lowest estimate from three recent U.S. empirical studies.
Percentage of subsidy transferred to foreigners through lower export prices	5.5	Based on a commercialization rate of 73%, a "gestation" lag of 2 years, an export intensity of 24%, and a 42% pass-through of the subsidy to prices. The pass-through percentage is developed assuming imperfect competition.
Percentage of subsidy absorbed in profits of foreign MNEs	1.6	Based on a 16% share of U.S. R&D performed by foreign MNEs and a 10% after-tax rate of return on R&D.
Administration and Compliance costs[3]		
Alternative Simplified Credit (ASC)		
Administration expenses	1.0	Based on expenses of the Canadian federal research tax incentive adjusted for differences in claim size.
Compliance costs	4.1	
Regular Credit		
Administration expenses	1.2	Developed assuming that fixed costs, which represent almost two-thirds of total costs, are 100% higher than for the ASC.
Compliance costs	6.3	

1. Elasticity, which is the percentage change in R&D spending induced by a one percentage point decline in the cost of performing R&D.
2. Dollar rise in real output per $100 of R&D induced by the subsidy.
3. Percentage of the subsidy provided.

Governments can in principle set the subsidy rate to maximize its net benefit. This possibility arises because increases in the subsidy rate generate benefits that are a constant share of the additional R&D induced by the subsidy and costs that are a rising share of the additional R&D.[32] Costs are a rising share of the additional R&D because increases in the subsidy rate cause the required private rate of return on R&D to fall at an accelerating pace, signaling a drop in the value of output. This relationship between benefits and costs causes the net benefit to have an inverted “U” shape: It initially rises along with the subsidy rate, but eventually declines as the private return on R&D continues to fall (see figure 2). In the absence of other costs, the net benefit would be maximized by setting the subsidy rate equal to the spillover rate, However, other costs, particularly the share of the subsidy transferred to foreigners, and also administration and compliance costs, increase relative to the spillover benefit as the subsidy rate rises; this reduces the net benefit and the optimal subsidy rate.

Key Assumptions

Using the benefit-cost framework to assess the federal credits requires estimates of the spillover rate, the responsiveness of R&D to subsidy-induced reductions in its cost, the proportion of the subsidy that is transferred to foreigners through lower export prices and through profits of foreign owned firms operating in the United States, and the costs incurred by governments to administer the incentive and by firms to comply with program requirements. Table 4 presents the values of these parameters used in the benefit-cost analysis, along with some brief notes on sources and methods. Additional detail is provided in annex 5.

The method of financing R&D tax incentives can also affect the net benefit. Financing the R&D subsidy by eliminating particularly wasteful spending or raising the least harmful taxes would reduce the output loss and increase the net benefit from the subsidy.[33] However, since the benefits from an improved tax structure or higher-quality spending could be obtained without subsidizing R&D, we use a more neutral financing assumption in the benefit-cost analysis. We assume the R&D tax incentives are financed by higher taxes on tangible business capital. This financing assumption leaves the overall tax burden on business investment unchanged, which, to a close approximation, means the tax incentive changes the composition of investment, not its level.

Results

The ASC generates a net benefit to Americans of about $3.5 billion, when the base case parameters are used in the benefit-cost analysis (table 5). The key benefit is the net increase in output from knowledge spillovers and the business-stealing effect. Transfer of the subsidy to foreigners via lower prices of commercialized R&D products is the largest cost element, amounting to almost 13 percent of the spillover benefit. Transfers via profits of foreign-controlled firms are much smaller, representing about 3 percent of the spillover benefit. Compliance costs incurred by firms are the second-largest cost element, amounting to about 10 percent of the spillover benefit. Combined with administration expenses, 12 percent of the spillover benefit is absorbed by the cost of applying for and processing claims. The lower private return on R&D induced by the subsidy represents only 5 percent of the spillover benefit. This cost does, however, increase at an accelerating pace as the subsidy rate rises.

Table 5: Benefit-cost analysis of the alternative simplified credit ($ millions, except as noted)

R&D spending by firms[1]	422,070
Tax revenue forgone[2]	11,600
Subsidy-induced R&D	14,890
Benefits	
Net increase in output arising from spillovers	5,040
Costs	
Lower private return on R&D	-260
Transfer of the subsidy to foreigners	
Profits of foreign-controlled firms	-140
Lower export prices of commercialized R&D	-640
Administration and compliance costs	-600
Total costs	-1,640
Benefits less costs	3,400
Percentage of tax revenue forgone	29.3%

1. National Science Foundation estimate for 2018.
2. See text for an explanation of how the fiscal cost is calculated.

The net benefit represents 29.3 percent of the fiscal cost of the ASC, which is estimated at $11.6 billion for 2018. This estimate of the tax revenue forgone is obtained by applying the ASC statutory rate to an estimate of the amount of spending eligible for the credit, with a further adjustment to capture the impact of the credit on the base for depreciation allowances. This calculation is equivalent to multiplying R&D spending in 2018 by 2.8 percent.[34] It does not include a reduction to capture the fact that not all credits are claimed as they are earned, and that some are never claimed.

We conducted several tests to examine whether plausible changes to key parameter values—the price responsiveness of R&D, the amount of the subsidy transferred abroad, administration and compliance costs, and the spillover rate—would alter the conclusion that the ASC generates a net benefit. These tests strongly suggest that the ASC generates a net social benefit when the spillover rate is 34 percent. The base case spillover rate is the lowest of three recent estimates for the United States.[35] Using the base case values for all other parameters, a spillover rate of about 12 percent (just above the 20th percentile of all estimates) would reduce the net benefit from the ASC to zero. Additional sensitivity tests that vary the price responsiveness of R&D and the percentage pass-through to prices, as well as the spillover rate, indicate that if the spillover rate is at least 18 percent, the ASC is highly likely to be generating a net benefit. Using the highest spillover rate found in the three recent studies, 44 percent, the net benefit rises to $4.9 billion, which is 42 percent of the fiscal cost.

We calculated the marginal and average credit rates using data over the 2011–2014 period. This averaging period excludes the first two years of the credit and the two years of economic turmoil during the financial crisis. It may or may not be representative of the current situation. The marginal and average rates are affected by changes in the dispersion of firm-level growth rates in R&D spending. They are expected to move in the same direction but not by the same amount, so the ratio of the marginal to average credit rate will change over time. The levels of the marginal and average credit rates affect the size of the net benefit, while the marginal-average ratio affects the ratio of the net benefit to the fiscal cost of the measure. The latter ratio can be described as its cost effectiveness, although that term is also used to describe the increase in R&D spending per dollar of tax revenue forgone.

An inspection of the data from 2007 to 2014 confirms that the marginal and average rates move in the same direction and that the ratio of the two rates is not stable. We investigated the sensitivity of the results to changes in marginal and average rates by setting them at their 2011 values, when their ratio was at its highest over the 2011–2014 period and both rates were below their average values. This change caused the net benefit to fall about $200 million, but the increase in the marginal-average ratio raised the net benefit per dollar of fiscal cost slightly from 29.3 percent to 32.0 percent.

When assessing the net benefit of the RC, in addition to changing the marginal and average credit rates, we increase administration and compliance costs to reflect the greater complexity of the RC. However, since there are no official estimates of administration and compliance costs available for either credit, the increase relative to the ASC should be considered illustrative. In our base case, we assume that the fixed costs of administering the credit and complying with program requirements are twice as large as for the ASC.[36] This increases total administration expenses by about 20 percent, and compliance costs by about 55 percent.

The base case net benefit is $2.3 billion, which is 35.6 percent of the estimated $6.5 billion fiscal cost of the RC compared with 29.3 percent for the ASC (table 6).[37] The RC is slightly more cost effective than the ASC because there is a greater gap between its marginal and average rates than for the ASC, which implies that the RC is slightly more successful than the ASC at limiting windfalls for research that would have been undertaken without the credit.[38]

Table 6: Benefit-cost analysis of the regular credit ($ millions, except as noted)

R&D spending by firms[1]	422,070
Tax revenue forgone[2]	6,400
Subsidy-induced R&D	9,660
Benefits	
Net increase in output arising from spillovers	3,290
Costs	
Lower private return on R&D	-110
Transfer of the subsidy to foreigners	
Profits of foreign-controlled firms	-70
Lower export prices of commercialized R&D	-350
Administration and compliance costs	-480
Total costs	-1,010
Benefits less costs	2,280
Percentage of tax revenue forgone	35.6%

1. National Science Foundation estimate for 2018.
2. See text for an explanation of how the fiscal cost is calculated.

We investigated the sensitivity of the results to changes in marginal and average credit rates. In a first experiment, we set these rates at their 2013 values, the low point of their ratio over the averaging period. These changes reduced the net benefit to $2.1 billion and reduced the cost-effectiveness ratio from 35.6 percent to 32.2 percent. In a second experiment, we reduced the weighted average marginal credit rate from 11.5 percent to 10 percent, effectively assuming that all firms claiming the RC are constrained by the requirement that the base spending be at least 50 percent of current spending. This assumption reduces the gap between the marginal and average subsidy rates. This scenario was motivated by the observation that the share of spending not constrained by the base limitation fell continuously from 2010 to 2013, when it reached 3 percent of QRE. The net benefit falls to $1.9 billion and cost effectiveness declines to 28 percent in this scenario.

Potential Biases in the Benefit-Cost Framework

The stylized model used in this paper does not capture all the impacts of the federal R&D ITCs. For example, the subsidy-induced expansion of R&D allows greater economies of scale for certain firms, something that is particularly important for firms in innovation-intensive industries. Unfortunately, there is not enough information available to quantify this benefit. In addition, if the benefit-cost model were embedded in a complete model of the economy, it would be possible to determine how the R&D subsidies affect net exports, the terms of trade, and thereby national income. While the overall level of R&D spending has significant terms-of-trade effects, the impact of raising R&D spending by 5 to 6 percent through existing federal credits appears to have second-order impacts on the terms of trade and hence income. (See annex 5.)

This paper focuses on the benefits from subsidizing R&D to address the knowledge externality, which is not the only benefit of increased spending on R&D. As previously discussed, market imperfections may mean that an expansion of the R&D-intensive sector raises overall productivity, even abstracting from knowledge spillovers. R&D subsidies also counteract a tendency for firms to invest less than the privately optimal amount in R&D due to pressures from equity markets for short-term results.[39] However, multiple market failures are best addressed with multiple instruments, and each intervention can be assessed independently.[40] Another perspective on this issue is that implementing measures to address the other market failures would not change the need for a subsidy to address the knowledge externality.

In most cases, we have chosen the central or most-likely values of key parameters in the model. An exception is the spillover rate. As discussed in annex 5, studies of U.S. spillovers by Bloom et al., Lucking et al., and Arqué-Castells prepared since 2013 have benefited from advances in econometric techniques and methods for defining the spillover pool.[41] In addition, the first two studies include both the knowledge spillover and the business-stealing effect. The study by Arqué-Castells and Spulber includes market transactions in technology, which substantially reduce the spillover rate, but not the business-stealing effect. Unfortunately, the quality of the data on market transactions does not appear to be good enough to obtain completely satisfactory estimates of their impact on spillovers. As a result, there are reasons to conclude that all three studies overstate spillovers. To account for this potential overstatement, we use the lowest estimate—but we have no way of knowing if this ad hoc adjustment is appropriate.

POLICY RECOMMENDATIONS

Improving the Cost Effectiveness of the Research Credits

The combined net benefit from the ASC and the RC is $5.7 billion. Since the subsidy rates are well below their optimal values, increases in either or both credits would result in a larger net social benefit. However, increases in the credit rates should be accompanied by changes to program parameters to increase their cost effectiveness. Policymakers implement incremental credits instead of volume credits with an eye to limiting the windfall gains associated with tax incentives. The more successful the credits are in limiting the subsidization of research that would occur without the incentive, the higher their cost effectiveness.

The most recent data available shows the ratio of the marginal to average credit rates, which is an indicator of cost effectiveness, is larger for both the RC and the ASC than for a volume credit. The source of the higher cost effectiveness of the RC is claims unconstrained by the 50 percent base limitation. To claim the 20 percent credit, the base for determining incremental spending under the RC must be more than 50 percent of current-year R&D spending. The share of these unconstrained claims is low, and trending down. If all claims are constrained by the base limitation, the RC will be no more cost effective than a volume credit.[42] The marginal-average ratio for the ASC has been trending down since 2009, which also suggests the need for changes to program parameters to restore cost effectiveness levels.

We do not have access to firm-level data that would allow us to assess specific options to raise the cost effectiveness of the two research credits. However, since the benefits of improved cost effectiveness could be substantial, this should be a priority concern for policymakers.

Targeting Statutory Rates for Research Credits

Simulations with the benefit-cost model indicate the net social benefit increases until the overall subsidy rate (both tax and grants) reaches 24.5 percent of business R&D spending. Under current law, the federal-state tax system provides a 9.5 percent subsidy for R&D (table 2) and direct federal assistance (grants) is about 0.2 percent of R&D, so increasing tax support by 15 percentage points would maximize the net benefit.[43] However, the net benefit rises relatively slowly as the subsidy rate is increased from 15.5 to 24.5 percent (figure 2). At 15.5 percent, the net benefit is 85 percent of its maximum value, and 95 percent with a 19 percent subsidy rate.

Setting the overall subsidy rate at 19 percent would put the United States in 16th position in our comparison group of 34 countries, while substantially raising the net benefit from supporting R&D. This target could be reached by increasing the ASC to 40 percent and the RC to 57 percent.

To reach the bottom end of the range, overall tax support would have to increase by 6 percent of R&D spending, which would put the United States in 17th position in our comparison group of 34 countries (see table 7). This could be achieved by slightly more than doubling the statutory rates for both credits: increasing the RC to 43.5 percent, and the ASC to 30.5 percent. Setting the overall subsidy rate at 19 percent would put the United States in 16th position in our comparison group of 34 countries. This target could be reached by increasing the ASC to 40 percent and the RC to 57 percent. Reaching the optimal subsidy rate would require the RC and the ASC credit rates to be increased 2.75 times (table 7). Setting the subsidy rate to 30 percent would raise it 5.5 percentage points above the optimal rate. At this rate, the net social benefit would be the same as with a 19 percent subsidy rate, which is 5.5 percentage points below the optimal rate—but the fiscal cost would be much higher.

Congress could raise the ASC rate to at least 38 percent and be assured that benefits would still outweigh costs.

Determining how much to increase only the ASC in order to achieve the target rate cannot be done with much confidence because a change in the relative benefits would cause firms to switch credits. Nevertheless, an illustrative calculation may be of interest. The ASC statutory rate would have to rise to 38 percent to increase the overall subsidy rate to 15.5 percent if no changes to the RC are made. In other words, Congress could raise the ASC rate to at least 38 percent and be assured that benefits would still outweigh costs.

Table 7: Target rates for R&D tax credits (percent, except as noted)

	Overall Subsidy Rate			
	15.5	19	24.5	30
Distance from optimal subsidy rate (24.5 percent)	-9	-5.5	0	5.5
RC statutory rate	43.5	57	78.5	100
ASC statutory rate	30.5	40	55	70
International ranking	17	16	10	5
Net Benefit ($ billions)	12.5	13.7	14.5	13.7

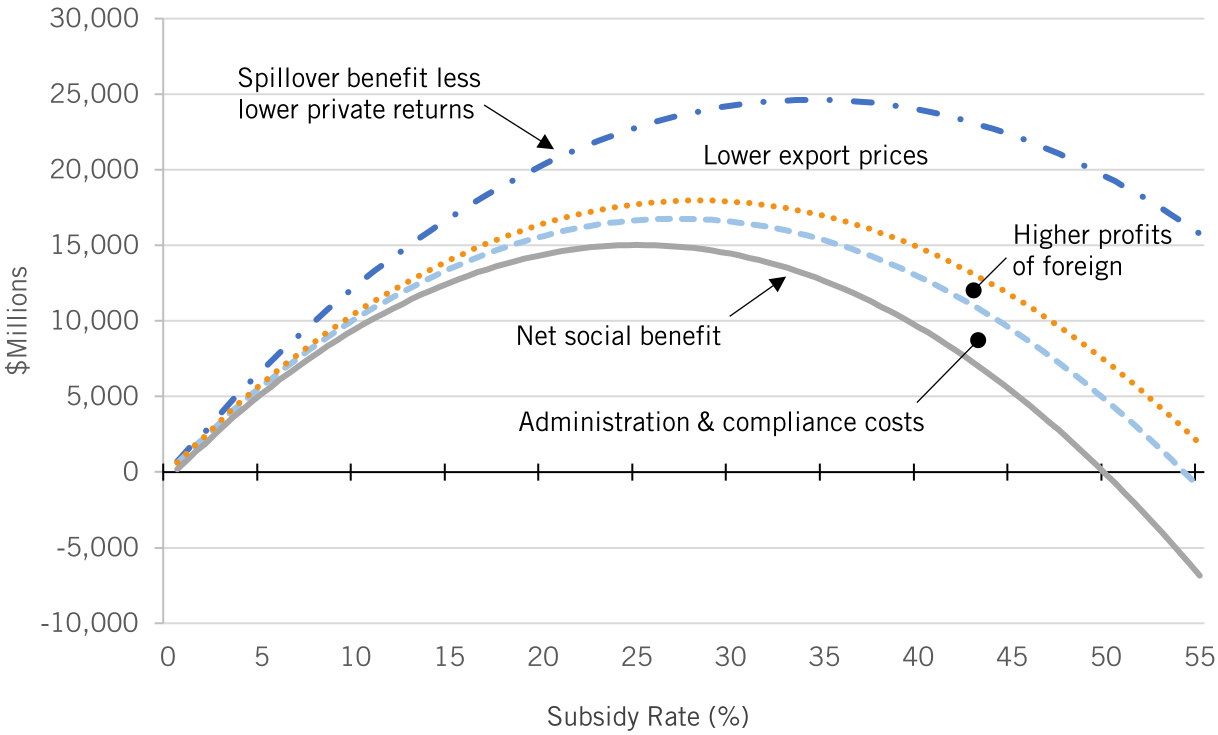
The federal changes to tax depreciation rules for R&D assets scheduled to come into effect in 2022 will reduce the federal R&D subsidy rate by 5 percentage points. The decrease will be 6.7 percentage points if state governments follow the federal lead. While it is theoretically possible to offset these impacts with increases in tax credits, there may be diminishing returns from rising credit rates. For example, very high credit rates give firms more of an incentive to classify ordinary expenditures as R&D, which, at a minimum, raises administration and compliance costs. As such, it would be better for Congress to repeal that provision of the 2017 law, while increasing the ASC and the RC credits to at least 30.5 percent and 43.5 percent respectively (see table 7). The American Innovation and Competitiveness Act of 2019 (H.R. 4549), introduced by Congressman John Larson (D-CT) with 31 cosponsors, would repeal that provision.[44]

It would be better for Congress to repeal elimination of expensing, while increasing the ASC and the RC credits to at least 30.5 percent and 43.5 percent respectively.

Achieving target subsidy rates using a variety of instruments could improve the benefit-cost ratio of making support for R&D more generous. In addition to continuing to allow current R&D expenses to be deducted in the year they are incurred, this could include modifying and enhancing the favorable tax treatment of income from intangible assets allowed under the Tax Cuts and Jobs Act. The reduction in the tax burden on commercialized R&D arising from the preferential tax treatment of FDII is roughly equivalent to providing a 1 percent subsidy for performing R&D (table 2). Expanding the favorable tax treatment to domestic sales would boost the R&D subsidy to about 3 percent. Such a policy change would make the measure more like a standard "innovation" or patent box. As discussed in Lester and Warda, innovation boxes can be a cost-effective policy initiative, provided the income taxed at a preferential rate is derived from domestically performed R&D.[45] With this link, or nexus, innovation boxes stimulate R&D while encouraging the retention in America of commercialization activity and the associated taxable income.

Expanding the favorable tax treatment of FDII to domestic sales would boost the R&D subsidy by about 2 percentage points. Such a policy change would make the measure more like a standard “innovation” or patent box.

Figure 2: Decomposition of the net social benefit of the alternative simplified credit



Box 2: Decomposition of the Net Benefit

Figure 2 shows how the net benefit and the contribution of various cost elements to the net benefit change as the subsidy rate rises. The top line in the chart shows the spillover benefit less the impact of lower private returns. It reflects the assumption that spillovers are a constant or falling share of the R&D induced by the subsidy while the cost of falling private returns to R&D becomes a larger share of the spillover benefit as the subsidy rate rises. If the spillover benefit and falling private returns were the only elements of the benefit-cost calculation, the net social benefit would be maximized by setting the subsidy rate equal to the spillover rate, which is 34 percent. However, transfers of the subsidy to foreigners also rise relative to the spillover benefit as the subsidy rate increases; this cuts the optimal effective subsidy rate to 26.5 percent. Administration and compliance costs initially fall relative to the spillover benefit as the subsidy rate rises due to fixed costs. However, variable administration and compliance costs rise with the subsidy rate and eventually dominate the fixed-cost component, causing the optimal subsidy rate to decline to 24.5 percent when all costs and benefits are considered.

CONCLUSION

U.S. tax support for R&D is low by international standards. A fiscally responsible target would be to increase the overall R&D subsidy rate to at least 15.5 percent from approximately 9.5 percent currently. Achieving this target would place the United States near the median level of support in a comparison group of countries consisting of all OECD countries with a population of more than four million, plus BRIC. More importantly, the increased support would provide a solid boost to the real income of Americans through its effects on competitiveness, innovation, and productivity. The target level of support should be achieved through changes to several instruments. Federal research credits should provide additional support through some combination of increases in statutory rates and changes to other program parameters that would boost their cost effectiveness. The tax preference for FDII should be restructured to become more like a standard innovation box that indirectly supports domestically performed R&D while encouraging the retention in America of commercialization activities and the associated taxable income. Finally, the legislated shift from expensing to five-year amortization of current R&D expenditures scheduled to take effect in 2022 should be reversed in order to avoid a sharp drop in support for R&D.

As the United States continues to compete with other nations, particularly China, for advanced technology leadership, and as innovation, particularly to fight climate change, continues to become more important, improving the tax system for R&D is a practical and important tool for the federal government to embrace.

ANNEX 1: STATE TAX CREDITS

Table 8: U.S. state tax credit summary, 2019

Follow federal credits (22 states); National R&D share: 63.0%
Research Credit (RC): Arizona, California, Delaware, Idaho, Minnesota, South Carolina, Utah Alternative Simplified Credit (ASC): Texas, Virginia, Wisconsin RC or ASC: Indiana, Iowa, Massachusetts, New Jersey, North Dakota, Rhode Island Percentage of federal research credit: Alaska, Hawaii, Nebraska, New Hampshire, New York, Vermont
Follow other incremental credit formulas (12 states); National R&D share: 18.4%
Arkansas, Colorado, Connecticut, Florida, Georgia, Illinois, Kansas, Louisiana, Maine, Maryland, Ohio, Pennsylvania
Provide level credits (2 states); National R&D share: 0.4%
Kentucky, New Mexico
Provide hybrid systems; incremental and level credits (counted above)
Connecticut, Maryland, Virginia
Provide intensity-based credits (counted above)
California (Alternative Incremental Credit), Georgia
Have no credits (14 states + D.C.); National R&D share: 18.2%
Alabama, D.C., Michigan, Mississippi, Missouri, Montana, Nevada, North Carolina, Oklahoma, Oregon, South Dakota, Tennessee, Washington, West Virginia, Wyoming
Have caps on credit benefits (11 states); National R&D share: 14.3%
Arkansas, Colorado, Florida, Hawaii, Kansas, Maryland, New Hampshire, North Dakota, New York, Pennsylvania, Virginia

Table 9: Summary of state-level R&D tax credits: 2019–2020

State	Regular credit statutory rate (%)	ASC-based statutory rate (%)	Combined effective credit rate on QRE (%)	Comments on tax credits
Follow federal RC and/or ASC (16 states); National R&D share: 57.8%				
Arizona	15.0		5.2	On first $2.5 million QRE 24%
California	15.0		2.2	Alternative Incremental Research Credit ranging from 1.48% to 2.48% included
Delaware	10.0		5.5	20% for SMEs
Idaho	5.0		1.7	
Indiana	10.0	10.0	5.8	15% on QRE <$1 million
Iowa	6.5	4.55	2.8	
Massachusetts	10.0	5.0	3.6	
Minnesota	2.5		1.8	10% on first $2 million QRE
New Jersey	10.0	10.0	5.4	
North Dakota	8.0	5.6	3.5	QRE: >100K 8% (ASC 5.6%), <100K 25% (ASC 17.5%); Maximum credit allowed $2million
Rhode Island	16.9	16.9	9.2	QRE: < 111.1K 22.5%
South Carolina	5.0		1.7	
Utah	5.0–7.5		2.5	Choice of 7.5%% credit with no carryover or 5% credit with carryover for 14 years
Texas		5.0	2.8	
Virginia				
Refundable credit		10.0	0.2-0.5	Refundable R&D Credit (10% ASC or 15% volume; Max QRE $300K); State budget cap $7 million
Major R&D credit		10.0		Major R&D Credit; State budget cap $20 million
Wisconsin		5.75	3.3	
Provide state credit as a percentage of federal research credit (6 states); National R&D share: 5.2%				
Alaska	18.0		1.6	On all federal credits, including research credit
Hawaii	100.0		0.4	State budget cap $5 million
Nebraska	15.0		1.3	
New Hampshire	10.0		0.6	On wages portion; Maximum $50K/firm; State budget cap $7 million/year
New York	50.0		4.3	Up to 6% of QRE; business must create min. 5 jobs
Vermont	27.0		2.3	

State-defined credit formulas (14 states); National R&D share: 18.8%

	Incremental	Volume	Combined Effective Rate	
Arkansas	20.0		0.01	Up to $10K/year per business
Colorado	3.0		0.3	Prorated in 25% installments over 4 yrs.

State	Regular credit statutory rate (%)	ASC-based statutory rate (%)	Combined effective credit rate on QRE (%)	Comments on tax credits
Connecticut	20.0	1.0–6.0	9.0	Volume credit on current spending less incremental at the following rates: QRE >$200M 6%, $100–200M 4%, $50–100M 2%,<$50m 1%
Florida	10.0		0.2	Subject to state budget cap of $9 million
Georgia	10.0		10.0	The base is [QRE - (average R&D intensity prior 3 years)*(current year sales)]
Illinois	6.5		0.9	
Kansas	6.5		0.6	Prorated in 25% installments over 4 yrs.
Kentucky		5.0	0.01	On R&D capital equipment and facilities
Louisiana	5.0		1.6	30% (<50 employees), 10% (50–99 employees), 5% (>100 employees)
Maine	5.0		0.7	
Maryland	10.0		0.5	The base is the lower of current QRE and average QRE in the previous 4 years. State budget cap $6.5 million
New Mexico		5.0	7.7	Base covers all R&D spending
Ohio	7.0		1.0	
Pennsylvania	10.0		0.6	State budget $55 million/year, of which 20% is for SMEs
Have no credits (14 states + D.C.); National R&D share: 18.2%				
Alabama, D.C., Michigan, Mississippi, Missouri, Montana, Nevada, North Carolina, Oklahoma, Oregon, South Dakota, Tennessee, Washington, West Virginia, Wyoming				
Have caps on credit benefits (11 states); National R&D share: 14.3%				
Arkansas, Colorado, Florida, Hawaii, Kansas, Maryland, New Hampshire, North Dakota, New York, Pennsylvania, Virginia				

Sources: State government websites, state tax credit forms and instructions, and various accounting organizations.

ANNEX 2: INTERNATIONAL COMPARISON OF TAX SUPPORT FOR R&D

Results From the User Cost and B-Index Frameworks

Table 10: Tax support for investment in R&D (percentage of the pretax user cost of capital)

		User Cost Framework			B-Index	
Rank[1]	Country	Income & Expenditure-Based Measures	Expenditure-Based Measures Only	Income-Based Measures Contribution	Subsidy rate	Gap With Expenditure-Based Measures
1	Chile	34.8	34.8	0.0	34.4	0.4
2	Portugal	32.5	32.6	-0.1	32.4	0.2
3	France	31.7	31.9	-0.2	30.8	1.0
4	Spain	29.7	26.3	3.4	25.3	1.0
5	Ireland	29.5	28.4	1.1	28.6	-0.2
6	Brazil	29.1	29.1	0.0	27.3	1.7
7	Slovak Republic	27.9	28.4	-0.5	27.8	0.6
8	China	25.8	25.8	0.0	24.6	1.1
9	Poland	24.9	22.1	2.8	21.3	0.8
10	Czech Rep.	22.1	22.1	0.0	21.3	0.8
11	Hungary	21.5	20.8	0.8	22.0	-1.3
12	Norway	20.9	20.9	0.0	19.5	1.4
13	New Zealand	20.5	20.5	0.0	18.9	1.6
14	Belgium	19.7	13.8	5.9	11.2	2.5
15	Netherlands	19.5	15.5	4.0	13.6	1.9
16	Canada	19.1	19.1	0.0	17.3	1.8
17	Austria	16.6	16.6	0.0	14.9	1.7
18	Japan	14.8	14.8	0.0	12.5	2.3
19	Russian Federation	13.1	13.1	0.0	11.6	1.5
20	United Kingdom	11.6	10.1	1.5	8.5	1.6
21	Greece	11.2	10.2	1.0	7.6	2.6
22	Turkey	11.0	6.5	4.5	4.3	2.2
23	Switzerland	10.4	10.2	0.2	8.4	1.8
24	United States	9.5	8.6	0.9	6.1	2.5
25	Australia	9.3	9.3	0.0	6.4	2.9
26	India	8.2	2.8	5.4	-1.2	4.0
27	Italy	5.8	2.4	3.5	-0.8	3.2
28	Sweden	6.4	6.4	0.0	4.2	2.1
29	Germany	4.8	4.8	0.0	1.6	3.2
30	Korea	4.3	4.3	0.0	1.3	3.0
31	Mexico	3.5	3.5	0.0	0.2	3.4
32	Denmark	3.3	3.3	0.0	0.8	2.4
33	Finland	1.7	1.7	0.0	-0.6	2.3
34	Israel	1.6	1.6	0.0	0.6	1.0
	Median	15.7	14.3	0.0	12.1	1.8
	Median ex. U.S.	16.6	14.8	0.0	12.5	1.7
	Mean	16.4	15.4	1.0	13.6	1.7

[1] Based on user cost estimates including both expenditure and income-based measures.

ANNEX 3: SUMMARY COMPARISON OF R&D TAX INCENTIVES

Table 11: R&D expenditure-based tax incentives, 2020 or latest

Country	Tax credit rate (%) Volume	Tax credit rate (%) Incremental	Super-deduction rate (%)	Payroll tax credits (%)	Comments
Group of Seven					
Canada (federal)	15 (small firms 35)				Small firms: on first CAD 3 million spending
France	5-30				Spending cap for 30 percent credit: 100 million euro
Germany	25				Spending cap 2 million euro
Italy		25			Credit cap: 10 million euro
Japan	6–10 (small firms 12)				
United Kingdom	12		130 (small firms)		Small firm super deduction cap: 7.5 million pounds
United States (federal)		20 (RC) 14 (ASC)			The Regular Credit is based on increases in R&D intensity. The Alternative Simplified Credit is based on increases in spending.
Group of BRIC					
Brazil			160		
China			175		
Russian Fed.			150		
India					150 percent deduction ceased in 2020
Other OECD economies (with populations over 4 million)					
Australia	38.5 (small firms 43.5)				Spending cap for large firms: AUD 100 million; For small firms: AUD 20 million in sales
Austria	14				
Belgium	3.99 (capital expenditures)			80	
Chile	35				Spending cap: USD 1 million
Czech Rep.			200		
Denmark			103		
Finland					No tax incentives
Greece			130		
Hungary			200	20	

Country	Tax credit rate (%)		Super-deduction rate (%)	Payroll tax credits (%)	Comments
	Volume	Incremental			
Ireland	25				
Israel					No tax incentives
Mexico	30				Credit cap: MXN 50 million
Norway	18 (small firms 20)				Spending cap: 25 million kroner
Netherlands				16	32 percent on first 350K euro
New Zealand	15				Spending cap: NZD 120 million
Poland			200		
Portugal	32.5	50			Cap only on incremental spending: 1.5 million euro
South Korea	3 (small firms 25)	25 (small firms 50)			
Slovak Rep.			200		Super-deduction with incremental part
Spain	25 (current), 42 (R&D Wages), 8 (technology)	42			Credit cap: 25–50 percent of corporate income tax
Sweden				10	Credit cap: SEK 2.76 million
Switzerland			150		On wages and contracts
Turkey			150 (incremental)	50	

Sources: OECD Compendium of Information on R&D Tax Incentives, 2019, located at http://oe.cd/rdtax; Deloitte, 2018 Survey of Global Investment and Innovation Incentives, located at https://www2.deloitte.com/global/en/pages/tax/articles/global-investment-and-innovation-incentives-survey.html; PriceWaterhouseCoopers, Worldwide Tax Summaries located at https://www.pwc.com/gx/en/services/tax/worldwide-tax-summaries.html; other tax accounting sources; government websites; and Google Alerts on R&D Tax Incentives.

ANNEX 4: INCOME-BASED TAX INCENTIVES FOR R&D IN THE COMPARISON GROUP OF COUNTRIES

In addition to expenditure-based measures, 16 countries in our comparison group provide preferential tax treatment for the income resulting from commercialization of R&D and other innovative activities.[46] China and Israel also provide income-based incentives, but these measures only cover income generated from the transfer or sale of assets, and are not modelled in this paper. All these countries have endorsed the OECD recommendation that there be a link or a "nexus" between the income taxed at a preferential tax rate and the expenditures undertaken to generate that income.[47] Endorsement implies income-based tax incentives introduced after mid-2016 will respect the nexus requirement, and existing regimes will be modified to be consistent with it by mid-2021. As of July 2020, patent boxes in four countries—India, Greece, Turkey, and the United States—are not consistent with the modified nexus approach.

When there is a link between the income taxed at a preferential rate and the expenditures undertaken to generate the income, these preferential tax measures indirectly subsidize R&D. To calculate the subsidy, we modified the user cost framework in two ways.[48] First, we included a lag between performing R&D and the realization of revenue, assuming a gestation lag of two years. Second, we adjusted the user cost calculation to allow the net income generated by the R&D to be taxed at the preferential rate and expenses to be deducted, on a present value basis, at the preferential rate. Expenses include those incurred during the commercialization phase and the R&D development costs.

However, not all countries implementing income-based incentives treat income and expenses symmetrically. Under the modified nexus approach, the preferential rate must be applied to net income, which means expenses incurred during the commercialization phase are effectively deducted at the incentive rate. The modified nexus approach does not specify which expenditures should be deducted from eligible income, stating only that allocated expenditures should be determined by applying ordinary domestic tax law provisions.[49] As a result, 11 of the 16 countries allow R&D expenses to be deducted at the regular rate, and the other 5 make adjustments to ensure these expenses are deducted at the incentive rate. Five countries do not require interest expense to be deducted when calculating net income eligible for the incentive.

The implications of symmetric and asymmetric treatment of income and expenses are illustrated in table 12.[50] In the example, a completely symmetric approach to taxing income and expenses during the commercialization phase results in a lower subsidy rate. This outcome reflects the well-known result that if tax depreciation exceeds economic depreciation by a wide enough margin, a tax reduction increases the effective tax rate on capital, which reduces the subsidy measure used in this study. Note that the impact on the subsidy rate rises with the level of the regular and incentive tax rates, thereby keeping the gap constant. The table also shows that a longer gestation lag reduces the impact of income-based incentives on the subsidy rate. As the commercialization phase gets pushed further into the future, the present value of lower taxes on net income from the R&D becomes smaller.

Table 12: Change in the subsidy rate arising from favorable tax treatment of income from intellectual property (percentage points)

	Corporate Income Tax Rates (Regular / Preferred)		
	25/15	35/25	25/05
Symmetric application[1]	-0.6	-0.7	-1.2
Asymmetric application[2]			
Interest	0.8	1.3	1.5
Interest and past R&D	4.0	5.3	7.2
Four-year gestation lag[3]	3.4	4.5	6.1

1. Past R&D costs and current expenses incurred in the commercialization phase are effectively deducted at the incentive tax rate.
2. Expenses incurred in the commercialization phase are effectively deducted at the regular tax rate.
3. A two-year gestation lag is assumed in all other cases.

Country Summaries

Table 13 presents the key features of income-based tax incentives in the international comparison group relevant to assessing how these incentives affect the decision to perform and commercialize R&D in the implementing jurisdiction. The table shows the subsidy rate on the R&D that can be linked to the income taxed at a preferential rate ("eligible" R&D), the share of eligible R&D in total R&D, and the subsidy rate on overall R&D.

The subsidy rate on eligible R&D depends on the gap between the regular and incentive rates, and on the treatment of expenses. The highest rates are in Belgium and India, which have large gaps between the regular and incentive rates. These two countries also allow all (India) or some (Belgium) expenses to be deducted at the regular rate. Turkey, the Netherlands, Italy, and Spain allow past R&D expenses to be deducted at the regular rate; this feature, along with a substantial gap between the regular and incentive tax rates, keeps the subsidy rate on eligible R&D above the median of 3.3 percent. The subsidy rates in Portugal, France, and the Slovak Republic are negative. These three countries require expenses, including R&D, to be deducted at the incentive rate. This requirement reduces the subsidy rate in the Slovak Republic and Portugal by about 3.5 percentage points; the impact in France is 7.4 percentage points. Switzerland requires R&D costs to be deducted at the incentive rate as well, but interest expense can be deducted at the regular rate, which keeps the subsidy rate above zero.

We converted the subsidy rates on eligible R&D to rates on all R&D using illustrative shares of eligible intellectual property (IP) assets to total IP assets that have been developed by performing R&D. Eligible assets in the countries providing income-based incentives range from narrowly defined patents (India and Greece) to all IP assets developed from domestically performed R&D (Turkey). However, most countries are aligned with the eligible assets set out in the OECD's modified nexus framework. The framework has two categories of assets owned by large firms that are eligible for preferential treatment. The first category consists of patents and other assets that are functionally equivalent to patents, because they are legally protected and subject to similar approval and registration processes. Assets functionally equivalent to patents include utility models and supplementary protection certificates. The second category consists of copyrighted software.

A review of the literature in an earlier paper concluded that the average share of inventions patented is 42 percent.[51] We use this share when eligible assets consist of narrowly defined patents. When eligible assets consist of the OECD's category 1 assets, we use a 63 percent share, which is 1.5 times the average propensity to patent. When eligible assets consist of the OECD's category 1 and 2, we use a 74 percent share, which is 1.75 times the average propensity to patent. We emphasize that there is no empirical evidence on the relationship between eligible assets and the share of total R&D that is used to develop these assets; the shares used are illustrative.

India, the United Kingdom, and Greece have the narrowest definition of eligible assets, and Turkey the highest. Nine of the sixteen countries use the OECD's category 1 and 2 to define eligible assets, although two countries—France, and Spain—do not allow firms to include "embedded" royalties in eligible income. Embedded income arises when IP qualifying for the incentive is used internally to produce products or provide services. Its value is generally determined through application of arm's-length transfer-pricing principles to calculate the income that would have been received by licensing the IP. This restriction limits the share of eligible R&D in total R&D by an unknown amount. The United States is a special case in that while there are no restrictions on the type of IP assets eligible for the incentive, only income that can be attributed to export sales is eligible for the incentive. We estimate that 24 percent of commercialized R&D products are exported. Using these illustrative shares, overall subsidy rates range from 5.9 percent to -0.5 percent, with a median value of 1.3 percent.

Table 13: Income-based tax incentives for R&D in 2020—large firms

	Corporate Income Tax Rate (%)				R&D Coverage (%)	Tax Rate Applied to Expenses			Implicit Subsidy Rate on R&D	
	Regular	Incentive	Gap	Eligible Assets[1]		Interest	Other Current	Past R&D	"Eligible" R&D	All R&D
Belgium	29.58	4.4	25.1	Broadly defined patents, copyrighted software	74	Incentive	Incentive	Regular	7.4%	5.9%
India	34.61	11.2	23.4	Patents[2]	42	Regular	Regular	Regular	10.8%	5.4%
Turkey	22	10	12.0	Inventions (inc. software) developed from R&D	100	Incentive	Incentive	Regular	4.5%	4.5%
Netherlands	25	7	18.0	Broadly defined patents, copyrighted software	74	Incentive	Incentive	Regular	5.1%	4.0%
Italy	27.81	13.91[3]	13.9	Broadly defined patents, copyrighted software	74	Incentive	Incentive	Regular	4.5%	3.5%
Spain	25	10	15.0	Broadly defined patents,[2] copyrighted software	74	Incentive	Incentive	Regular	4.4%	3.4%
Poland	19	5	14.0	Broadly defined patents, copyrighted software	74	Incentive	Incentive	Regular	3.6%	2.8%
U.K.	19	10	9.0	Patents, medicinal and botanic innovation rights	42	Regular	Incentive	Regular	3.3%	1.5%
Ireland	12.5	6.25	6.3	Broadly defined patents, copyrighted software	74	Incentive	Incentive	Regular	1.5%	1.1%
Greece	28	0[4]	28.0	Internationally recognized patents	42	Regular	Regular	Regular	2.0%	1.0%
United States	25.76	17.94	7.8	Intangible assets used to generate export income	24	Regular	Regular	Regular	3.4%	0.9%
Hungary	9	4.5	4.5	Broadly defined patents, copyrighted software	74	Incentive	Incentive	Regular	1.0%	0.8%
Switzerland	21.15	11.05	10.1	Broadly defined patents	63	Regular	Incentive	Incentive	0.4%	0.2%
Portugal	22.5	11.25	11.3	Broadly defined patents, copyrighted software	74	Incentive	Incentive	Incentive	-0.2%	-0.1%
France	32.02	10	22.0	Broadly defined patents,[2] copyrighted software	74	Incentive	Incentive	Incentive	-0.2%	-0.2%
Slovak Rep.	21	10.5	10.5	Broadly defined patents, copyrighted software	74	Incentive	Incentive	Incentive	-0.6%	-0.5%
Israel	23	6	17.0	Assets sold to foreign-controlled corporations	?			Not modelled		
China	25	12.5	12.5	Transfers by technology and software firms	?			Not modelled		
Median									3.3%	1.3%

General note: Broadly defined patents are consistent with Category 1 assets described in the OECD modified nexus approach; category 2 consists of copyrighted software.
1. Eligible income from assets includes embedded royalties unless otherwise noted.
2. Excludes embedded royalties.
3. Tax exempt for three years only.
4. Minimum rate, which applies for a maximum of five years.
Sources: Reports from the Council of the European Union, Code of Conduct Group, Business Taxation (http//data.consilium.europa.eu/doc/document); Deloitte 2018 Survey of Global Investment and Innovation Incentives; correspondence with Deloitte representatives in Greece, Hungary, India, Italy, and Turkey; and correspondence with government officials in the Netherlands.

ANNEX 5: THE BENEFIT-COST METHODOLOGY

The benefits of subsidizing R&D

As discussed in the text, R&D subsidies are good public policy because they correct a market failure. R&D benefits the performing firm but, some of the knowledge created becomes available to other firms. When deciding on how much R&D to perform, firms do not consider the spillover benefits received by other firms, so investment in R&D is too low from society's perspective: The social benefit of an increase in R&D exceeds the social cost of performing the R&D. The social benefit or social return to R&D consists of the return to the performing firms—the private return—and the spillover benefit. The social cost of performing R&D consists of the private costs incurred to perform it and the loss in output arising from R&D-induced competition in the market place, which is often described as the business-stealing effect. In this limited context, the net social benefit is therefore the spillover benefit less the business-stealing effect. The two components of the net benefit are not separately identified in the benefit-cost analysis. Although the social benefits accrue to firms in the United States and abroad, the benefit-cost analysis focuses on the net benefit received in the United States, which bears the fiscal cost of supporting R&D performed in the country.

Estimates of the social rate of return and its two components are typically obtained through regression analysis of a production function, which relates real output to conventional inputs (labor and tangible capital), R&D capital, and what is often described as the spillover pool. The spillover pool is the knowledge that is available to firms through the R&D performed by other firms.

The spillover benefit used in the benefit-cost analysis is therefore the change in aggregate output per dollar increase in the R&D spillover pool. Since the level of conventional inputs is held constant, the spillover benefit can be described as an increase in productivity. This may strike some as an incomplete measure since the spillover benefit allows firms to improve existing products and introduce new products, as well as reduce production costs.

However, if prices are correctly measured, the change in real output captures the complete spillover benefit. The return to bringing a new product to market is shared by the producer, who gets extra revenue, and consumers, who on average value the product at more than the selling price. Quality-adjusted consumer prices fall when improvements are made to existing products and new products are introduced, which results in higher real output. While it is common practice to adjust prices for quality changes and the introduction of new products, an upward bias remains in existing price indexes.[52] Imperfect quality adjustment of consumer prices causes the spillover estimates to be biased down by an unknown amount.

The benefit-cost analysis also incorporates the assumption that, in the absence of externalities, markets allocate resources as efficiently as possible. As a result, the partial effect—that is, abstracting from spillovers—of shifting resources into the R&D-performing sector is to reduce efficiency. The loss in efficiency can be illustrated by the reduction in the private rate of return to R&D that occurs because of the subsidy. In the benefit-cost analysis, it is calculated as the loss in producer surplus calculated using a simple version of the Harberger Triangle methodology.[53]

Box 3: On Industrial Policy

In standard economic theory, markets allocate resources as efficiently as possible. As a result, policies designed to shift resources from one sector to another harm rather than help economic performance. Advocates of industrial policy counter that productivity varies by sector so real income gains are possible by using subsidies to shift resources across sectors. While it is not always explicit, the assumption is total factor productivity varies by sector, which implies that rents are being earned in some sectors. An important point is high wages or high returns to capital do not necessarily mean rents are being earned. High wages may reflect skill differences, and high profits may include a return to risk. Identifying and quantifying rents (wage premiums or above-normal returns to capital) requires careful examination of the data.

The starting point for much of the analysis in this area is the generally accepted empirical finding of large and persistent productivity differentials between observably similar firms in the same industry. Researchers then attempt to determine whether wages are affected by these productivity differences. There are two strands to the empirical literature.[54] The first examines the relationship between firm-level productivity and wage rates. This literature generally finds that, after controlling for worker characteristics and industry-wide productivity shocks, firm-level productivity affects wage rates. The second strand examines what happens to wages when workers change jobs. In a perfectly competitive labor market, workers would be paid the value of their (fixed) marginal product by all employers. This literature finds that wages for the same employee vary across firms, which adds to the evidence suggesting labor markets are imperfectly competitive.

Card et al. found evidence that high-productivity firms hire more productive workers and pay wage premiums to all workers. Industry-level wage premiums could therefore be observed if the distribution of high-productivity firms varies by industry. Card et al. did not advocate the use of industrial policy based on their findings. They have reservations about both the model they used—described as a simple static wage setting model—and the empirics, particularly the ability to isolate exogenous changes in productivity. The authors state that more evidence is required on how such policies affect firm and worker behavior before a recommendation on pursuing industrial policy can be made.

Assuming wage premiums are identified and quantified in R&D-intensive industries, what would be the appropriate policy response? Given that sectoral differences in wages may be driven by firm-level developments, a broad-based ITC is unlikely to be the optimal policy response. Syverson discussed the sources of firm-level differences in productivity.[55] The factors identified are directly or indirectly related to the quality of management, so policies that “level up” management skills should be considered. Policies that effectively discourage entry (or encourage exit) of low productivity firms should also be considered. If high wages are compensation for skill differences, the appropriate policy response could be to increase the subsidy for the acquisition of the skills required in the R&D intensive sector.

The assumption that markets are allocating resources efficiently rules out an additional benefit sometimes claimed for subsidies: The targeted sector is characterized by above-average productivity such that shifting resources into it raises overall productivity, and hence income. However, evidence is accumulating that wages for equally skilled workers differ by firm and industry, which is inconsistent with the competitive model (see box 3). In principle, this finding supports the use of an industrial policy to favor high-wage industries. In practice, wage premiums—payments in excess of a worker's opportunity cost—are difficult to identify and quantify. Depending on the circumstances, high wages may include a premium, or may exactly compensate workers for additional skills obtained through investment in human capital.

We do not know enough about R&D-intensive industries to determine whether wage premiums provide an additional benefit from subsidizing R&D. Further, even if it could be demonstrated that a wage premium exists in the R&D-intensive sector, the case for subsidizing R&D is independent of the industrial policy argument. If government support for R&D-intensive industries succeeded in eliminating a wage premium, the amount of R&D performed would still be too low from society's perspective because of knowledge spillovers. As a result, a subsidy would continue to be appropriate.[56] In addition, optimal correction of two market failures is likely to require two separate instruments that target the source of each failure. The two policy measures should therefore be assessed separately.

A similar issue arises when considering that firms appear to underinvest in R&D, particularly in basic and applied research, relative to what would be rational for them due to pressures from equity markets for short-term results. This market failure should be addressed with a separate instrument independently of knowledge spillovers.

Another potential benefit of subsidizing R&D is increased scale economies. Given the assumed price elasticity of -1.05, R&D spending is about 5.5 percent higher because of the federal tax credits. This rise consists of increases on the intensive and extensive margins, so the overall rise overstates the potential for increases in scale. We did not find any information in the literature that would help determine how the increase should be split between old and new performers. Further, a literature search did not turn up any scale-elasticity estimates for R&D, so quantifying the impact would be difficult.

Modelling Framework

The benefit-cost analysis is implicitly undertaken in the context of full employment. Expansion of the R&D sector is accompanied by a contraction in other sectors. While the economy may have under-utilized resources when a subsidy is introduced or when it is increased, a permanent subsidy should be evaluated assuming average economic conditions, and should incorporate the assumption that the resources used to perform additional R&D were contributing to output in other sectors of the economy.

We perform the benefit-cost analysis assuming that the benefits and costs can be calculated independently of each other, and the interactions of the subsidy with the overall economy are largely in one direction: from the R&D-performing sector to the economy. The alternative is to embed the benefit-cost analysis in a complete model of the economy. The "partial-equilibrium" model used in this study is the most common approach in the literature.[57] It has the advantage of simplicity, but some second-round impacts will not be captured. For example, R&D subsidies result in lower prices for R&D-intensive products, which increases demand by domestic and foreign consumers. The increased demand improves the trade balance, which puts upward pressure on the exchange rate. The resulting improvement in the terms of trade raises the real income of Americans. However, the subsidy has a small impact on exports of R&D-intensive products: An illustrative calculation suggests overall exports are about 1 percent higher as a result of the subsidy.[58]

In some benefit-cost analyses, social benefits and costs are presented on a gross basis.[59] That is, the subsidy-induced increase in output in the R&D sector is shown as a benefit, and the reduction in output caused by higher taxes or lower government spending required to finance the subsidy is shown as a social cost.[60] In this study, we present the net effect only, which is negative given the assumption that abstracting from spillovers, resources are being allocated efficiently.

Although not all the benefits and costs are explicitly adjusted for differences in timing, the net benefit can be interpreted as an annual accrued amount in response to an annual subsidy. Administration expenses, compliance costs, and resource misallocation costs occur annually in response to the subsidy. Although knowledge spillovers occur over time, with certain assumptions, the spillover rate, which is the rate of return on the spillover pool, can be interpreted as an annual rate of return on R&D.[61]

Current spending on R&D also gives rise over time to products and services that are sold by the firms performing the R&D. In this case, however, the delay in commercializing R&D has to be explicitly recognized. Based on a U.S. survey by the National Science Foundation (NSF) and other agencies, we assume the average lag between performing R&D and realizing revenue from the investment is two years.[62] We apply a three-year lag to the generation of profits.

Key Assumptions

Spillovers

There is a rich empirical literature on the returns to R&D covering both the rate of return to the firm performing the R&D and the spillover benefits to other firms. Researchers typically estimate the parameters of a production or cost function that includes the owned stock of R&D, tangible capital, and labor as inputs along with some measure of R&D that is external to the firm as an additional factor affecting output. A positive coefficient on the stock of external R&D, or the spillover pool, indicates that firms benefit from the knowledge created by other firms.

Hall, Mairesse, and Mohnen presented a comprehensive review of the literature on estimating the returns to R&D.[63] They reported 22 estimates of the rate of return on the spillover pool. Kim and Lester found six studies prepared after the survey by Hall, Mairesse, and Mohnen in which spillover rates were reported or could be calculated.[64] Including the Kim-Lester results, the median spillover rate for the 29 estimates is 29 percent, which implies a dollar spent on R&D by 1 firm reduces costs of other firms by 29 cents. There are 11 spillover estimates for the United States; the median spillover rate for these estimates is 34 percent.

Three recent studies of U.S. spillovers are of interest, for several reasons. First, the eight earlier studies are based on datasets that ended in the 1970s (seven studies) or the 1980s (one study). The recent studies use datasets that end in the mid-2010s, allowing them to capture any changes in the structure of the economy that occurred over time.[65] Second, and more importantly, there have been advances in econometric techniques and methods of calculating the spillover pool that make the recent estimates more credible. In the recent studies, each firm's spillover pool is calculated using weights that reflect the technological similarity of R&D performed by other firms.[66]

Third, none of the earlier studies capture the negative product market rivalry effect—they measure the positive knowledge spillovers only, so there is some concern that empirical estimates of spillovers are overstated. The study by Bloom, Schankerman, and Van Reenen—henceforth BSVR—and a more recent one by Lucking, Bloom and Van Reenen—henceforth LBVR—provide convincing evidence that the spillover benefit remains positive when product market rivalry effects are included in the analysis. The two studies, which apply the same methodology to different samples of U.S. firms, find net spillover rates of 34 percent and 44 percent, respectively. Product market rivalry effects reduce the knowledge spillover rate by about 10 percentage points in both studies. These spillover rates are much higher than the rates obtained in the 8 earlier studies, where the median spillover rate is 12.5 percent.

A third recent study of U.S. spillovers prepared by Arqué-Castells and Spulber—henceforth ACS—investigates the role of market transactions in IP, such as licensing, on spillovers.[67] Their concern is that purchases of IP are not appropriately captured in most datasets used to investigate spillovers, which could lead to knowledge spillovers being overstated. In the context of estimating a production function, this would occur if market transactions in technology increase profits of the purchaser, and the market transactions are correlated with the spillover pool. ACS obtain a spillover rate of 72 percent when market transactions in IP are excluded, but this estimate falls to 44 percent when they are included. However, the lower rate should be considered illustrative rather than definitive given the quality of the data on market transactions (see box 4).

Box 4: Assessing Recent Spillover Studies

ACS found that expanding the analysis of spillovers to include market transactions in IP has a large impact on the spillover rate. Taken at face value, their analysis suggests the estimates by BSVR and LBVR are overstated by almost 30 percentage points. However, the results presented by ACS should be considered illustrative rather than definitive given the quality of the data on market transactions. These transactions are not fully reported in the financial statements of firms. Some firms report royalty transactions, but the value of cross-licensing and R&D alliances is reported on a net basis, if at all.[68] As a result, the authors gathered information on market transaction in IP between firms and developed estimates of how these transactions affect sales revenue. While the authors demonstrated that market transactions in IP can affect the size of knowledge spillovers, quantifying its impact is a work in progress.[69]

The large gap—28 percentage points—in the standard spillover estimate obtained by ACS and LBVR is surprising given they used similar methodologies, particularly for calculating the spillover pool, and worked with similar sample periods. There are, however, two important differences in the studies. First, LBVR (and BSVR) included product market rivalry effects, which reduces the reported spillover rate by 10 percentage points. Second, the ACS sample consisted of a smaller number of firms that are substantially larger than the LBVR sample. BSVR demonstrated that spillovers increase with firm size. Their explanation is that smaller firms operate in "technological niches" that limit the value of their R&D to other firms.[70] The spillover rate in BSVR rises from 27 percent for firms in the first quartile to 46 percent in the top quartile. The index of technological similarity rises by 90 percent over the same range. The overall technological similarity index in ACS is 80 percent higher than in BSVR, so there is plenty of scope for firm-size differences to contribute to the gap in spillover rates.

None of the recent studies provides a complete analysis of spillovers. The ACS estimate of "pure" knowledge spillovers (72 percent) is too high because it excludes product market rivalry effects, and the sample may not be representative of all R&D performers (see box 4). On the other hand, all three estimates should be reduced by an unknown amount to capture the impact of market transactions in IP. As a result, we use the lowest of the 3 estimates—34 percent—from the BSVR study, in the base case analysis.

The Responsiveness of R&D to Subsidies

The amount of additional R&D induced by the tax credits is a key element of the benefit-cost analysis: The net benefit rises with the responsiveness of R&D to a subsidy, provided the subsidy rate is not above the optimal rate.[71] Studies examining the response to tax credits typically examine the relationship between the percentage change in the price of R&D arising from the subsidy and the percentage change in the amount of R&D performed—the price elasticity of R&D. The increase in R&D arises primarily from additional investment by domestic and foreign firms located in the jurisdiction implementing the subsidy but may also reflect investment by foreign firms that set up new facilities in the implementing jurisdiction.

Unitary price elasticity means the price and amount of R&D performed change by the same percentage. This relationship implies the amount of R&D induced by a small change in the tax credit is equal to the amount of additional tax revenue forgone—that is, self-financed private R&D spending does not change. A price elasticity of less than 1 (in absolute value) indicates crowding out of private spending, while a price elasticity greater than 1 indicates crowding in of private spending on the margin.

A survey of the literature by Lester turned up 31 studies prepared since 1993 with price elasticity estimates for all firms or for large firms.[72] The median value of these estimated elasticities is -1.05. Seven of the studies provide estimates for the United States; the median value of these estimates is -1.40. However, none of these estimates make use of data from the 2000s. The median value of the 6 estimates using data from the 2000s is -0.83; countries covered are France, the United Kingdom, and various groupings of OECD countries, including the United States, in panel data estimation. In the base case analysis, we use -1.05 as the price elasticity of demand for R&D.

Transfer of the Subsidy to Foreigners

The benefit-cost analysis calculates the net benefit accruing to Americans, who absorb the fiscal cost of the subsidy through higher taxes and lower government services. If the subsidy payments are received, directly or indirectly, by other Americans, the subsidy has no first-round impact on incomes. However, if some of the subsidy is received by foreigners, the income of Americans is reduced. This could occur through export sales of products and services developed using subsidized R&D through subsidy-induced profits accruing to foreign-owned firms. While these are important elements of the benefit-cost analysis, limited information on their determinants means their estimated costs should be considered illustrative.

Terms of Trade Effects

The R&D subsidy reduces costs, but unless producers can sell as much of their output as they want without affecting prices—unless the demand curve is horizontal—some of the subsidy will be passed through to purchasers in the form of lower prices. To the extent R&D-intensive products are exported, some of the subsidy will be transferred to foreigners, thereby reducing real income in America. How much of the subsidy is transferred depends on the amount of additional R&D induced by the subsidy, the success rate in commercializing R&D projects, the export share of sales, and how much prices have to fall in order to sell the additional commercialized products.

Lee and Markham reported a commercialization rate of approximately 68 percent for R&D spending on product development by North American firms—for each dollar spent on R&D, 68 cents support the development of a product or service brought to market.[73] We assume that this commercialization ratio applies to all R&D spending. The rate is higher for large firms—73 percent—which is more relevant for the U.S. market. Data available from NSF indicates the export intensity of R&D performers was approximately 24 percent in 2016.[74]

How much prices must fall in order to sell the additional R&D-intensive products—the percentage of the subsidy that is passed through to prices—depends on the responsiveness of demand and supply to changes in prices, and on the degree of competition in the market. There is no direct information on the demand and supply responsiveness, or the elasticity, of R&D-intensive products to price changes.[75] The empirical literature on international trade indicates imports of similar but not identical products, which is relevant when considering R&D-intensive products, are sensitive to prices, but not so sensitive that firms have no pricing power.[76] Romalis found supply elasticities of North American traded goods that are in the same range as the import demand elasticities.[77]

Based on this incomplete evidence, we assume in the base case analysis that the demand and supply elasticities for R&D-intensive products are roughly equal. If the market for R&D-intensive products consisted of many firms selling identical products—if the market were perfectly competitive—this assumption would mean half of the subsidy is passed through to prices.[78] However, as suggested in the preceding paragraph, the firms producing R&D-intensive products have some power to set prices because they sell similar but not identical products. As a result, the pass-through percentage will be less than in a perfectly competitive market. How much less depends on the degree of market power firms have and how the demand elasticity varies with the quantity sold. For example, using the methodology set out by Weyl and Fabinger, the pass-through is 36 percent for a monopolist selling in a market wherein demand and supply elasticities are equal, and the elasticity of demand is constant.[79] If there are enough sellers to reduce firm market power to half that of a monopolist, the pass-through rises to 42 percent, the midpoint of the response under perfect competition and monopoly.

We use the 42 percent pass-through in the base case analysis. Combined with the commercialization rate and the export share of R&D-intensive products, about 7 percent of the subsidy is passed through to foreigners via lower export prices. After discounting to account for the delay in commercializing R&D, the pass-through percentage falls to about 5.5 percent.

Profit Outflows

Subsidizing R&D puts downward pressure on the market rate of return on R&D. Profits are unaffected because the subsidy compensates for the decline in the market rate of return. Some of the subsidy will show up in the profits of foreign-owned firms that perform R&D in the United States. Although these firms add to the income of Americans through the wages they pay, their profits accrue to foreigners, so some of the subsidy gets passed through to foreigners, which reduces the income of Americans. However, since only a small share of R&D is performed by foreign-owned firms, the impact is quite small. On average, over the five years ending in 2017, foreign-owned firms accounted for about 16 percent of the R&D performed in the United States.[80] Assuming the target net-of-tax return to investing in R&D is 10 percent, only about 1.6 percent of the subsidy would be transferred to foreigners.[81]

Administration and Compliance Costs

There is no direct information on either the administration or compliance costs of the federal and state credits. We use administrative and compliance cost data for R&D tax credits in Canada to develop illustrative estimates for the U.S. federal credits.

A survey undertaken for the Canadian government indicates that applying for the federal subsidy and complying with the program requirements costs large firms 4.7 cents per dollar of tax credit received, and 14.2 cents for small firms.[82] If these rates were applicable to the United States, the weighted average rate for all firms applying for a federal credit would be 5.3 cents per dollar claimed.[83] However, there is a substantial fixed cost in applying for the subsidy: In Canada, for both large and small firms, fixed costs account for about two-thirds of total compliance costs.[84] These fixed costs are spread over larger average claims in the United States, which reduce compliance costs to 4.1 cents per dollar claimed.[85]

Administering the Canadian federal government R&D credit cost 2.2 cents per dollar of claim processed in 2018–2019. Assuming fixed costs represent 66 percent of total administration expenses, the higher average claim size in the United States suggests administration expenses are about 1 cent per dollar of claim processed.

Acknowledgments

This report has greatly benefited from comments and questions by Robert D. Atkinson. Responsibility for any errors and omissions rests with the authors.

About the Authors

John Lester is a former Canadian government economist who writes on public policy issues. Mr. Lester's last public service assignment was as director of Research for the Expert Panel Review of Federal Support to Research and Development. Prior to that, he managed the Tax Evaluations and Research Group at Finance Canada. Since leaving the public service, Mr. Lester has published papers with The School of Public Policy, the Canadian Tax Journal, Canadian Public Policy, and the C.D. Howe Institute. His research and current interests include the federal government's expenditure management system (including evaluation policy), cost-benefit analysis of government programs, particularly those related to R&D and innovation, as well as market failures in the financing of innovative projects and entrepreneurship policy.

Jacek Warda is president of JPW Innovation Associates Inc., a company specializing in comparative analysis of innovation policy measures with a focus on tax incentives. Mr. Warda has consulted with OECD on the B-index, the European Commission (chair and member of expert groups), and the government of Canada on innovation policy matters. He is co-author of the 2012 ITIF comparative study on R&D tax incentives. Jacek is former principal research associate at the Conference Board of Canada, where he spent 20 years developing programs in innovation policy research. He holds an MA in Economics from the University of Windsor and earned a diploma in Public Administration from Carleton University.

About ITIF

The Information Technology and Innovation Foundation (ITIF) is a nonprofit, nonpartisan research and educational institute focusing on the intersection of technological innovation and public policy. Recognized as the world's leading science and technology think tank, ITIF's mission is to formulate and promote policy solutions that accelerate innovation and boost productivity to spur growth, opportunity, and progress.

For more information, visit us at www.itif.org.

ENDNOTES

1. There is also a credit for funding basic research at universities as well as a credit for funding R&D in consortia. While these are important, their overall funding levels are quite small, so this analysis does not include them.
2. For firms with both sales and qualified R&D spending for the first time after 1983, or for fewer than 3 tax years from 1984 to 1988, the fixed-base percentage is set at 3 percent for the first 5 years. In subsequent years, it is calculated using averages of qualified research spending and sales. By the 11th year, the fixed-base percentage is calculated as the ratio of qualified spending to sales in 5 of the preceding 6 years.
3. H. Watson, "The 1990 R&D Tax Credit: A Uniform Tax on Inputs and a Subsidy for R&D," *National Tax Journal* 49, no. 1 (1996): 93–103.
4. U.S. Department of the Treasury, "Research and Experimentation (R&E) Credit," 12 October 2016, https://www.treasury.gov/resource-center/tax-policy/tax-analysis/Documents/RE-Credit.pdf.
5. Some analysts calculate effective credit rates by reducing statutory credit rates by the corporate income tax rate. This approach understates the incentive effect of R&D tax credits: The user cost of capital declines by the credit rate when deductible expenses include only costs incurred by firms.
6. The effective rates are calculated using average values over the 2011–2014 period, which is appropriate because the marginal rate varies with firm-level changes in spending on R&D. The share of spending eligible for each credit is influenced by the dispersion of firm growth rates in R&D spending. The dispersion of growth rates can also affect the RC marginal rate by changing the share of spending constrained by the minimum base requirement.
7. Adjusted for delays in using the credits, the overall marginal effective credit rate would be 4.8 percent on business R&D. However, the impact of delays in claiming the credit on the incentive to invest is not clear-cut. Some firms may undertake R&D with the expectation that the credits will be used more or less as earned, but changes in the economic environment such as a cyclical downturn or an intensification of competition that reduces profits may prevent them from doing so. Other firms, particularly start-ups, may claim the credits anticipating that they will not be used as earned and calculate the expected present value of the credits when assessing their response to the incentive. There is not enough information about use of the credits to develop a defensible estimate of how delays in using the credits affect investment incentives.

8 For a detailed description of FDII and a comparison with innovation boxes in other countries, see Susan C. Morse, "International Cooperation and the 2017 Tax Act," *Yale LJF* 128 (2018): 362.

9. This is the R&D-share weighted average of export intensities by industry found in the National Science Foundation survey, Business Research and Development and Innovation: 2016 (NSF 19-318), Table 8.
10. Adjusted for deductibility of state taxes, the federal corporate income tax rate is 19.73 percent. The weighted average tax rate on R&D income is ((1 – 0.243) * 0.1973) + (0.243 * 0.13125 * (1 – 0.0603)) = 0.1794, where 0.0603 is the weighted average state corporate income tax rate.
11. Dan De Jong and Raj Lapsiwala, "Responses to Federal Tax Reform in Key States," *Tax Executive* 71 (2019): 32.
12. All expensing is scheduled to be replaced with five-year amortization starting in 2022.
13. Wendy CY Li and Bronwyn H. Hall, "Depreciation of Business R&D Capital," *Review of Income and Wealth* 66, no. 1 (2020): 161–180.
14. Estimates of subsidies arising from expenditure-based tax incentives prepared by the OECD are developed using the B-Index. See Silvia Appelt, Fernando Galindo-Rueda, and Ana Cinta González

Cabral, “Measuring R&D Tax Support: Findings from the New OECD R&D Tax Incentives Database,” 2019.

15. In the user cost framework, tax incentives are measured relative to the net-of-tax user cost of capital. This normalization facilitates international comparisons since the net-of-tax user cost is assumed to be the same for all countries. Note that this approach causes the contribution of federal tax credits to the user cost subsidy rate to be less than their effective rate.
16. For a detailed review of patent boxes, see Robert D. Atkinson and Scott Andes, “Patent Boxes: Innovation in Tax Policy and Tax Policy for Innovation” (ITIF, October 2011), https://itif.org/publications /2011/10/04/patent-boxes-innovation-tax-policy-and-tax-policy-innovation.
17. For a detailed description of the user cost framework, including a comparison with the B-Index, see John Lester and Jacek Warda, “An International Comparison of Tax Assistance for Research and Development: Estimates and Policy Implications,” University of Calgary School of Public Policy Research Paper 7 (36), 2014; Lester and Warda, “An International Comparison of Tax Assistance for R&D: 2017 Update and Extension to Patent Boxes,” The School of Public Policy Publications, SPP Research Paper, University of Calgary, Vol 11:13, April 2018, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3182887; The School of Public Policy Publications 11 (13) provides a description of how innovation boxes are modelled.
18. D.G. McFetridge and Jacek Warda, Canadian R & D Incentives: Their Adequacy and Impact, Canadian Tax Foundation/Association Canadienne d’études Fiscales, 1983, 70.
19. Subsidy rates are calculated for firms that have sufficient taxable income to claim the credits as they are earned. Not all firms are in this situation, but information on the timing of claims is available only for a few countries. Further, as discussed in the section on federal investment tax credits, the impact of delays in claiming credits on the incentive to invest is not clear-cut.
20. Israel provides accelerated depreciation for equipment and buildings used in performing R&D. Finland provides accelerated depreciation for buildings only.
21. Note that in the absence of refundability, a lower corporate income tax rate reduces the value of tax credits by making it more difficult to use the credits as they are earned.
22. In Australia, expenses eligible for the R&D tax credit cannot be deducted from taxable income. This provision reduces Australia’s subsidy rate by approximately 20 percentage points.
23. “Base effects” refers to an increase in spending in one year raising the base for calculating incremental spending in subsequent years. The share of eligible spending is readily available in the United States, but not in other countries. We developed illustrative estimates of eligible spending for the other countries by adjusting the United States estimate for country-specific circumstances.
24. Calculated as t/(1-t), where this the corporate income tax rate. After adjustment for the deductibility of state taxes, the federal tax rate is 19.73 percent
25. In addition, Italy allows firms to claim credits against regional income taxes or social security contributions.
26. Joe Kennedy, “ITIF Supports Legislation to Boost the R&D Tax Credit for Start-Ups,” *ITIF Innovation Files,* July 24, 2019, https://itif.org/publications/2019/07/24/itif-supports-legislation-boost-rd-tax-credit-start-ups.
27. New Zealand, Norway, Spain, and the United Kingdom.
28. See Albert Bravo-Biosca, Chiara Criscuolo, and Carlo Menon, “What Drives the Dynamics of Business Growth?,” *Economic Policy* 31, no. 88 (2016): 703–742.
29. Some other countries providing super-deductions also have preferential income tax rates for small firms, but the amount of income eligible for the special rate is very small.

30. Germany implemented a 25 percent tax credit in January 2020. The credit applies to a maximum of 2 million euros in R&D wage costs. We estimate that the relatively low cap means that only 15–20 percent of spending by large firms will qualify for the credit.

31. Russia provides a 150 percent super-deduction, which is similar to the 160 percent and 175 percent deductions in Brazil and China, respectively, but the corporate income tax rate is lower in Russia, which reduces the value of the super-deduction to Russian firms. India eliminated a 150 percent super-deduction in March 2020. In the absence of a patent box, India's subsidy rate would be around 3 percent.

32. The hypothesis that policy-induced rises in R&D spending generate constant spillovers has not been explicitly tested in the literature, but there is some evidence that spillovers are stable over time—a larger stock of R&D does not appear to be putting downward pressure on the spillover rate. For example, Lucking, Bloom, and Van Reenen (2017) assessed the stability of the spillover rate over the 30 years ending in 2015. They concluded the spillover rate has been "broadly stable" over this period.

33. Joe Kennedy, "A Budget-Neutral Way to Encourage Business Investment in Research" (ITIF, February 2020), https://itif.org/publications/2020/02/17/budget-neutral-way-encourage-business-investment-research.

34. The 2.8 percent rate is obtained as 0.14 * 0.79 * 0.249, wherein 0.14 is the ASC statutory rate, 0.79 adjusts for the reduction in the base for tax depreciation allowances, and 0.249 represents the share of incremental spending in total R&D spending on average over the 2011–2014 period.

35. These studies are discussed in annex 5.

36. Fixed costs are those costs that do not rise with the size of the claim.

37. The fiscal cost is calculated as 0.79 * 0.2 * 0.0927 = 0.0146 times R&D spending in 2018, wherein 0.79 adjusts for the reduction in the base for depreciation allowances, 0.2 is the RC statutory rate, and 0.0927 is the 2011–2014 average ratio of the credit base to total R&D spending.

38. Department of the Treasury (2016) reports a similar finding for 2013. However, the gap between the marginal and average credit rates is understated because the authors adjusted the marginal rate as well as the average rate to capture the impact of reducing the base for tax depreciation allowances by the amount of the credit.

39. John Wu, "Why U.S. Business R&D Is Not as Strong as It Appears" (ITIF, June 2018), https://itif.org/publications/2018/06/04/why-us-business-rd-not-strong-it-appears.

40. The dictum that multiple market failures require multiple instruments is attributed to Jan Tinbergen, *On the Theory of Economic Policy* (North-Holland Publishing Company, Amsterdam, 1952).

41. Nicholas Bloom, Mark Schankerman, and John Van Reenen, "Identifying Technology Spillovers and Product Market Rivalry," *Econometrica* 81, no. 4 (2013): 1347–1393; Brian Lucking, Nicholas Bloom, and John Van Reenen, "Have R&D Spillovers Declined in the 21st Century?" *Fiscal Studies* 40, no. 4 (2019): 561–590; Pere Arqué-Castells and Daniel F. Spulber, "Measuring the Private and Social Returns to R&D: Unintended Spillovers versus Technology Markets," *Northwestern Law & Econ Research Paper*, no. 18–18 (2019).

42. For a discussion of this point, see U.S. Department of the Treasury, "Research and Experimentation (R&E) Credit," 12 October 2016, https://www.treasury.gov/resource-center/tax-policy/tax-analysis/Documents/RE-Credit.pdf.

43. Estimate developed from data provided by Raymond M. Wolfe, project officer, Research and Development Statistics Program, National Center for Science and Engineering Statistics, National Science Foundation.

44. American Innovation and Competitiveness Act of 2019, H.R.4549 , 116th Cong. (2019), https://www.congress.gov/bill/116th-congress/house-bill/4549/text.

45. John Lester and Jacek Warda, “An International Comparison of Tax Assistance for R&D: 2017 Update and Extension to Patent Boxes,” *The School of Public Policy Publications* 11, no. 13 (2018): 36.

46. This annex is based on material presented in Lester and Warda.

47. OECD, “Action 5: Agreement on Modified Nexus for IP Regimes" (Organisation for Economic Co-operation and Development, Paris, France, 2015), page 42, note 14, https://www.oecd.org/ctp/beps-action-5-agreement-on-modified-nexus-approach-for-ip-regimes.pdf.

48. See Lester and Warda for a detailed description.

49. OECD, “Action 5: Agreement on Modified Nexus for IP Regimes.”

50. The analysis abstracts from current expenses incurred to manage and improve intellectual property.

51. Lester and Warda, “An International Comparison of Tax Assistance for R&D.”

52. Erica L. Groshen et al., “How Government Statistics Adjust for Potential Biases from Quality Change and New Goods in an Age of Digital Technologies: A View from the Trenches,” *Journal of Economic Perspectives* 31, no. 2 (2017): 187–210.

53. The formula used is $(0.5 \ * s^2 * \varepsilon \ * R\&D_t)/\big((1 - s * \varepsilon)\big)$, wherein s is the subsidy rate, ε is the absolute value of the price elasticity of demand for R&D, and R&D is spending on *R&D.*

54. David Card et al., “Firms and Labor Market Inequality: Evidence and Some Theory,” *Journal of Labor Economics* 36, no. S1 (2018): S13–S70.

55. Chad Syverson, "What Determines Productivity?" Journal of Economic Literature 49, no. 2 (2011): 326–365.

56. If the spillover rate falls as the amount of R&D performed increases, the optimal subsidy rate would decline when R&D-intensive sectors are subsidized. However, as discussed in the text, growth in the stock of R&D over the last 30 years has not put downward pressure on the spillover rate.

57. We are aware of nine benefit-cost analyses of R&D investment tax credits prepared by other authors since the early 1990s: Australian Bureau of Industry Economics (1993), Australian Industry Commission (1995), Lattimore (1997), Finance Canada and Revenue Canada (1997), Cornet (2001), Russo (2004), Yoon & Lee (2004), Dahlby (2005), and Parsons and Phillips (2007). Three of the studies use a general equilibrium model: the Australian Industry Commission, Finance/Revenue Canada, and Russo.

58. The subsidy-induced change in exports was calculated as follows. The 5.5 percent subsidy arising from federal tax credits is estimated to increase R&D spending by approximately 5.5 percent. Empirical work by Lucking, Bloom, and Van Reenen, “Have R&D Spillovers Declined in the 21st Century?” finds that a 1 percent increase in R&D increases overall output of R&D performers by 0.15 percent. A 5.5 percent increase in R&D would therefore raise output by 0.825 percent. Sales of firms that performed or paid for R&D were $12.29 trillion in 2016, so the subsidy accounted for about $100 billion in sales. Exports represent about a quarter of sales, so the subsidy-induced rise in exports could have been as much as $25 billion, which was just over 1 percent of the $2.24 trillion in exports in 2016.

59. Bev Dahlby, "A Framework for Evaluating Provincial R&D Tax Subsidies," Canadian Public Policy, University of Toronto Press, vol. 31(1), 2005, https://www.researchgate.net/publication/4749817_A_Framework_for_Evaluating_Provincial_RD_Tax_Subsidies..”

60. Financing the R&D subsidy with debt can result in a net increase in economic activity during a cyclical downturn, but when the economy returns to normal activity levels, the additional R&D squeezes out other spending.

61. See Hall, Mairesse, and Mohnen (2010, 6) for a discussion. If the marginal product of R&D and the discount rate are constant, and the planning horizon is infinite, direct estimation of the rate of

return results in a coefficient that can be interpreted as the internal rate of return on the spillover pool. The internal rate of return equates a dollar of investment in R&D to the present value of the marginal productivities of that investment in the future.

62. Quoted in Li and Hall (2016). The survey covered 6,381 firms in 38 industries. The average gestation lag is 1.94 years, and the lag is longer than 3 years for only 1.35 percent of firms.
63. Hall, Mairesse, and Mohnen, "Measuring the Returns to R&D."
64. Myeongwan Kim and John Lester, "R&D Spillovers in Canadian Industry: Results from a New Micro Database," Research Report (Centre for the Study of Living Standards, 2019).
65. The study by Lucking, Bloom, and Van Reenen (2019) found, however, that the spillover rate was broadly stable over the 1985–2015 period.
66. Technological similarity is determined by the classification of patents granted to each firm. In earlier studies, the spillover pool was often calculated as either the unweighted sum of R&D performed by firms in the same or similar industries. Another approach was to use patent citations to identify firms working in similar technological fields.
67. Arqué-Castells and Spulber, "Measuring the Private and Social Returns to R&D."
68. Ibid.
69. The ACS sample covers 1990 to 2014 while the LBVR sample covers the 1985-2015 period.
70. Bloom, Schankerman, and Van Reenen, "Identifying Technology Spillovers and Product Market Rivalry."
71. When the subsidy rate is well above the optimal rate, the benefit of performing additional R&D is less than the cost.
72. John Lester, "Benefit-Cost Analysis of Federal and Provincial SR&ED Investment Tax Credits," *School of Public Policy Publications*, SPP Research Paper, Forthcoming. The survey builds on work by Parsons and Phillips (2007) and Fowkes, Sousa, and Duncan (2015).
73. Hyunjung Lee and Stephen K. Markham, "PDMA Comparative Performance Assessment Study (CPAS): Methods and Future Research Directions," *Journal of Product Innovation Management* 33 (2016): 3–19.
74. Data on domestic and export sales of R&D performers is available in Business Research and Development and Innovation: 2016, Table 8. We weighted industry-level export intensities by shares of R&D to obtain a weighted average export intensity of 24.3 percent.
75. Note that the relevant demand elasticity is a weighted average of domestic and export sales.
76. Erkel-Rousse and Mirza (2002) report import price elasticities for industries producing differentiated products ranging from -1.2 to -4.2. Imbs and Mejean (2015), working with U.S. imports over the 1996 to 2004 period, report a median price elasticity of -4.1 over 56 manufacturing industries. The authors also report that the elasticities are highest for industries producing differentiated products, although detailed results are not provided in the paper.
77. John Romalis, "NAFTA's and CUSFTA's Impact on International Trade," *The Review of Economics and Statistics* 89, no. 3 (2007): 416–435.
78. The pass-through percentage equals $\eta/(\eta - \varepsilon)$, wherein η is the elasticity of supply and ε is the elasticity of demand, a negative number.
79. E. Glen Weyl and Michal Fabinger, "Pass-through as an Economic Tool: Principles of Incidence under Imperfect Competition," *Journal of Political Economy* 121, no. 3 (2013): 528–583.
80. Bureau of Economic Analysis "Activities of US Affiliates of Foreign Multinational Enterprises," releases issued from 2015 to 2019.

81. This is consistent with a pretax return of 14.5 percent given a federal-state corporate income tax rate of 25.9 percent and a withholding tax rate of 5 percent.
82. The survey, which was undertaken in 2011, is described in Lester (2012).
83. In Canada, small firms with less than C$500,000 in net income and C$10 million in assets are eligible for a 35 percent refundable subsidy on up to C$3 million in spending on R&D. The size constraints were assumed to correspond to firms with fewer than 100 employees, which account for about 7 percent of R&D spending in the United States.
84. Lester, "Benefit-Cost Analysis of R&D Support Programs."
85. The average claim size for large firms in Canada was 65 percent of the U.S. all-firm average in 2007, which is the only year average claim data by size of firm is available for Canada.

ERRATA

This report was updated on October 16, 2020 to correct data points in the "Combined effective credit rate on QRE (%)" column on Table 9 in Annex 1.