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The impact of R&D policies: A review of recent studies

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ABSTRACT

In this paper, I review the empirical literature of the last 20 or so years on the impact of public support to R&D, focusing on direct R&D subsidies and on R&D tax credits. The review considers both the impacts on R&D inputs, meaning private R&D expenditures, and outputs, such as patenting activity and productivity growth. In the survey, I include both macro-level studies, which examine the effects of public R&D support at the aggregate level, and micro-level analyses, which evaluate the impacts on firm- and worker-level outcomes. The studies covered in the review indicate a strong effectiveness of public R&D policies in stimulating private R&D activity. The effects on innovation and productivity are more uncertain, and might take long to materialize, but most of the works considered gave a positive assessment of public support to R&D.

JEL Codes: O30, O31, O32, O38

Keywords:
R&D,
public R&D policy,
public innovation policy,
productivity growth,
literature review

TIIVISTELMÄ

Julkisen T&K-politiikan kirjallisuuskatsaus

Tässä artikkelissa tarkastelen viimeisten noin 20 vuoden empiiristä kirjallisuutta julkisen tutkimus- ja kehitystuen (T&K) vaikutuksista, erityisesti suoria T&K tukia ja T&K verohyvityksiä. Katsauksessa tutkitaan sekä vaikutuksia T&K panoksiin, eli yksityisiin T&K menoihin, että innovaation tuotoksiin, kuten patentointi ja tuottavuuden kasvuun. Katsaus sisältää sekä makrotason tutkimuksia, joissa tarkastellaan julkisen T&K tukien vaikutuksia kokonaistasolla, että mikrotason analyysejä, joissa arvioidaan vaikutuksia yritys- ja työntekijätason tuloksiin. Käsitellyt tutkimukset osoittavat, että julkinen T&K-politiikka on tehokasta yksityisen T&K-toiminnan edistämisessä. Tukien tehokuuden innovaatioihin ja tuottavuuteen on epävarmempi ja niiden vaikutus toteutuminen voi kestää kauan, mutta useimmat analyysia katsauksessa antavat myönteisen arvion julkisesta tuesta T&K:lle.

JEL-koodit: O30, O31, O32, O38

Avainsanat:
T&K,
julkinen T&K-politiikka,
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kirjallisuuskatsaus

The impact of R&D policies: A review of recent studies

Paolo Fornaro[1]

Highlights

- Based on the review of empirical studies spanning the last 20 or so years, R&D public policies can be considered effective in terms of boosting R&D investments, innovation and productivity.
- There is a degree of uncertainty in terms of the estimates obtained in different works, which becomes larger for outcomes further along the innovation process.
- Public R&D policies, both direct subsidies and tax benefits, are effective in stimulating private R&D investments, generating a crowding in effect.
- At the same time, public innovation policies positively affect innovation and lead to significant positive knowledge spillovers.
- Finally, the evidence points toward a positive impact on employment and productivity growth, even if the latter can take a long time to materialize.

Abstract

In this paper, I review the empirical literature of the last 20 or so years on the impact of public support to R&D, focusing on direct R&D subsidies and on R&D tax credits. The review considers both the impacts on R&D inputs, meaning private R&D expenditures, and outputs, such as patenting activity and productivity growth. In this survey, I include both macro-level studies, which examine the effects of public R&D support at the aggregate level, and micro-level analyses, which evaluate the impacts on firm- and worker-level outcomes. The studies covered in the review indicate a strong effectiveness of public R&D policies in stimulating private R&D activity. The effects on innovation and productivity are more uncertain, and might take long to materialize, but most of the works considered give a positive assessment of public support to R&D.

JEL codes: O30, O31, O32, O38

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Keywords: R&D; public R&D policy; public innovation policy; productivity growth; literature review

1. Introduction

Given the importance of innovation in driving economic growth (see, for example, the work of recent Nobel laurates Philippe Aghion and Peter Howitt, e.g. Aghion and Howitt, 1992), it is not surprising that a vast literature has developed around the topic of R&D policies, their impact on innovation and other outcomes, as well as the channels underlying these relationships. The enormous size of the literature in question does not permit a fully comprehensive survey and requires us to impose some boundaries.

Firstly, the review presented here concerns empirical works. While the theoretical aspects underlying the generation of new ideas and technological developments, and how these translate to higher economic growth, are interesting, this report is focused on the practical side of public R&D policies and on their estimated impact on various outcomes of interest. A comprehensive review of the theoretical literature on public innovation policies is available in Akcigit et al. (2022a), while a number of ex-ante analyses, based on large theoretical models, of EU R&D policies are provided in Christensen (2018) and Ravet et al. (2019).

Moreover, we disregard analyses linking non-R&D-specific policies to innovation activities. For example, we do not cover studies on the relationship between income tax and the attraction of international inventors, the effect of education policies on the propensity of becoming innovators, or the link between market competitiveness and innovation. Some studies on the relationship between innovation and corporate and personal taxes are Akcigit et al (2022b), Madsen et al. (2023), Akcigit et al. (2022c) and Cloyne et al. (2024), while Benedetti-Fasil et al. (2017) provides an interesting analysis regarding the impact of entry barriers on the innovativeness of European countries. Another topic that we do not cover is the link between trade policies and the generation of new innovations. Akcigit et al. (2018) offers an interesting example on the subject, for the interested reader. Finally, we do not consider studies concerning how an increase in human capital *supply*, via, e.g., new university places, leads to more innovation. For the Finnish context, Toivanen and Väänänen (2016) represents an interesting empirical analysis on this subject.

Moreover, again for the sake of brevity, we concentrate our survey on relatively recent studies, spanning roughly the last 20 years. While the impact of R&D policies has been the subject of older works, more recent studies tend to rely on more comprehensive data and refined identification approaches, improving their reliability. However, we provide a short summary of the conclusions reached in some past literature surveys and meta-analyses, to give the reader a quick background of the consensus found in the literature on older works.

Despite a degree of heterogeneity, the studies collected in this review point toward an overall effectiveness of public R&D support. In particular, numerous studies document that public support, both via direct subsidies and tax credits, stimulate private R&D spending, and they do that in an additional fashion, leading to an overall increase in research efforts. The effectiveness of public R&D support becomes more uncertain when we look at the impacts on innovation outputs, such as patenting activity, and economic outcomes, in particular productivity growth, even though the majority of the studies considered in this review indicate a positive impact on these outcomes. However, it is important to underline that the context and the way the support policy is implemented are crucial, based on the findings of the reviewed literature.

The remainder of the current review is focused on the main public R&D policies used to stimulate innovation, namely R&D subsidies (and public R&D spending) and R&D tax credits. We divide the survey into four main subsections. Firstly, we summarize the conclusions reached by previous literature surveys and meta-analyses, to try to give an overview of the consensus reached in the literature so far. We then start the actual survey, starting from a coverage of studies which look at the Finnish context, to then move to a selection of empirical analyses where the outcome of interest is at the macroeconomic level (e.g., state or region), and we finally conclude by surveying studies investigating the impact of R&D policies on firm-level or worker-level outcomes. In all cases, we consider the effects of R&D policies on both R&D inputs, such as private R&D expenditures, outputs, mainly new innovations and patents, and a wide range of economic outcomes, such as productivity and employment growth. We end the survey with a short summary of the main findings highlighted by the reviewed papers and with a summary table.

2. Summary of past surveys and meta-analyses

Given the wide interest surrounding the topic, the literature extends well before the time coverage we adopt here. Here, we try to give an overview of the conclusions reached by previous literature reviews and meta-analyses, to give the reader some background.

An early review is provided in Hall and Van Reenen (2000), who evaluate the evidence gathered on the effectiveness of R&D tax credits. While they find substantial difficulties in making adequate comparisons across studies, they assess that both US and non-US analyses point toward a substantial effectiveness of tax credits in stimulating R&D expenditures. Hall and Van Reenen (2000) observe that the impact of tax credits takes time to materialize and, despite heterogeneity across studies, they estimate the tax price elasticity to be near unity.

A more recent survey by Zúñiga-Vicente et al. (2014) also uncovers substantial heterogeneity in the findings of the previous literature, when considering the link between public R&D support and private R&D investments. They conclude that methodological differences are not the main explanatory factor behind the differing results across studies, while they argue that different composition of R&D at the firm-level, as well as the financial constraints possibly faced by firms and the source of funding, play a bigger role in explaining the heterogenous results uncovered in the survey. Zúñiga-Vicente et al. (2014) find that the majority of studies (around 60%) support crowding-in, while at the same time observing a substantial amount of research pointing toward crowding out or finding a non-significant relationship between R&D subsidies and private R&D expenditures.

Another interesting literature review is provided in Becker (2015), who covers works concerning different R&D support policies, including direct subsidies, tax credits, support to university research and policies targeted at increasing cooperation between R&D-related entities. One prominent finding of this review is that relatively older workers give a more pessimistic assessment of R&D support policies, usually finding crowding-out effects, while more recent studies tend to support the view that public R&D support is effective at stimulating private R&D. Another interesting insight brought up in Becker (2015) is that direct R&D subsidies tend to have a larger effect on the medium-to-long term, while tax credits are more effective in stimulating R&D investments in the short term. Becker (2015) also draws the conclusion that increased support for university research and for fostering research collaborations is linked to more R&D investments in the private sector, based on the literature covered in the review.

Dimos et al. (2016) rely on a meta regression analysis approach to evaluate the evidence gathered in 52 micro-level studies on the impact of R&D public policies on private R&D investments. Interestingly, they find that once taking into account possible publication bias, the evidence points toward a rejection of crowding out, i.e. public support to R&D does not cause a reduction in private investments, but at the same time they estimate that the response of private R&D to public policies is weak.

3. Lessons from Finland

We start by going over few works which consider the impact of R&D public policies in Finland. The studies covered here belong to the microeconometric class, because they tend to analyze the impact of R&D public policies on firm-level outcomes. Moreover, the studies considered here concern only direct subsidies. An early contribution to the literature is offered in Hyytinen and Toivanen (2005), where the authors examine how direct government subsidies (including R&D subsidies) alleviate capital market imperfections for SMEs. They find that government subsidies are beneficials to firms facing more severe capital market imperfections, leading to higher R&D expenditures and sales growth. However, the results provided in the study do not allow for an overall assessment of the welfare effects of R&D subsidies. Einiö (2009, 2014) represent two analyses that focus on the exogenous variation in R&D subsidies due to EU-level rules on population density across different regions, where regions with lower population density receive relatively more R&D grants. These studies find that direct R&D support is effective, leading to an increase in private R&D expenditures (with evidence of crowding-in), employment and sales, with a positive effect on firm-level productivity in the long run.

Karhunen and Huovari (2015) examine the impact of R&D grants on firm-level productivity and find a non-significant impact for the 5-year period after grant. However, they show a significant positive effect on employment and firm survival rates. The analysis in Takalo et al. (2013), relies on a structural model combined with project-level data to estimate the impact of R&D subsidies on profits, as well as possible spillovers which are not internalized by the firm conducting the research. They find quite heterogeneous impacts, with larger spillovers associated with larger firms and more challenging projects. Moreover, they observe that, on average, firms internalize roughly 60% of the returns to the subsidies, implying substantial spillovers. Finally, Takalo et al. (2013) point out that R&D grants provide aggregate returns that are slightly larger than their costs, making the policy effective. In a recent paper, Takalo et al. (2026) compare the welfare impact of direct R&D subsidies and the newly introduced R&D tax credits, again using a structural approach. The main finding of the study is that direct subsidies to R&D have a welfare reducing effect, due to application costs, while tax credits on R&D are welfare-enhancing because they have a broader reach, even though they lead to a higher fiscal cost compared to subsidies.

Looking at the impact of different types of firm subsidies (including R&D subsidies) on productivity growth, Koski and Pajarinen (2015) do not find a significant effect. At the same time, they estimate a negative effect on the exit rate of less productive firms, suggesting that firm subsidies might slow down an efficient reallocation of resources. Fornaro et al. (2020) also evaluate the link between public R&D grants and a number of firm-level outcomes, relying on coarsened matching difference-in-differences (DID) estimator. While they find that R&D subsidies lead to a persistent increase in R&D expenditures and in the number of R&D workers, as well as a higher propensity of subsidized companies to collaborate with external entities, they do not observe significant impacts on labor productivity. Moreover, they do not find significant spillover effects, but, as in Koski and Pajarinen (2015) identify a positive relation with the survival rate of less efficient firms.

4. International Macro-Level Studies

A great deal of research has focused on the link between R&D policy interventions and their effects at the macro-level. While considering aggregate outcomes creates numerous challenges in terms of establishing a causal relation, it allows us to get a grasp of the overall economic impact of R&D policies, by taking into account possible general equilibrium effects and moving away from impacts at the margin.

We start by mentioning a number of works concerning the use of direct R&D subsidies and their effects. Looking at multi-country studies, an interesting example is provided in Wolff and Reinthaler (2008), who examine how direct R&D subsidies in OECD countries are related to the growth in R&D-related employment and total R&D expenditures. They find that public subsidies lead to a substantial increase in R&D expenditures, pointing to additionality, while finding a more muted employment response, which can indicate an overall increase in the average wage of R&D personnel. Another analysis covering multiple countries is Rehman et al. (2020), where the effectiveness of public R&D funding is assessed before and after the Great Recession of 2008. The main finding of the study is that there is a positive causal relation between public R&D spending and private one, which is stronger for years before 2008.

Shifting the focus to city-level innovation patterns, Schweiger et al. (2022) evaluate how public R&D spending in the former Soviet Union, and in particular the creation of so-called Science Cities, have shaped long-term outcomes, which persisted even after public funding in R&D stopped. The authors show that former Science Cities are still characterized by a higher share of highly skilled workers and R&D activities (measured by patent output), as well as higher salaries and better economic conditions, when compared with similar towns. In a secondary analysis, Schweiger et al. (2022) also measure the degree of spillovers to nearby firms and find that the firms located near former Science Cities are more likely to innovate and be more productive. Another interesting example that concerns the impact of public R&D investments in a non-advanced economy is offered in Akerman et al. (2025). Looking at the effects of the establishment of agriculture-focused public research centers in Brazil from the 1970s onward, Akerman et al. (2025) show that public innovation investments led to additional research in topics related to Brazil-specific soil and crop conditions, without crowding out research from other institutions. Moreover, they show that municipalities with a closer ecological proximity to the research conducted in these public research centers experienced significantly higher agricultural productivity, and that the overall program has been highly effective in terms of economic returns.

Using a structural vector autoregression (SVAR) approach, De Lipsis et al. (2023) study how direct R&D public investments, in particular mission-oriented spending, affect private R&D intensity and GDP, for the US economy. The main findings of the study are that a public R&D stimulus has a persistent positive impact (up to 8 years) on private R&D spending and

GDP, with large output multipliers, even after taking into account the expectations of the private sector. Ciaffi et al. (2024) represent another study covering the medium run effect (specifically up to 5 years) of public R&D funding shocks. The authors estimate a number of local projections (LP) linking public R&D investments to private R&D expenditures and GDP for a number of OECD countries. They find strong fiscal multipliers linked to public R&D expenditures, which are significantly higher than the ones estimated for general government spending. Recognizing possible anticipatory behavior by private agents, the authors identify unanticipated government spending shocks, using forecasts of public spending as control in a VAR system, and obtain similar results as in their main analysis.

A number of studies have dealt with the long-term impact of public R&D shocks in the US context. For example, Gross and Sampat (2023) estimate the effects of the surge in government-funded R&D during World War II (WW2) on the formation of innovation clusters, defined as a county-technological area pair. The main finding of the paper is that the shock to public R&D during WW2 had long-term repercussions on the present US innovation landscape. Specifically, clusters which were funded during WW2, and produced innovations during that period, show significantly higher patenting activity decades later, compared to other non-treated clusters. The main mechanism behind this high degree of persistence is agglomeration, where treated clusters displayed higher firm formation and in-migration, as well as an increase in employment. The authors also evaluate the aggregate impact of this shock, by comparing US firms operating in a treated technological area compared to foreign firms in a similar field, and find a substantial growth in patents of US firms. Fieldhouse and Mertens (2024) take a more general approach and assess how public R&D shocks, measured by appropriations (the budget allocated to a given government spending item), affect total factor productivity (TFP) and private R&D expenditures. The main finding of the paper is that public nondefense R&D shocks are associated with a significant response in TFP, which takes a long time to concretize (more than 8 years), innovation activity (patents, number of researchers), while they cannot find a similar effect for defense-related R&D shock. The main mechanism behind this result is that publicly funded R&D tends to focus on basic, instead of applied, research, which can generate more spillovers. In a follow-up paper, Fieldhouse and Mertens (2026) make an assessment of how implementing fully the R&D fund increases authorized under the CHIPS act would impact productivity growth. They find a strong impact on productivity growth, which remains significant even after 15 years, and estimate that the productivity benefits would exceed substantially the fiscal costs of the CHIPS act. Less positive results are obtained in Kantor and Whalley (2025), a study on impact of the public R&D shock related to the space race. This specific example is interesting because causal identification is allowed by the geopolitical causes of this shock, while the funding amount is quantitatively large (roughly 0.7 percent of GDP). The authors observe that county-industries pairs whose technological specialization were more related to the space race before the launch of Sputnik benefited more from NASA spending and increased their patenting activity, as well as experienced significant growth in value added, employment and capital. However, the estimates of the fiscal multiplier they obtain, around 0.4, are at the lower end of the scale w.r.t previous works, meaning that the R&D funding related to the space race was not very effective, in a bang for bucks' sense. Another very recent example is offered in Gazzani et al. (2025), where the impact of public vs. privately funded patents on various macroeconomic outcomes, like GDP, TFP and private R&D spending, is estimated. The main finding of the study is that publicly funded, but privately owned, patents are linked to a large positive response in output and productivity. In particular, the authors note that despite accounting for only 2% of the patents, publicly funded innovations explain roughly 20% of movement in GDP and productivity, while showing a crowding in effect on private R&D spending. Moving to the European context, Bergeaud et al. (2025) examine how the public financing of academic clusters generates spillovers from public research to the private sector, both in terms of R&D expenditures and innovation output, measured by patenting activity. They find that industry-commuting zone pairs which are geographically and technologically more exposed to funded academic clusters experience a significant increase in R&D expenditures, implying a crowding-in effect, and innovation.

Public R&D spendings related to military activity have also been of interest for the literature, given their plausibly exogenous nature. Two very recent studies on the topic are Antolin-Diaz and Surico (2025) and Moretti et al. (2025). The former study evaluates the long-term impact of public R&D shock, both related to defense spending and to more general public R&D investments, on GDP and productivity, for the US economy. The authors use a Bayesian VAR (BVAR) which allow for the inclusion of many lags (in this case up to 60 quarters), and find that both types of public R&D shocks have long term impacts on both TFP and GDP, even though the effects materialize only after many years. Moretti et al. (2025) consider the impact of military-related R&D shocks on private R&D expenditures at the industry level for a set of OECD countries. The main result of the study is that government-funded R&D causes an increase in private R&D (so-called crowding in), which displays also some degree of international spillover effects. Finally, the authors estimate a positive and significant impact of public R&D shocks on TFP, even though the effect is relatively small.

A related public policy which can have meaningful impact on innovation activity is public procurement, and in particular its focus on industries which involve more R&D activity. Slavtchev and Wiederhold (2016) look at shifts in the procurement of the US federal government toward more high-tech products. In particular, they estimate the relationship between an increase of federal purchases of high-tech products and private R&D expenditures across different states, finding that a 1$ shift from low- to high-tech industries leads to 21 cents increase in private R&D. Looking at an industry-country panel covering multiple OECD countries, Crespi and Guarascio (2019) examine the effect of public procurement on patenting activity in the private sector. They find a strong positive effect, which applies to both the standard measure of public procurement and an alternative measure which approximates the procurement innovation intensity. Interestingly, the study highlights a moderating effect on imports, meaning that the public procurement which involves more imported products has a smaller positive impact on patenting activity.

We now turn to studies concerned with the other main public R&D policy, namely R&D tax credits. An early example is provided in Bloom et al. (2002), which is a study covering a panel of nine OECD countries. The authors estimate that R&D tax credits are associated with higher R&D intensity, with an effect that becomes larger over the long run. However, Bloom et al. (2002) argue that their results do not offer a complete assessment of the effectiveness of R&D tax credits. Thomson (2013) examines the impact of tax credits on private R&D expenditures, for a panel of industries across 23 OECD countries. The main finding is that tax credits stimulate private R&D expenditures, quantified at around 24 cents increased R&D investments for each tax dollar forgone. However, Thomson (2013) points out that these are short-run effects, which could give a partial picture. Focusing on the biotech industry Moretti and Wilson (2014) look at state-level tax credit subsidies, as well as more specific biotech-related subsidies, in the US, and how they stimulate the birth of biotech clusters. They estimate that R&D tax credits positively affect the arrival of biotech star scientists in a given state, while the effect is more muted on the patenting activity of resident scientists. Moreover, the positive impact is not limited to the employment of new scientists but rather extends to the biotech industry workforce. Minniti and Venturini (2017) examine the long-run impact of tax credits on the productivity growth of US manufacturing industries. The results of the study indicate a long-term positive and significant effect of R&D tax credits on labor productivity growth, which the authors quantify as a 0.4% permanent increase in productivity growth for 10% increase in tax credits. Interestingly, the authors do not observe a similar impact for direct R&D subsidies. An analysis offering US state-level evidence on the effectiveness of R&D tax credits is Chang (2018), where the changes in federal corporate tax laws are used as instruments for state-level tax legislation. The main finding of the paper is that 1% increase in tax credits leads to an increase in private R&D between 2.8 and 3.8%, which is larger than what was found in older studies.

Shifting the focus towards the impact of R&D tax credits on entrepreneurial activity, Fazio et al. (2020) examine state-level tax credits in the US and their effect on county-level entrepreneurial activity. They find a long-term link between R&D tax credits and the birth of new businesses, as well as the quality of the new firms (a measure which includes a number of indicators, such as whether the new firm eventually has an initial public offering, whether the firm is registered in Delaware or its patenting activity). The impact on both outcomes is roughly equal, meaning that the resulting quality mix of new firms does not change, and it takes more than five years to materialize. The authors compared R&D tax credits with general investment tax credits and find that the latter do not impact entrepreneurship. Finally, Melnik and Smyth (2024) investigate the effects of state-level tax credits on innovation output. Their proxies of innovation are patent-based, ranging from the number of patents, their quality (measured by citations), novelty and market value associated with them. While the results of the analysis highlight a positive effect of tax credits on R&D expenditures, the impact on the number of patents produced and their quality is insignificant. On the other hand, the authors find a positive link between tax credits and patents' novelty and market value. Interestingly they find some heterogeneity in their results, finding that tax credits are effective at stimulating state-level patenting activity of small firms, while the effect is non-significant for large ones.

While most studies covered so far evaluate the impact of individual R&D tax credit schemes, Koski and Fornaro (2022) provide an interesting international comparison of different R&D tax incentives, and gauge how different design features are related to R&D expenditures and innovation outcomes (measured by patent applications). They find that incremental, as opposed to volume-based, tax credit schemes are the most effective at stimulating R&D expenditures, obtaining similar results when considering schemes which favor SMEs and allow for carry-forward deduction. Looking at innovation output, the analysis in Koski and Fornaro (2022) indicates that hybrid schemes, which include both incremental and volume-based features, are linked to a rise in patent applications.

5. International Micro-Level Studies

We follow a similar structure as in the section describing macro studies, i.e., we separate the review of past works based on the main R&D policy of interest, direct R&D grants and R&D tax credits. While macro-level analyses provide a more generalizable and comprehensive picture of the impact of public R&D policies, micro-level studies, which aim to estimate the effect of R&D policies on individual firms or workers, allow for a more precise identification of causal impacts via the use of quasi-experimental empirical setups.

Starting with direct R&D subsidies, which usually take the form of grants or advantageous loans, Bronzini and Piselli (2016) examine the impact of R&D grants on firm-level patenting activity in the Italian region Emilia Romagna. They find that grants receivers patented more than comparable firms (intensive margin), with a stronger effect observed for smaller companies. Moreover, they observe an extensive margin effect, i.e. firms starting to apply for patents, but only for small firms. Cin et al. (2017) find that public R&D grants are positively linked with private R&D expenditure and labor productivity growth of Korean manufacturing SMEs. Azoulay et al. (2019) study the impact of grants awarded by the US National Institutes of Health on firm-level patenting in the biotech sector. Leveraging on the institutional characteristics of how these grants are awarded, the authors identify a significant impact on patenting activity, which creates substantial private value (even though the estimates are uncertain). Finally, the results of the study indicate the presence of spillovers to research areas that were not targeted by the original grant. An interesting example of analysis on the link between public R&D subsidies and knowledge spillovers is offered in Castillo et al. (2020). This paper identifies the effects of an innovation support program on Argentinian firms and employees, finding a positive impact on firm survival, export propensity and employment growth, together with a positive effect on the wage growth of employees of treated firms. Interestingly, the analysis highlights positive spillovers, with firms hiring workers from treated companies having better performances. Knowledge spillovers are also the focus of Myers and Lanahan (2022). The study identifies the effect of US Department of Energy (DOE) grants for small companies on patenting activity, and how this positive shock to innovation spreads to different geographical and topical areas. The main result of the study is that DOE grants lead to significant spillovers, with patents funded by these grants being cited by patents which can be quite distant from the original theme and that originated outside of the US. Howell and Brown (2023) also study the effects of DOE grants to small firms, in particular on the wage growth of workers employed in those companies. They find an increase in revenues and employment for treated firms, as well as stronger earnings growth for their employees. Interestingly, the effect is driven by incumbent workers, and it is positively associated with workers' tenure. Howell and Brown (2023) estimate that this higher wage growth is due to relatively lower initial wages, compared to workers' productivity, in consequence of financial constraints. Moving from the corporate world to US universities, Babina et al. (2023) investigate the impact of cuts to federal research funding on university researchers' performance, measured by patenting and publication activity, as well as the propensity to create a high-tech startup. The main result of the paper is that large funding cuts lead to fewer publications and lower entrepreneurial activity, while they have a positive effect on patenting activity. While the latter result can be surprising, the authors notice that these patents tend to be less cited and less generalizable, and identify a shift toward more private funding as the likely mechanism behind this result. Another work focused on the impact of spillovers generated by public research is Dyevre (2024). Relying on a firm-level panel spanning 70 years, Dyevre (2024) quantifies the existence of positive spillovers generated from public R&D, which are much larger compared to the ones resulting from private research efforts. The main finding of the analysis is that the spillovers generated from public R&D patents (instrumented by public R&D spending shocks) have a sizable impact on firm-level productivity growth and innovation activity (between 0.14 and 0.21 % productivity growth for 1% increased exposure to public R&D), which translates to sizable industry and aggregate-level impacts. Santoleri et al. (2024), study how R&D grants to SMEs impact a wide range of firm-level outcomes. They estimate that firms benefiting from these grants increase their patenting activity (quantified as roughly 0.76 patent per million euros spent), as well as their investments in intangible capital, and are able to attract more private funding. Moreover, they observe positive local spillovers, with areas where treated firms are located experiencing a surge in entrepreneurial activity. Interestingly, the empirical setup of the paper allows the authors to separate the impact of actual funding vs. a positive signaling of treated firms, finding the latter not associated with better firm performances. Remaining in the European context, Reshid et al. (2025) examine the impact of R&D subsidies from the Eurostar initiative on small Swedish firms and on the spillovers generated from workers' mobility. They find that employees of treated firms do not have a higher propensity to become entrepreneurs, but that the firms they create have higher survival rates and employment growth. Moreover, they observe that firms hiring ex-employees of treated firms tend to have higher employment, sales and productivity growth.

We now turn to the other main public innovation policy, i.e. tax subsidies, in particular tax credits. As in the case of direct grants, the literature on the impact of tax credit is very wide and we do not attempt to cover it comprehensively. One of the main questions regarding tax credits is whether they lead to additional private R&D expenditures (crowding in), which renders the tax subsidy economically effective. Lokshin and Mohen (2012) investigate the effectiveness of tax credits in the Netherlands, finding that it led small firms to invest more in R&D, even though they come to the conclusion that the overall tax scheme was ineffective in terms of public costs, due to the level-based nature of the tax credits. More positive estimates of the impact of tax credits are offered in Agrawal et al. (2020), for small Canadian firms, and Rao (2016) for US firms. In both cases, the analyses underline a crowding-in effect, with a dollar of tax forgone leading to more than one dollar extra of R&D expenditures. Bøler et al. (2015) examine Norwegian firms, and how the introduction of tax credits affected their R&D investments as well as their import of intermediate goods. They estimate that lowering R&D costs via tax credits leads to higher R&D expenditures and imports of intermediate products, highlighting a degree of complementarity between the two. Leveraging on the changes in UK tax credits law, which lowered the threshold for firms to be considered small and thus receive a more favorable tax credit treatment, Guceri and Liu (2019) study the effectiveness of fiscal subsidies on private R&D expenditures, finding tax credits to be highly effective in terms of input additionality. Chen et al (2021) adopt a regression discontinuity (RD) approach to investigate the impact of R&D-related tax incentives for Chinese firms. While the results of the paper signal an increase in private R&D investments, the evidence also points toward a significant increase in expenditure-relabeling activity. McShane and Merih (2023) examine an interesting angle regarding the mechanism behind the overall increase in R&D spending as a consequence of tax credits. In particular, they study how the reduction in R&D costs due to tax credits stimulate large firms to acquire startups, thus increasing research investment outside of the large company itself. The flipside of the coin is that these small startups, which are originally constrained and not able to benefit from the R&D tax credits, are able to increase their innovation investments by being acquired by a large company.

While R&D expenditures have been one of the most studied outcomes, the literature has been interested in identifying the effect of tax credits on a large number of different firm and worker characteristics. For example, Bartik and Hollenbeck (2012) study the impact of tax credits introduced in the state of Washington, and how these affect employment growth in treated firms. They find that the introduction of tax credits led to the creation of new jobs, but at a high cost per job created, making this policy ineffective. Hombert and Matray (2018) do not study the impact of tax credits directly, but rather use these as instruments for R&D investments, and examine how the latter helped US manufacturing firms in facing Chinese import competition. They find R&D tax credits to be a strong instrument for R&D tax expenditures (suggesting additionality), and that firms investing more in R&D are less negatively affected by import competition. Dechezlepretre et al. (2023) rely on the same tax credit policy change examined in Guceri and Liu (2019) but investigate a wider share of outcomes for UK firms. They find the policy to be highly effective in stimulating private R&D expenditures, as well as patenting activity. The authors point that the relatively high estimates they obtain can be due to the focus on small firms, which are more likely to be credit constrained. Examining the implementation of tax credits in California, Balsmeier et al. (2024) find that fiscal incentives lead to higher patenting activity. However, the results indicate that the new patents tend to stay within the technological areas known to the patenting firm, which signal less disruptive innovation, with this more conservative research behavior stronger in industries with more profit uncertainty. Interestingly, Balsameier et al. (2024) observe that tax credits are positively linked to an increase in markups and stock market valuation, together with a more diffused use of “blocking” patents and less entry of competitors, indicating a stifling effect on the creative destruction process. Tax credits have also been studied in relation to their effect on labor mobility. Using a linked employer-employee panel from the US, Babina and Howell (2024) estimate that tax credits (used as an instrumental variable) stimulate R&D

investments, and that these in turn are causally linked to an increase in entrepreneurial activity of employees of treated firms, while they do not observe increased worker mobility to other firms or outside of the labor market.

6. Summary

This brief survey of recent articles on the effectiveness of R&D public policies includes studies covering different geographic and historical context, making a degree of variation across the results expected. However, we are able to draw a set of broad conclusions, based on the evidence we have reviewed (summarized in Table 1). Both the macro- and micro-level studies covered in the review have highlighted that R&D policies such as direct grants and fiscal benefits, most importantly R&D tax credits, do stimulate private R&D spending, and they do that in an additional fashion, rather than just via a substitution of privately funded research with publicly funded one. In other words, public support leads to a higher rate of R&D investments overall. There are some support policies that seem less effective, such as the use of level-based vs incremental-based tax credits, but the aggregate picture offers a favorable assessment of public innovation policies, in terms of stimulating R&D.

This positive result does not tell the whole story, because this additional R&D spending might not lead to actual productive innovation and economic growth. For example, the aforementioned analysis in Chen et al. (2021) points toward the risk of expenditure-relabeling activity, or, as found in Balsmeier et al. (2024), the quality of patents produced as a result of tax credits might be of lower quality and aimed at stifling competition. However, taken as a whole, most of the studies we examined indicate a positive impact of public intervention on innovation and patenting activity, with some analyses estimating a substantial increase in private value because of these innovations, thus pointing toward economic effectiveness of these policies.

Also, recent studies have highlighted the importance of public R&D interventions in generating positive knowledge spillovers.

Even more variation is found in the results regarding the impact of innovation policies on economic growth, usually measured as the effect on employment, wages and productivity. The broad conclusion we can draw in this regard, based on the articles covered in the review, is that public intervention aimed at stimulating R&D is positively linked to employment and productivity growth, even though the effect can materialize over the long term, making an assessment of the effectiveness of these policies in terms of public finances difficult. While some examples of public interventions, such as the public funding of agricultural-related research in Brazil (Akerman et al., 2025) or the WWII-related R&D investments studies in Gross and Sampat (2023), have proven to be effective in stimulating long-term economic growth, other cases, such as the public investments related to the space race of the 1960s studied in Kantor and Whalley (2025), give a much less optimistic picture. This indicates that the effectiveness of public intervention depends on the context and on the implementation of the policy. Moreover, it is important to point out that the evidence we reviewed may suffer from a publication bias which might impact our conclusions, as found, e.g., in Dimos et al. (2016).

To conclude, while we observe more uncertainty in the evaluation of the effectiveness of public R&D policies as we move forward further along the innovation process, from the initial stimulus to R&D investments, to innovation and finally to productivity and economic growth, the overall picture is positive. Based on the evidence we have reviewed, public intervention in R&D is effective in generating innovation and in stimulating productivity growth.

Table 1: Summary of studies in the review

Article	Country	Target Outcomes	Policy of interest	Unit of observation	Method	Main results
Bloom et al. (2002)	Multi-country	R&D expenditures	R&D tax credits	Country	OLS (instrumental variable)	Tax credits lead to increasing R&D intensity in both the short and long run.
Hyytinen and Toivanen (2005)	Finland	R&D expenditures and sales growth	Direct R&D subsidies	Firms (SMEs)	OLS (Fixed effects)	Public funding alleviates capital market imperfections which affect SMEs and leads to higher R&D investments and growth. Overall welfare effects cannot be assessed.
Wolff and Reinthaler (2008)	Multi-country	R&D employment and expenditures growth	General government support to R&D	Country	OLS (Instrumental variable)	Higher public support for R&D leads to higher R&D expenditures and employment, with the former effect stronger, implying average wage growth.
Einiö (2009)	Finland	R&D expenditures	Direct R&D subsidies	Firm	OLS (Instrumental variable)	Direct subsidies lead to higher private R&D expenditures. The subsidy is economically effective
Bartik and Hollenbeck (2012)	US (Washington)	Jobs, earnings, earnings per worker	R&D tax credits	Firms	OLS (Instrumental variables)	Jobs were created, but at high cost.
Lokshin and Mohen (2012)	The Netherlands	R&D expenditures	R&D tax credits	Firms	OLS (Instrumental variable)	Tax incentives boost R&D spending, with a crowding-in which becomes larger over time, but only for small firms. Not effective in terms of welfare, mostly due to the high costs of a level-based scheme.
Takalo et al. (2013)	Finland	Profits, spillovers	Direct R&D subsidies	Firms	Structural model	Profits increase, but spillovers are smaller (60% profits). Larger firms and harder projects generate more spillovers,. Overall welfare effect is positive.
Thomson (2013)	Multi-country	R&D expenditures	R&D tax credits	Industries	OLS	Statistically significant benefits.

Einiö (2014)	Finland	R&D Expenditures, employment, sales and productivity	Direct R&D subsidies	Firms	OLS (Instrumental variable)	Positive effect on employment, R&D expenditures and sales. No short-term effect on productivity but positive long-term effects
Moretti and Wilson (2014)	US	Presence of star scientists, employment and wages. Patenting	R&D tax credits	States	OLS (Diff-in-diff)	R&D incentives lead to more star scientists, as well as to employment growth and more patents of the biotech clusters. No effect on wages
Bøler et al. (2015)	Norway	R&D expenditures, imports	R&D tax credits	Firms	OLS (Diff-in-diff with instrumental variable) and structural model	Tax credits boost R&D investments as well as imports of intermediates
Karhunen and Huovari (2015)	Finland	Productivity, survival	Direct R&D subsidies	Firms	OLS (Diff-in-Diff with propensity score matching)	Subsidies do not impact productivity, but lead to higher employment growth and survival rate of SMEs.
Koski and Pajarinen (2015)	Finland	Productivity, survival	Multiple subsidies, including R&D subsidies	Firms	OLS (Diff in diff with instrumental variable)	No effects on productivity, increased survival rate of less efficient firms.
Bronzini and Piselli (2016)	Italy (Emilia Romagna region)	Patents	Direct R&D subsidies	Firms	OLS (Regression discontinuity)	Effective at the intensive margin, stimulating patenting activity, especially for small firms. Extensive margin (firm starts to patent) improves only for small firms.
Bøler et al. (2015)	Norway	R&D expenditures, imports	R&D tax credits	Firms	OLS (Diff-in-diff with instrumental variable) and structural model	Tax credits boost R&D investments as well as imports of intermediates
Karhunen and Huovari (2015)	Finland	Productivity, survival	Direct R&D subsidies	Firms	OLS (Diff-in-Diff with propensity score matching)	Subsidies do not impact productivity, but lead to higher employment growth and survival rate of SMEs.
Koski and Pajarinen (2015)	Finland	Productivity, survival	Multiple subsidies, including R&D subsidies	Firms	OLS (Diff in diff with instrumental variable)	No effects on productivity, increased survival rate of less efficient firms.
Bronzini and Piselli (2016)	Italy (Emilia Romagna region)	Patents	Direct R&D subsidies	Firms	OLS (Regression discontinuity)	Effective at the intensive margin, stimulating patenting activity, especially for small firms. Extensive margin (firm starts to patent) improves only for small firms.

Rao (2016)	US	R&D expenditures	R&D tax credits	Firms	OLS (Instrumental variable)	Tax credits boost R&D intensity, mostly through wages and intermediate products. Both short and long run effects. Not much difference between small and big firms (or young and old). Significant heterogeneity across industries
Slavtchev and Wiederhold (2016)	US	R&D expenditures	Public procurement shift toward high tech ind	States	OLS (Instrumental variable)	A shifts of public procurement towards high tech leads to increased R&D investments.
Cin et al (2017)	South Korea	Productivity and employment	Direct R&D subsidies	Firms	OLS (Diff-in-diff with probit/logit)	Subsidies positively impact both employment growth and productivity
Chang (2018)	US	R&D expenditures	R&D tax credits	States	OLS (Diff-in-diff with instrumental variables)	Significant additionality of R&D expenditures to tax credits
Hombert and Matray (2018)	US	Resilience to import competition (measured by sales and profits, capital stock and employment)	R&D tax credits	Firms	OLS (Instrumental variable)	R&D tax credits are used as instruments to R&D expenditures. R&D-intensive firms are more resilient to import competition
Azoulay et al (2019)	US	Patenting activity	Direct R&D subsidies	Research topics	OLS (Instrumental variables)	Subsidies lead to more patenting in funded topics. Hard to measure the value of these patents. Innovation spillovers to other research areas.
Crespi and Guarascio (2019)	Multi-country	Patenting activity	Public procurement	Industries	OLS (Fixed effects Poisson regressions)	Procurement stimulates patenting, but the effect is attenuated by the degree of import penetration
Guceri and Liu (2019)	UK	R&D expenditures	R&D tax credits	Firms	OLS (Diff-in-diff)	Tax credits stimulate private R&D spending, with strong additionality

Agrawal et al. (2020)	Canada	R&D expenditures and wages	R&D tax credits	Firms	OLS (Diff-in-diff)	Tax incentives boost private R&D expenditures (wages) and suggest additionality. The policy is more effective for firms which already have enough fixed capital
Castillo et al (2020)	Argentina	Spillovers, worker wages, firm profits and employment	Direct R&D subsidies	Firm/Employees	OLS (Fixed effects)	Workers exposed to public grants experience higher wage growth, with high-skilled workers benefiting more. Firms hiring affected workers improve performance, suggesting spillovers.
Fazio et al. (2020)	US	Quantity and quality of new businesses	R&D tax credits and investment tax credits	Counties	OLS (Diff-in-diff)	Increase in quantity and quality-adjsuted quantity of entrepreneurship over 10 years. Investment tax credits have much smaller impact.
Fornaro et al. (2020)	Finland	R&D expenditures, innovation, productivity, collaboration propensity	Direct R&D subsidies	Firms	OLS (Propensity score matching)	Subsidies lead to more R&D expenses and hirings, subsidized firms collaborate more, but regression results for those are insignificant due to lack of observations. No impact on productivity and no spillovers.
Rehman et al. (2020)	Multi-country	R&D expenditures	Public R&D investments	Countries	GMM	Public R&D stimulates private R&D, especially before the 2008 recession
Balsmeier et al (2021)	US (California)	Markups, patenting	R&D tax credits	Firms	OLS (Coersened exact matching)	Tax credits lead to more patents, but less innovative ones. This is in turn associated with higher markups and valuations, and lower valuation for competitors.
Chen et al (2021)	China	R&D expenditures, spillovers and productivity	Corporate tax cuts linked to R&D	Firms	Bunching estimator	R&D expenditures increase, but quite a lot of relabeling. However, there are sign of effective policy in terms of raising productivity and generating positive spillovers.

Minniti and Venturini (2017)	US	Productivity growth	R&D tax credits and federal subsidies	Manufacturing Industries	OLS (Cross-sectionally augmented distributed lags)	10% tax credits increase lead to 0,4% increase in yearly labor prod, direct subsidies have no long-lasting effects.
DeLipsis et al. (2023)	US	R&D expenditures and GDP	Public R&D investments (and expectations of future investments)	Country	OLS (Structural VAR)	Crowding-in of private investments, permanent boost to aggregate output, expectations matter.
Koski and Fornaro (2022)	Multi-country	R&D expenditures and patent applications	R&D tax credits	Countries	OLS	Incremental deduction or hybrid scheme boost more expenditures, as well as SMES preference. Hybrid schemes help innovation more.
Myers and Lanahan (2022)	US	Patents and spillovers	Direct R&D subsidies (Department of energy grants)	Firms/technology areas	OLS (Instrumental variable)	Substantial spillover effects from grants to small firms, mostly occured within the US and spreading to non-related tech areas.
Schweiger et al. (2022)	Russia	Presence of high-skilled workers, R&D and ICT sectors, patents, economic activity and productivity	Public R&D investments	Municipalities	OLS (Diff-in-diff with matching)	Persistent impact of public R&D spending on science cities, which fare generally better even after the cut in spending.
Ciaffi et al. (2024)	Multi-country	GDP, productivity and private R&D expenditures	Public R&D investments	Country	OLS (Local projections)	Significant positive impact on GDP, productivity growth and private R&D (crowding-in)
Dechezlepretre et al. (2023)	UK	R&D expenditures, patenting, productivity, employment	R&D tax credits	Firms	OLS (Regression discontinuity)	Tax credits boost R&D expenditures, patenting and productivity, generating spillovers. Strong effects might be due to the subsample examined (SMES).

Howell and Brown (2023)	US	Earnings, employment, revenues	Direct R&D subsidies (Department of energy grants)	Firms	OLS (Diff-in-diff with regression discontinuity)	Grants lead to higher average wages (for "stayers" and increasing with tenure), revenues and employment. Wage growth is mostly due to initial "too low" wages growth in credit-constrained firms.
Gross and Sampat (2023)	US	Innovation and clustering, employment growth and firm creation	R&D public investments	Technology cluster (county X tech area), County, Aggregate	OLS (Diff-in-diff)	Strong positive effects on innovation clusters, through agglomeration, employment and firm creation. Also improved patenting in treated areas, compared to foreign countries.
McShane and Merih (2023)	US	R&D expenditures, mergers and acquisition activity	R&D tax credits	Firms	OLS (Including Poisson regression)	Tax credits lead to more expenditures and more MA activity. Acquired startups benefit from the tax credits obtained by large firms.
Dyevre (2024)	US	Productivity growth	Direct R&D subsidies (cuts in fundings)	Firms, region, aggregate	OLS (Instrumental variables)	Public R&D spillovers are significant, larger than private ones, linked with productivity and own R&D spending growth. Significant aggregate effect, explaining 1/3 of productivity growth decline
Fieldhouse and Mertens (2024)	US	Innovation and productivity	R&D public appropriations, separating military and civilian R&D	Country	OLS (Local projections)	Non-military R&D boosts productivity, but with long lags, and innovation. Effect is smaller for miltary R&D. Results are explained by focus on basic research. Not much of an effect on private R&D.
Melnik and Smyth (2024)	US	R&D expenditures and patenting activity	R&D tax credits	States	OLS (Doubly-robust diff-in-diff)	Positive effect on R&D expenditures. No effect on patents quality and quantity (measured by citations), but increase in novelty and market value of patents. The results are driven by larger firms and are larger for higher tax credit rates.

Santoleri et al (2024)	Multi-country	Firm-level outcomes including investments, innovation, survival and growth, spillovers	Direct R&D subsidies	Firms	OLS (Regression discontinuity)	Positive impact on investments (especially intangibles), patents and external financing with heterogeneity (relatively smaller and younger firms benefit more). Signs of positive spillovers.
Akerman et al (2025)	Brazil	Agricultural productivity and patenting.	Public R&D investments	Municipalities	OLS (Instrumental variables)	Public R&D investments have been effective in boosting research and agricultural productivity, effective in economic terms.
Antolin-Diaz and Surico (2025)	US	GDP and productivity growth	Military spending and public R&D spending shock	Country	OLS (VAR)	Public R&D investments (and to a lesser extent military spending shock) have a long run effect on GDP and productivity, via R&D and innovation channel. Multiplier becomes large after a long time.
Bergeaud et al. (2025)	France	Private R&D spending and innovation output	Public funding to R&D clusters	Industry-commuting zone pairs	OLS (Diff-in-diff)	Public funding to a given academic clusters generate positive spillovers to firms geographically and technologically close to the clusters, both in terms of R&D expenditures and innovation output.
Gazzani et al. (2025)	US	GDP, productivity growth, private R&D investments	Public R&D spending	Country	OLS (Local projections)	Publicly funded patents that are owned by privates explain a disproportionate share of GDP and TFP fluctuations. Crowding in effect of public R&D investments on private ones.

Kantor and Whalley (2025)	US	Value added, employment, capital accumulation and productivity	R&D public investments (space-race)	County-industy pairs.	OLS (Triple difference, instrumental variables)	Positive effects on value added, employment and capital accumulation in industries associated with the space race. However, the fiscal multiplier is relatively small and there are no effects on productivity
Moretti et al (2025)	Multi-country	R&D expenditures and productivity growth	Defence-related R&D shocks	Industry-country, firm-level	OLS (Instrumental variables)	R&D shock leads to crowding-in of private R&D expenditures and productivity growth
Reshid et al. (2025)	Sweden	Spillovers (proxied by new firm creation), firm performance and wages	Direct R&D subsidies	Firms/Employees	OLS (Diff-in-diff with regression discontinuity)	Firms founded by employees leaving a subsidized firm have higher survival chances and higher employment growth, even though the entrepreneurship rate of employees is the same. Existing firms who hire a treated employee perform better (among SMEs), no earning effect on the employee. Overall, signs of positive spillovers.
Fieldhouse and Mertens (2026)	US	Productivity growth	Direct R&D subsidies, specifically the CHIPs act	Country	OLS (local projections)	Find that implementing fully the R&D funding increase authorized by the CHIPS act would lead to substantially higher productivity growth. The implied benefits would exceed dramatically the costs of the program.
Takalo et al. (2026)	Finland	Welfare effects	Direct R&D subsidies and R&D tax credits	Project-level	Structural model	R&D subsidies have a negative welfare impact of 0.7% due to application costs, while tax credits are welfare-enhancing (0.6% welfare improvement). Tax credits are much more expensive for the government, reducing greatly their welfare benefits.

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