Innovation Policy Effectiveness in Emerging Countries: Lessons from Impact Evaluation Studies

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Introduction

In MICs, innovation policy is one of the most important questions for policy makers seeking to facilitate catching-up and building new competitive advantages. Innovation is a key determinant of long-term growth (Rostow 1959; Romer, 1990; Griliches, 1998) and countries' competitiveness. Innovation activities -which include both knowledge creation and technology diffusion activities- are fundamental for catching up with high income countries (HICs) (Lee, 2013). Research has shown the returns to in-house investments in R&D and innovation increase as countries move up to higher stages of development (Goñi & Maloney, 2017), which makes of innovation a key question for MICs.

Yet, how innovation policy can work for MICs and the mechanisms and conditions through which it can support transformation and impact are not fully understood. Knowledge and innovation investments -notably in terms of R&D- do not unconditionally translate to productivity growth: many complementary factors need to be in place for that to happen. Rich evidence exists from HICs on these questions -notably in the use and effectiveness of policy instruments (e.g., Zuniga-Vicente *et al.,* (2012), Becker (2015) and Petrin (2018) for surveys of research), but lessons cannot directly apply or be generalized to MICs' contexts.

This Note aims at facilitating understanding about the effectiveness of innovation policy instruments -notably R&D and innovation subsidies and collaborative modalities-, and their relevance and potential for addressing innovation needs in MICs. We review the findings and lessons from empirical research on the effects of interventions in terms of input (crowding-in private innovation investment) and output "additionality" and firm economic performance.

We also review key findings and insights from empirical research for MICs regarding the heterogeneity of impact across different types of firms and industry contexts -and compare these results with those from HICs. We are interested in understanding what type of firms and industry conditions respond better to policy incentives and how countries can leverage policy effectiveness through improved targeting. We also discuss policy lessons regarding the uptake of programs and the role of complementary policies for their deployment and impact. In particular, the paper seeks to provide insights from research regarding the potential interplay of innovation policy interventions with other public policies, notable with respect to competition and supportive policies. We review evidence regarding how competition conditions may affect the effectiveness of policy interventions.

Finally, we discuss the evidence on indirect effects (knowledge spillovers) and identify mechanisms to favor their development and impact of innovation policies. Our literature review focuses mostly on recent empirical research (from the mid-2010s and onwards) and evaluation studies that deal with selection bias and endogeneity of treatments.

This Note is organized as follows. In the first part, we revisit the rationale of innovation policy and briefly review key concepts and trends in policy practice. In the second part, we review the role of innovation and evolving approach to innovation policy across countries with different income levels. In the third part, we review the results and key messages from impact evaluation studies; we distinguish the direct and indirect (spillover) effects, and the evidence regarding impact (firm and sector) heterogeneity. In the conclusion section, we summarize lessons for the design of more effective innovation policies in MICs.

1. Innovation Policy: Main Concepts and Rationale

The rationale for innovation policy is well known. As discussed by (Hall B. , 2009) and Hall and Lerner (2010), innovation activities are subject to important market and system failures. This is due to the weak appropriability of ideas and the risks associated with costly and uncertain investment (especially R&D). This situation results in private investment levels lower than the socially optimal (Arrow 1962; Nelson 1959). Other failures may prevent firms from engaging in innovative activities, such as (lack of) coordination (e.g., connectivity between public and private innovation actors; or among related firms facing common innovation challenges); or institutional failures -i.e., deficiencies in norms, practices, culture, or regulatory frameworks that constrain or weaken firm innovation incentives. Other constraints relate to gaps in human capital and infrastructure, or economic uncertainty (macro-economic conditions).[1]

In general terms, governments use three mechanisms to alleviate market failures in innovation: (1) public R&D activities through research institutes or national laboratories; (2) strengthening the protection for intellectual property rights (IPR); and (3) implementing policies and programs that help lower the costs and risks of investing in R&D and innovation. Innovation policies include direct funding support to businesses research and development (R&D) and innovation through grants, subsidies (including credit lines and guarantees) or indirect incentives through tax benefits (credits, allowances, or accelerated depreciation of investments) -see Box 1 in Annex for a summary of instruments -, and direct technical assistance by public knowledge or private providers, among others.

Innovation policy can help ease obstacles to technology uptake and foster innovative enterprises and productivity, but it is not an automatic process. For their deployment and impact, innovation policy needs framework conditions and baseline policies in place to be effective. The

[1] According to the Oslo Manual (OECD and European Comission, 2015) innovation activities include those associated to Research and Development (R&D), the acquisition of machinery and equipment supporting innovation (including investment in information and communication (ICT) technologies and software), the purchasing of technology through licenses or through the acquisition of intellectual property rights; training activities associated with innovation (product, process, or non-technological innovation), the contracting of knowledge and technology services (i.e. external R&D or purchasing of engineering services), and investments in activities related to marketing, branding, and commercializing innovations, among others.

effectiveness of subsidies (and tax incentives) in leveraging additional investment may differ across different types of firms, and types of investments, and depends on other policy measures enabling innovation investments and their uptake -e.g., in complementarity with other support measures.

A major challenge for policymakers is how public support translates into long lasting benefits in terms of innovation activity and firm performance, and how this support can promote spillovers more widely in the economy -beyond supported firms. Impact of policy intervention is above all expected in terms of knowledge spillovers -or how interventions can promote change and productivity improvement through demonstration and knowledge spillovers effects.

It must be noted that new approaches in innovation policy are emerging (e.g., mission-oriented innovation policies (Mazzucato, 2018) that mobilize traditional instruments as well as new mechanisms (e.g. collaborative models) to address innovation challenges at a larger scale. The motivation of mission-oriented policies, for instance, aim at providing better directionality (resources and actors) -compared to the past- and articulation of policy efforts to solve specific industry or societal challenges -e.g., the green transformation, the creation of new strategic sectors with global relevance (e.g., green hydrogen and lithium industries -e.g., Chile). In deploying these new approaches, countries should know how to mobilize instruments and ensure these actions are effective in reaching goals and returns to public resources.

2. Innovation Policy and Development

There is no one-size-fits-all approach to innovation policy. The type of innovation activity (e.g. technology acquisition) to be targeted as well as the supportive policy mix, changes with different income levels. Different sets of policies are relatively more appropriate for countries at different stages of economic development (Lundvall, 1992; 2003). More generally, national innovation systems (or NIS) [2] and supportive policies need to be tailored to the level of development (Lundvall, 1992; Freeman, 1987) addressing countries' different demands for learning, diffusion, and innovation. Their understanding highlights the need for policy action at different levels -e.g., addressing capacity building (actors), the supply of resources or the demand-side and lack of markets (Cirera & Maloney, 2017).[3]

From the evolutionary perspective, policy interventions, more than isolated actions, are expected to support collective learning and enhanced inter-linkages across the different parts

[2] National Innovation Systems (or NIS) are the networks of institutions and actors in public and private sectors whose activities, practices and interactions contribute jointly and different ways to the creation, use and diffusion of knowledge, technologies, and innovations (Lundvall, 1992).

[3] By providing a roadmap, this approach allows the identification of a broad range of market and systemic failures hindering the innovation process (Lundvall et al., 2003; Cirera and Maloney 2017).

(Teubal,1996; 2002). It is within this perspective that innovation policies should be conceived, leveraging lasting capacity and connectivity across actors.

The focus of innovation policies (IP) changes with countries' income level. At early stages of development, governments seek to create private sector industries and want to favor capital investment-oriented strategies. At this stage, acquisition of machinery and equipment (imported capital and equipment) and other forms of technology adoption are the main sources of productivity performance and technological learning. Embodied technological change through capital accumulation is often found to be more effective in generating productivity growth than R&D (e.g., El-Shal & Morsi, 2020).[4] Innovation policies at this stage then focus on facilitating technology adoption and learning (by importing and by-doing).[5] These developments are supported by access to markets, access to finance, and technical education and training systems. In turn, in countries in the middle-income group (lower), consolidating more widely a network of technology diffusion institutions gains in importance.

As the economy grows, the importance of developing in-house knowledge competences increases as more complex forms of technology transfer require an internal capacity to identify, "absorb" and assimilate technologies more effectively (e.g., Cohen & Levinthal, 1989; Griffith, Redding, & Van Reenen (2003); Elkomy, Inghman, & Read (2021). Spillovers from expanding global integration though foreign direct investment are maximized by investments in knowledge (R&D) competences (e.g., Eaton & Kortum, 1999; Coe & Helpman, 1995) -returns to external technology increase with investments in absorption capacity and more sophisticated technical skills (Griffith *et al.,* 2003). Thus, fostering R&D capacity becomes as important as fostering technology diffusion. At some point (in upper middle income and beyond), productivity gains cannot longer be supported by traditional cost advantages and external technology; home-grown innovation becomes more critical. Finally, close to the frontier, competitive advantages are mostly driven by R&D and technological innovation, and countries compete in leading the technological frontier.

According to some research, leveraging private sector's R&D in emerging countries and MICs can potentially yield high returns. While the contributions of physical and human capital-augmented labor are approximately constant across the development process, the returns to R&D trace an inverted U-shape relationship (Goñi and Maloney, 2017). Rates of return to R&D investment increase up to a threshold around middle (upper) levels of development (e.g. reaching the highest returns at the levels of Argentina, Mexico, Hungary, or Malaysia- see Goñi

[4] Imported technologies and new varieties of intermediate goods are also associated with improved productivity resulting from specialization (Grossman & Helpman 1991) and spillovers from trade (Coe & Helpman, 1995).

[5]Yet as discussed by (Guimon and Agapitova, 2013), some public R&D effort might still be necessary to develop a minimum level of absorptive capacity to support productivity and technology transfer in key sectors of the economy (e.g. agriculture, energy, etc.).

and Maloney, 2017; see also Griffith *et al.,* 2003), and diminish beyond this point.[6] For some MICs, private R&D returns have been estimated to be as large as for advanced economies, e.g., around 40% for Chinese industries ((Goh, Wei, & Xu, 2015) while in Chile, the estimate is about 30%, which is found largely superior to returns on capital investment (16%). At the firm level, the productivity effect of capital investments is higher for firms that invest in R&D -see evidence for Egyptian firms (Masso and Tiwari, 2022). In addition, private R&D can engender productivity growth in other firms through knowledge spillovers (Bloom, Schankerman, & Van Reenen, 2013).

Therefore, R&D policy is important for MICs. There is evidence that R&D policies played a key role in the take-off of Asian economies such as South Korea, China, and Singapore. However, fostering this capacity has been proven difficult. Fundamentally, returns to private R&D depends on how effectively knowledge is created, diffused, and commercialized, and the ability to appropriate profits -which entails a large range of framework conditions. Above all, returns depend critically on the human capital base of countries, which determines their capacity of absorption, and the capacity to create more innovative and more technologically advanced products and services. However, often MICs and some developing countries tend to jump into R&D policies without developing a sufficient base of advanced human capital or technology diffusion capabilities (Shapiro *et al*., 2014; Cirera *et al.,* 2020), and with deficiencies in the access to and allocation of resources (e.g. finance).

3. The rise of Innovation Policy Instruments in MICs

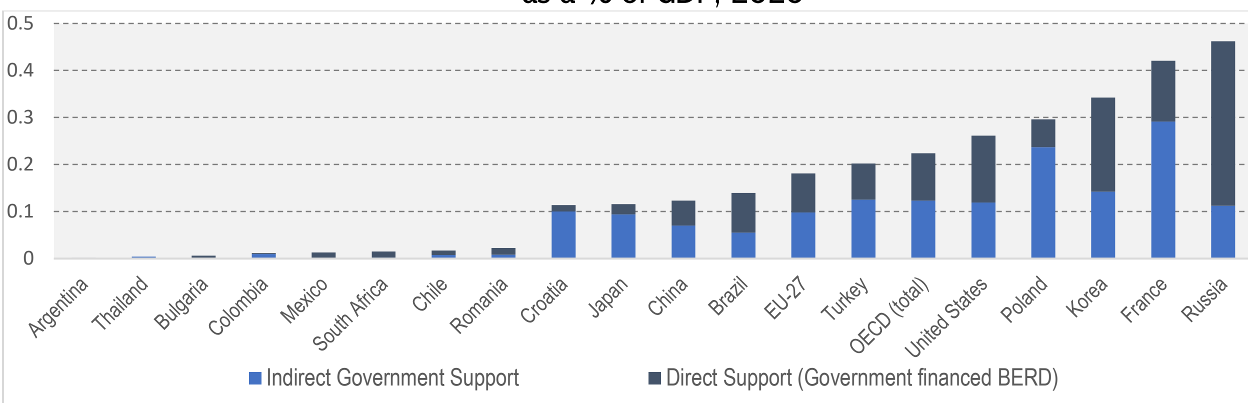
MICs tend to use a diversity of public programs for R&D and innovation support, and technology transfer. These are expected to support the development and functioning of national innovation systems. Innovation policies include direct support to businesses, research and development and innovation through grants, subsidies (including credit lines) and tax credits, and direct technical assistance by public providers or qualified private providers, among others.

Within innovation policies, subsidies (grants and matching grants) and tax incentives for promoting R&D and innovation have gained importance in MICs' innovation policy mix. While the use of subsidized loans and guarantees is quite frequent for the acquisition of machinery and equipment, and the purchasing of new technologies, the use of innovation funds (and R&D subsidies) address the need for investments in business R&D and public-private collaboration in research and innovation. Thus, subsidies help address not only funding failures but also coordination failures in innovation systems.

[6] Returns to R&D investment sharply decline with larger distance from the frontier, including potentially negative values for the countries at the very bottom of the income distribution (ibid).

With few exceptions (e.g. China), however, MICs invest very little in R&D and technology- compared to more advanced economies. As a percentage of GDP, it is around 2 percent of GDP in HICs, around 0.6 percent of GDP in MICs, and less than 0.2 percent of GDP in LICs. Another significant difference between developed and developing countries is the structural composition of R&D. In HICs, the private sector finances the majority of total R&D, more than 60 percent. In contrast, in most MICs (with few exceptions, such as Malaysia and China), the public sector is the main actor in R&D performing 70-90 % of total R&D activities and funding about the same ratios.

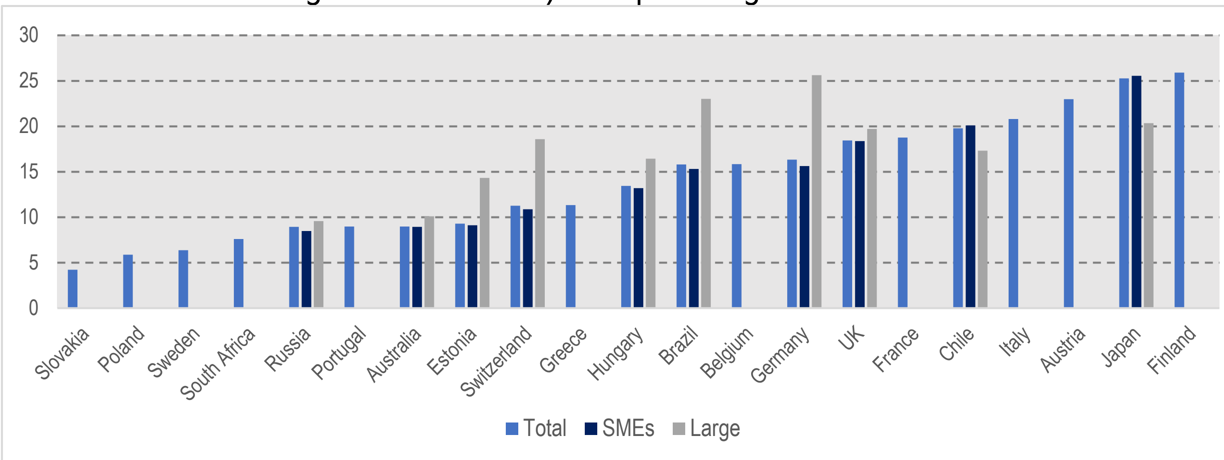
Figure X.1: Direct and Indirect Government Support for Business R&D as a % of GDP, 2020



Source: OECD Tax Incentive Database (2023).
Note: Direct government support refers to total Business R&D (BERD) that is financed by governmental sources. Indirect government support refers to % of Business Expenditure on R&D that received tax incentives.

Although innovation and R&D support programs seem to multiply in MICs, the scale and reach of these programs, and total funding allocated remains very small. In addition, in many MICs and emerging countries, the number of firms supported (as share in total innovation-active firms)-, differs drastically from figures reported for more advanced economies. For instance, in South Africa and Russia less than 10% of innovative firms report some type of public funding for innovation, whereas this figure is about 26% in Japan and Finland. An exception are Turkey and Chile where about 20% of innovative firms declared to receive some type of public funding for R&D and innovation investments – according to data from the OECD Business Innovation Indictors (2022).

Figure X.2: Firms receiving government funding for innovation (including R&D and excluding contracts for goods and services) as as percentage of innovation-active firms



Source: OECD Business Innovation Indicators (2022) based on data from national innovation surveys.
Note: Innovative firms refers to firms that have reported innovation activities or introduced product or process innovation.

4. Innovation Policies and Evaluation Methods

What is R&D and innovation grants and how do they work? R&D and innovation subsidies are common tools used by governments to encourage innovation and research and development activities. R&D and innovation subsidies often take the form of a competitive funding program (project-based) in which selected firms receive a (non-reimbursable) grant or matching grants (co-financing mechanisms). In the later, the government matches private funding for the deployment of an innovation/R&D project (running over one-two years) at certain pre-defined percentages.[7]

In some cases, projects can be individual firm projects or collaborative linking several firms, or firms with public S&T institutions. It must be noted that in MICs, these innovation programs not only target R&D investments. Often, the call for competitive projects considers - under eligibility criteria -a variety of investments related to reaching product or process innovation such as technology acquisition, design and engineering, adoption of organizational or new marketing practices, among others. Projects involving more complex knowledge and (more basic) R&D targeting more complex technological solutions are often addressed through collaborative programs.

R&D tax incentives are designed to promote R&D activity by reducing the user cost of R&D and encouraging private companies to increase their innovation efforts. In general, tax cuts improve operating cash flow and provide firms more financial resources to fund innovation

[7] In some countries, subsidized loans an also follow the same evaluation criteria. For grants and matching grants, the time of support often ranges between one-two years for purely business projects whereas for larger projects involving different entities (consortiums), project support can take 3-4 years.

(Atanassovand Liu, 2020; Mukherjee *et al.,* 2017). Under a neoclassical framework, if R&D expenditure is fully deductible, the tax rate should not affect innovation since it does not change the after-tax marginal benefit and cost of innovation. However, when the financial market is incomplete or inefficient and a firm mostly relies on its own after-tax profit, a lower effective tax rate could affect innovation investment.

R&D and innovation tax incentives can take a variety of forms (see Appelt et al., 2016): discounts, credits, allowances, accelerated depreciation or amortization, reduction, or exemption of taxes (on innovation investments or outputs) or special treatment granted by the government to firms with positive innovation spending or that are implementing innovation projects. They can apply to the overall volume of (R&D) investment (incurred in the previous year or period of years), or to the incremental changes in this amount. In most countries, these incentives focus on R&D activities, but in some countries, they extend to other forms of expenditures. In some MICs (e.g. Brazil, India, and Argentina), tax incentives apply to the hiring of researchers and other specialized labor, innovations resulting in patenting (e.g. Brazil), importing of technologies and equipment (reduced tariffs), and/or the contracting of R&D services and other intangible investments (e.g. software and ICT).

An extensive body of econometric work has examined the effects of R&D and innovation policies -mostly focused on R&D subsidies and tax incentives- on private innovation investment (e.g., for a review of evaluation studies see Zuniga-Vicente *et al.,* 2014; Beck (2015) and Petri, (2017), among others). The key policy question is to evaluate the impact of policy interventions or how much a firm would have invested in innovation if she had not received public support. Governments are also interested in impacting firm innovation performance, and how this translates into improved economic performance. In this sense, researchers look at different outcome measures associated with innovation investment and outcomes (after intervention) and firm economic outcomes and evaluate whether public policies generate “additionality” effects and leverage firm performance.

In conducting policy impact evaluations, the problem of endogeneity and selection bias is a major issue. Selection bias arises because the allocation of subsidies is not necessarily a random process and prone to "selection bias" (Klette et al., 2000; David et al., 2000). Selection bias is treated through different methods including propensity matching methods (PSM), PSM with conditional differences, regression discontinuity, and endogenous treatment models (IV or structural equations), as well as counterfactual analysis with panel methods. Counterfactual analysis allows comparison with comparable firms (control groups) while helping with selection bias whereas fixed effects address unobserved heterogeneity.

Evaluation exercises using counterfactual analysis have become quite popular. In general terms, the first question to be answered in the evaluation of R&D support is “what the firm would have spent on R&D had it not received the subsidy” (Lach, 2002); thus, a contrafactual group is required for comparison from the group of non-beneficiaries. To determine whether the recipients of support (in comparison to non-recipients) increased their R&D or innovation activity thanks to subsidy, (parametric) regression methods and (non-parametric) matching methods often combined DID estimation are extensively used.

In this report, we review empirical studies from MICs that evaluate the impact of R&D/innovation tax incentives and subsidies on firm innovation activities and economic performance. We focus on studies that employ econometric techniques dealing with sample selection and endogeneity of treatment, and unobserved heterogeneity -preferably with panel data. We mostly focus on empirical research from the last 10-15 years. Findings across countries may vary not only in terms of significance and magnitude, but also in the direction of effects (especially in sub-groups). This is mostly due to sample issues (research designs are quite similar), differences in support programs as well as specificities of national contexts (e.g. industry composition; tax or startup policy, among others).

We should be aware that measuring additionality only provides a partial picture of the overall effectiveness of interventions. To determine the net effectiveness of policy interventions on welfare requires a full cost-benefit analysis. The latter should consider direct and indirect impacts of policies, implementation, and compliance costs, plus the public resources needed to finance policy interventions (David et al., 2000; Appelt *et al.*, 2019; OECD, 2020). Few studies, however, have undertaken this exercise since often lack of data constraints such analysis.

5. Policy Impacts: The Direct Effects

In the case of R&D-innovation subsidies, policy impact is evaluated at three different dimensions of additionality or "crowding-in", namely "input" additionality, "output" additionality and "behavioral" additionality (Veugelers, 2015). Input additionality or "crowding-in" (i.e., additional inputs that would not have been created without policy intervention) refers to the impact interventions may have in leveraging private investments -additional to the amount of public support after intervention. In terms of overall "effectiveness" of subsidies, however, the additional investment should be compared to the amount of public funding. The "average additionality" (or multiplier effect) refers to how much additional private investment is leveraged by one monetary unit of public funding (Appelt *et al.,* 2019).

Crowding-in inputs can occur if the subsidy or tax support effectively reduces the costs of investment and encourages firms to expand innovation investments -discounting public funding (extensive margin). Additionality in innovation activities can also take the form of "new firms" entering R&D and innovation ("the intensive margin"). Output additionality is related to increases in the proportion of innovation outputs (e.g., new product innovation or service innovation, new or significantly improved production processes, patenting, new exported products, etc.) because of the policy that would not have been achieved without the public intervention. In addition, government subsidies can generate a “signaling” or “certification effect” for supported firms and their business projects - which further leverage resources to invest in R&D and innovation (Feldman and Kelley, 2006).

There are several reasons why innovation policy interventions may not be effective (Veugelers, 2019). First, public funded R&D may directly substitute for private funding of (R&D) projects that would have been undertaken anyway in the absence of this public support. This possibility is more likely to happen in firms reporting low financial constraints or being strong R&D performers. Identifying firm financial conditions in detail though is rather difficult for public agencies -but some indicators could be considered. Crowding-out can also occur because governments tend to reduce the risks of failure and may favor selection of strong performers - i.e., firms already engaged in R&D which may not necessarily be those that suffer the most from funding failures. These firms, in turn, might use such resources for other purposes.

Second, extra R&D investment generated by public funding may indirectly crowd-out private R&D and innovation, by increasing the demand for R&D inputs, leading to higher costs of research inputs. This crowding-out effect will be more significant the more inelastic the supply of research inputs. This makes sense, especially for the supply of specialized human capital (researchers and technologists), which can be fixed in the short run. As most of the R&D spending could reflect salary payments for R&D and innovation workers, this effect may turn out to be highly dominant (see Goolsbee, 1998). The evidence available suggests, however, that this effect (wage increases and labor supply contraction) is rather limited -at least for the case of developed countries (OECD, 2020; Appelt et al., 2019). Finally, there is the problem of political capture, resulting in the selection of the wrong projects -not the most innovative, or benefitting firms that would have invested in innovation regardless of support. (Fang *et al.,* 2018).

According to the available evidence for MICs and developed countries, public support through innovation subsidies and R&D tax incentives can help promote innovation investments and firm performance in beneficiary firms -compared to non-supported in control groups (see Box 2 in Annex -for a list of examples of programs). By reducing costs in R&D and innovation investment, encouraging skills upgrading and/or facilitating access to specialized skills and infrastructure through innovation partnerships, innovation support programs can leverage private investment in R&D and innovation. Thereby subsidies help address not only funding failures but also coordination failures in innovation systems, and the need for firms to access knowledge competences and expertise at national public research and technology institutions.

For R&D and innovation subsidies, there is evidence of a multiplier or crowding-in effect (“additionality”) in LAC and European countries, meaning that public funds leverage private investment, or at the very least, help accelerate private investments in R&D and innovation, and thereby help improve firm innovation and economic outcomes in the medium run. Individual country evaluations showing evidence of crowding-in effects in LAC countries include Chudnovsky *et al.* (2006) for Argentinian firms (in entrant firms), De Negri *et al.* (2006a and 2006b) and Agerber et al., (2012) for Brazilian firms, Castillo *et al.,* (2011) for Colombian firms; Aboal and Garda (2015) for Uruguayan firms, Crespi and Taczir (2011) for Panamanian firms; and Alvarez et al., (2013) for Chilean firms, among others. Evidence of crowding-in effects in private R&D investment in other countries has been reported for Turkey (Oszcelic and Taymaz, 2008), Central Eastern European countries (Foreman-Peck and Zhou, 2022) and in a sample of European firms (e.g., Bianchini et al., 2013).

In contrast, more mixed evidence including lack of impact in terms of internal R&D investment (or intensity) has been found in some studies for China (Boeing, 2016; Cheng & Chen (2006), and Poland (Zablocka-Abi Yaghi *et al.,* (2013). We must mention though that most of Chinese studies use samples of stock market-listed firms -which are firms relatively larger and with higher profit ratios -and are likely less financially constrained than non-listed firms.

Several messages stand out from our review of impact evaluation studies. First and foremost, innovation subsidies can be a powerful tool to encourage the entry of new firms into R&D and innovation activities in MICs. The evidence shows that innovation subsidies (and potentially R&D tax incentives) stimulate both the intensive and the extensive margin (entry of new performers) of innovation activities with the second effect being particularly strong in MICs (see evidence for Argentina (Chudnovsky et al., 2006), Uruguay (Aboal and Garda, 2015; Bukstein et al., 2016), Panama (Crespi *et al.,* 2011), and China (Howell, 2017) -while lower effects are reported in existing R&D performers. This is important for MICs, where the number of innovation performers is quite low and only few firms engage permanently in R&D and innovation activities (e.g. less than a quarter of Chilean firms invest in innovation (INE, 2018).

In addition, innovation support through subsidies have been found to promote innovation outcomes including certain types of technological innovation as well as marketing and organizational innovations (e.g., see Szczygielski *et al.,* (2017) for Polish firms; for product innovation evidence see Crespi et al., (2015) for Colombian firms, and Aboal and Garda (2015) for Uruguayan firms, for exporting see Guo et al., (2016)). However, according to some evidence from Latin American and Chinese firms-(e.g., Benavente et al., (2007) for Chile and Gao et al., (2021)), innovation subsidies are more prone to promote incremental forms of innovation (new to the firm and process innovation) rather than radical or more disruptive innovation (new to markets) while effects on patenting (another form of radical innovation) are often null. This result differs from findings (R&D subsidies) reported for developed countries (e.g. Appelt *et al.,* 2020) where the opposite is more likely to prevail.

There are other benefits associated with the use of R&D and innovation subsidies and the building of a more efficient innovation capacity in firms. Innovation policy programs can also promote behavioral changes such as increased collaboration with external actors (e.g., see

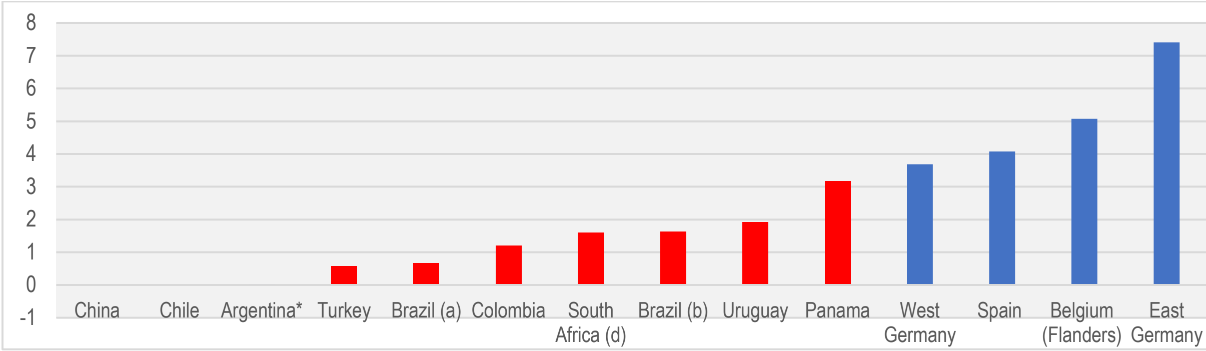
Benavente et al., (2007) for Chilean firms, Taczir and Crespi (2016) for Panama firms and Aboal and Garda (2015) for Uruguayan firms). Through innovation support programs -notably those with a collaborative approach- firms can learn about the value of different sources of knowledge, integrate innovation networks and reach new partners (e.g. startups or public S&T). Subsidies have also been found to promote new collaborations with S&T institutions in beneficiaries in Eastern European firms (see Bruhn and Mckenzie (2019) for Polish firms) and help improve firm access to other sources of finance- the "certification" effect provided by public grants (e.g., Chiappini *et al.,* 2022; and Hottenrott and Richstein, 2020).

It must be noted, though R&D subsidies show larger impacts in promoting private R&D investment intensity (see figures 3-4) in developed countries compared to firms from MICs. Although subsidies do help crowding in private investment in R&D in some MICs, this impact is much larger in richer countries (Zúñiga-Vicente *et al.* 2014; Becker, 2015).[8] In contrast, innovation support programs in MICs show larger responses in terms of total innovation investment (taking the form of non-R&D investments) than in more advanced countries (e.g. De Negri *et al.,* 2006a; Zucollotto *et al.,* 2016; Aboal and Garda, 2015). R&D tax incentives also appear more powerful instruments in developed countries.

These trends are explained by the fact that innovation resources are more readily available in HICs and framework conditions more conducive to investments than in MICs. Differences are also explained in terms of development of innovation systems and more open public S&T systems. Another important point is that the effect of innovation subsidies on existing performers (e.g. innovation-active firms) could be mostly taking place in traditional forms of investment, namely machinery and equipment. When looking at the composition of innovation investment -see e.g., the studies by Rochina Barrachina and Rodriguez-Moreno (2022) for Ecuadorian firms see and Berrutti and Bianchi (2020) for Uruguayan firms-, crowding-in mainly prevail in this type of assets rather than in R&D.

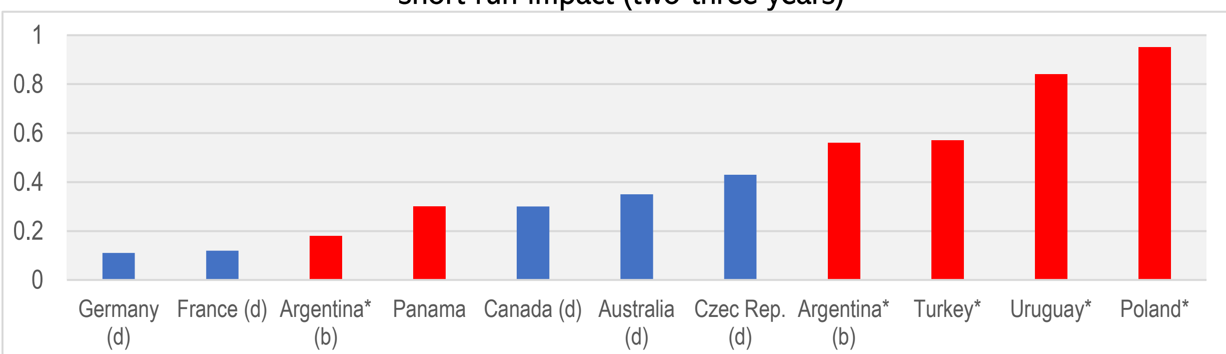
[8] For instance, estimates from counterfactual analysis (PSM) indicate that beneficiaries in Brazil (ADTEN program) reported a 0.66 percent points difference in R&D intensity (relative to sales) with respect to the control group (De Negri et al., 2007a) in a three-year period study. In a similar study, South African firms that received R&D subsidies showed 1.59 percent p.p. in internal R&D intensity compared to non-supported firms in the control group (Czartnizki and Bento, 2010) whereas in Eastern German or French companies, this impact range between 3-5 p.p..

Figure X.3: Impact of R&D/innovation subsidies on private R&D intensity (PSM estimates) - short run impact (two-three years)- percentage points difference between treated and control



Sources: Estimates from PSM estimation (first difference) are reported or coefficients from fixed effect regresion (with PSM); evlauations are conducted within the first and three years after intervention. Estimates for Argentina refer to private innovation investment. Estimates for China and Chile are non-significant.[9]

Figure X.4: Impact of R&D subsidies on total R&D or Innovation investment (PSM estimates) - short run impact (two-three years)



Source: Argentina (b): Chudvnoski et al., (2006); Turkey and Poland: Szczygielski et al. (2017); Panama: Crespi et al., (2012), Uruguay: Aboal and Garda (2015); and OECD countries (d): Appelt et al., (2019). *: Total innovation expenditure. For developed countries (d), the outcome variables are total private R&D expenditures.

Empirical evidence also indicates that the effects of innovation subsidies on firm economic performance are not immediate; they take time to materialize. Although innovation subsidies may have a null (or negative) effect on firm economic performance in the very short run (due to firm adjustments in resources and organization), innovation (particularly R&D) subsidies can help leverage productivity and firm growth in the medium and long run. Evidence along these lines is found in Crespi *et al, (*2011) for Colombian firms; Monge-Gonzalez and Rodriguez-Alvarez (2013) for Costa Rican firms; Alvarez *et al.* (2012); Averaga *et al.,* (2012) for Brazilian firms and Foreman-Peck and Zhou (2022) for Central Eastern European firms). For instance, for Colombian firms, innovation subsidies leverage labor productivity by 15% with

[9] For Argentina: estimates from Chudvnosky et al., (2006); Brazil (a): De Negri et al., (2006a) for the ADTEN Program); Brazil (b) De Negri et al., (2006b) for the FNDTC program; China (Howell, 2017); Panama: Crespi and Taczir (2013), Uruguay: Aboal and Garda (2015); Colombia: Crespi et al., (2012); Chile: Benavente et al., (2006); and d: estimates from developed countries and South Africa by Czarnitsky and Lopes-Bento (2005).

most of the impact taking place between three and five years after intervention (Crespi *et al.,* 2015) while in Costa Rican firms innovation subsidies have found raising firm employment by 19% on average over a period of 10 years (Monge-Gonzalez and Rodriguez-Alvarez (2013). For Polish firms, supported firms (receiving a grant or a loan) increased employment by 14.5 percent, value-added by 18.7%, sales by 19.2% and export value by 28.7% (Tan et al., 2019).[10]

Figure X.5: Impact of innovation subsidies on product innovation and upgrading (ATT from PSM) in European countries

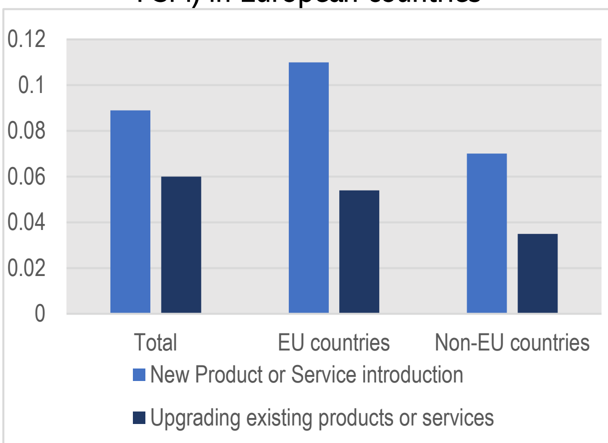
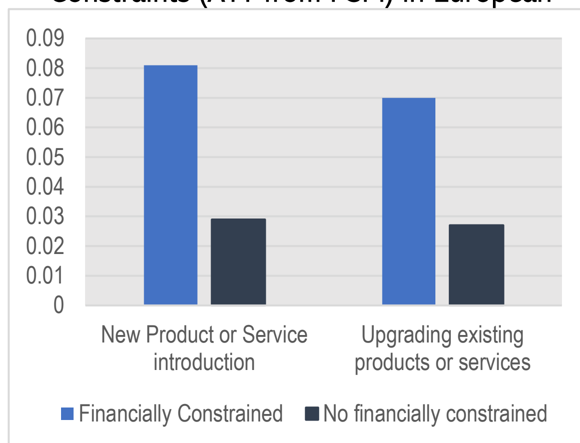


Figure X.6: Impact of innovation subsidies on innovation outcomes: The role of Financial Constraints (ATT from PSM) in European



Source: Mateut *et al.,* (2018) based on data from the Business Environment and Enterprise Performance Survey (BEEPS). Note: EU: European Union. New Product=1 if the firm introduced a new product or service in the last three years; ugrading: if the firm upgraded an existing product or service in the last three years years.

The evidence for Chinese firms, is however more mixed. Some studies report positive impacts on firm patenting and exporting after intervention compared to non-supported firms (Guo *et al.,* 2016). On the other hand, no impact of innovation grants on firm innovation, international patenting or survival has also been found (Boeing, 2018; Wang *et al.,* 2017). Accordingly, the lack of impact in Chinese beneficiaries could reflect biased allocation practices and, in some cases, political factors affecting selection (Fang *et al.,* 2023) -allocating grants or tax incentives to those that need the less or would have invested regardless of support.

With few exceptions (e.g., Chen *et al.,* 2018 and Bruhn and McKenzie, 2019), innovation policy interventions in MICs are found to be weakly influential in affecting firm patenting activity -even when considering a time delay. This suggests that supported projects in MICs are more likely focused on technological improvements rather than disruptive innovation. In parallel, R&D subsidies (and tax incentives) have also been found having a larger impact on traditional forms

[10] In Central Eastern European countries (CEECs), innovation subsidies from the EU encourage labor productivity by an average of 2.32% whereas this impact was around 2% in western European countries (Foreman-Peck and Zhou, 2022).

of innovation investment, namely machinery and equipment (embodied forms of technology), and other forms of technology acquisition compared to R&D (see Berruti and Bianchi, 2020; Crespi *et al.,* 2017). These findings reflect the prevalence of increment and adaptative innovation strategies associated with technology transfer and catching up (Navarro et al., 2011; Zuniga and Crespi, 2012). Evidence also indicates that public funding may help prevent a decline of firms' knowledge capital during recessions (Busom and Velez-Ospina, 2021).

- The role of Collaborative Programs with public S&T institutions

Innovation policies that create platform-like effects and promote positive externalities from public research have been found very effective in fostering innovation and reporting more lasting impacts on firm performance -than traditional programs (e.g. individual firm projects). An important mechanism for leveraging the impact of public research and technology institutions and knowledge transfer is collaborative R&D projects between private firms and public S&T institutions. These programs address the need for more breakthrough and complex knowledge by facilitating access to research expertise at public S&T institutions and specialized infrastructure. Although they can be more difficult to set-up, collaborative models of this kind are particularly relevant for promoting R&D activities in the business sector, since often companies in MICs have weak or no internal R&D capacity, and S&T partners can help filling such gaps. They are also more suitable to promote spillovers (than individual projects) given the more basic nature of R&D and are found more suitable to promote patenting (e.g., Castillo *et al.*, 2016; Brhun and McKenzie, 2019

In fact, collaborative programs in this approach report the largest additionality effects and impact on firm innovation performance (e.g., De Negri *et al.,* 2006b Castillo *et al.,* 2014; Brhun and McKenzie, 2019). For LAC countries, these type of innovation programs have shown having more lasting effects (longer run impact) on productivity than traditional innovation subsidies programs (see De Negri et al., 2006b; Alvarez *et al.*, 2012; Crespi *et al.,* 2015; Monge-Gonzalez and Rodriguez, 2013). Examples of these programs include: the FNDCT in Brazil (Sectoral Funds) or the program Co-Financiacion (and its new variants for regional innovation projects) in Colombia. This suggests that the participation of public partners brings additional valuable knowledge making firm investments more efficient, and helping firms develop more disruptive innovation outcomes (see Hattenrot and Veugelers, 2015; and Appelt *et al.,* 2020).

Several challenges prevail regarding the use of public-private collaborative programs in emerging countries. In both Brazil (De Negri *et al.,* 2006) and Russia (Simachev *et al.,* (2016), for instance, very few collaborations transcend over time, which indicates that public intervention through funding may not be enough to foster long run linkages between the public and private sector. At the same time, in these two countries a common criticism to these programs is that they are predominantly used by traditional actors (i.e., large firms and leading sectors); in the case of Russia, it has been argued that these mainly contribute to the "capitalization" of existing partnerships (ibid) and little to the creation of new alliances.

- The experience in R&D and Innovation Tax Incentives

In contrast to subsidies, the evidence available on the effectiveness of R&D and innovation tax incentives in MICs is more mixed -although research for these countries is still limited. One should notice that the use of R&D and innovation tax incentives has been expanding in MICs. Countries such as Chile, China, India, Turkey, Mexico, Brazil, Argentina, and Colombia use such incentives since the early or mid-2000s while in Uruguay and South Africa is more recent.

In empirical studies for MICs, R&D tax incentives have been found to have low or moderate marginal effects on private R&D investment but large responsiveness (crowding-in or higher elasticity rates) in terms of overall innovation investment. A weak elasticity of private R&D with respect to user cost -i.e., lower than one -, has been found in several empirical studies (Turkey, Brazil, Argentina, and Ecuador) whereas in OECD countries this elasticity is often reported superior to one; see Appelt *et al.,* (2020) for a cross-country study (micro-level), and Guceri et Lou (2016) and Dechezlepettre *et al.,* (2018) for U. K. firms. The findings for Israel are also noteworthy since Israel is a recently (newly) industrialized country (NIC). Lach (2000) finds evidence that R&D subsidies stimulated long-run private R&D investment in Israeli manufacturing firms, but its multiplier effect is lower than the additionality reported in other studies for developed countries (less than one). This partial crowding in effect could be explained by a strategy of selecting high performers (i.e., supporting projects that would have been undertaken even in the absence of support), and second, firms adjust their portfolio of R&D projects closing or slowing down non-subsidized projects-after the subsidy is received.

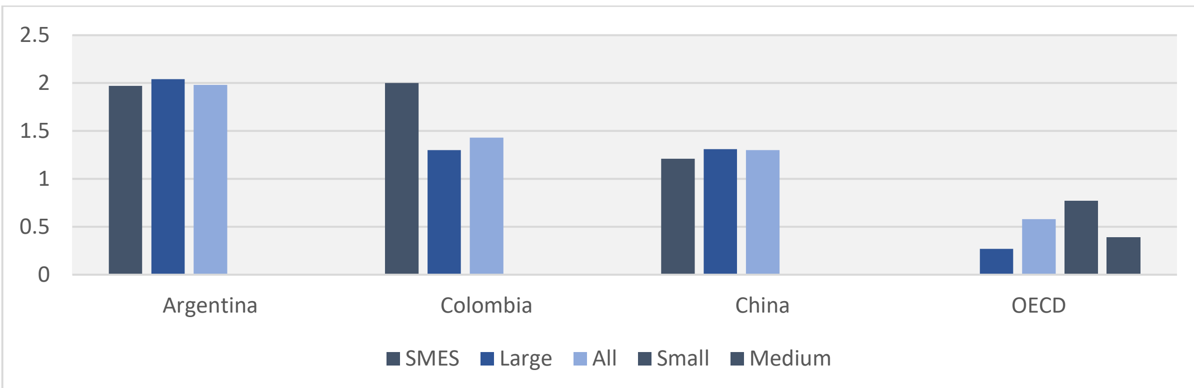
For R&D investment, these results combined suggest that in emerging countries although firms report increasing investments, this change is lower than the change in the user cost due to tax benefits.[11] In contrast, firm responsiveness to tax incentives in terms of non-R&D investment (machinery and equipment or other technologies) can be substantial: elasticities are often largely superior to one (see evidence by Crespi *et al.,* (2017) for Argentinian firms). There is also emerging evidence that innovation tax incentives can encourage and help firms to employ highly skilled workers, which helps enhance firm innovation performance (e.g. for Brazilian firms see Kannebley et al., 2013; Gama e Colombo and Noguera da Cruz, 2021; for Mexican firms see Calderon, 2010 and Chávez, 2020). Nevertheless, evidence for China points out to moral hazard

[11] The short run (user cost) elasticity to innovation tax incentives for R&D investment is estimated about 0.78 in Argentinian firms (Crespi et al, 2017), between 08-0.30 in Taiwanese firms (Yang et al., 2012) whereas in Ecuadorian and Turkish firms (Tasz and Erdil, 2022), this figure is 0.22 and 0.71–respectively.

behavior in the use of R&D tax incentives in the sense that firms might relabel expenditures to take advantage of more favorable tax treatment for innovation activities.

Relabeling of (R&D investments) can be a serious issue though. According to a recent study for Chinese companies, relabeling would represent about 37% of the reported increase in R&D (Chen *et al.,* 2019) -the impact though remains large. While this issue also exists in HICs, it is likely to be more severe in MICs (Bachas and Soto, 2019). Reducing this risk and preventing potential misallocation requires implementing policy auditing and enforcement mechanisms (Crespi and Maffioli, 2014). Further, the prevalence of informality and tax evasion in developing economies implies that this type of instrument could be weakly demanded (especially in SMEs) by firms seeking to avoid tax control and registration.

Figure 7: User cost elasticity for R&D Investment (long-run): Differences across firm sizes



Sources: Argentina (Crespi et al., 2016); Colombia (Mercier-Blackham, 2008), OECD (Appelt et al., 2020), and China (Chen et al., 2016). *Note*: The studies for Argentina, Colombia and China use data for manufacturing firms while the study of OECD uses data for all economic sectors. The study of OECD (2020) uses firm-level data for 20 OECD countries. The estimates for Argentina refer to investment in total innovation (R&D plus expenditures in machinery, equipment, software, etc.).

- Impact Heterogeneity: Young and Small firms

The effectiveness of innovation policies (subsidies and tax incentives) in leveraging additional R&D and innovation investment may differ across different types of firms -and types of investments. Their impact also depends on how these instruments are designed and implemented, and how they reach different types of firms -enabling entry into programs.

One question that arises regarding types of firms is related to potential misallocation of public resources -i.e., not the most suitable firms for policy impact and spillovers are being supported-, or alternatively, is it effective (in terms of impact and spillovers) supporting leaders? If support leverages market dominance (through innovation), it may favor market concentration -and related counter-weighing effects on long run productivity.

Misallocation of resources across firms can have important effects on aggregate productivity (Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009). If subsidies are biased to larger firms that would conduct innovative activities anyway, there may also be misallocation in the sense that the rest of firms -which would probably benefit more in terms of impact -cannot get public support (González *et al.,* 2005; Czarnitzki and Ebersberger, 2010; Becker, 2015). A similar logic applies to R&D tax incentives. R&D tax incentives may have the unintended consequence favoring incumbent firms while raising barriers to new firms (access to resources). This may slow down the reallocation process hindering aggregate productivity (Bravo-Biosca *et al.,* 2013; Acemoglu *et al.,* 2014). In addition, if the firms that benefit most from R&D fiscal incentives are those for which R&D is less likely to generate spillovers, R&D fiscal incentives might not be associated with increases in aggregate productivity growth (Bloom *et al.,* 2010). In a theoretical model, Acemoglu *et al.,* (2018) explains that these effects can be counterbalanced if the R&D of entrants is also subsidized, and the exit of inefficient incumbents encouraged.

The question of supporting young firms is quite transcendental. Governments also have another policy rationale to promote innovative young: innovative startups -notably those in the fields of emerging technologies- can play a significant role in fostering aggregate productivity[12] by promoting the diffusion of new technologies -e.g., software and IT (Andrews et al.; 2016; Calvino et al., 2018) and related business practices (i.e. e-commerce for instance). They are found to leverage important knowledge spillovers across industries (e.g., see Grover *et al.,* 2019). Also, through their effect on competition, innovative startups can push innovation efforts by incumbent firms (Aghion et al., 2009; Acemoglu and Cao, 2015).[13] Promoting innovative entrepreneurship, however, remains quite challenging in MICs.

The evidence tends to indicate that both subsidies and R&D tax incentives appear more effective in fostering additional investment in small and medium sized firms, and young enterprises -which are both often the most financially constrained. Non-significant impacts or even crowding out of private investments are more likely to occur in large enterprises (e.g., see evidence for Mexico or Argentina). Hence large firms are more likely to use grants to substitute private innovation investment with public funding; investment that they were probably already planning to undertake.

For instance, the early studies by Lach (2002), Gonzalez *et al.* (2005), Ozcelik and Taymaz (2008), and Bronzini and Iachini (2014) in Israel, Spain, Turkey, and Italy, respectively, find that

[12] Recent evidence from HICs indicates that innovation startups (especially those with high growth) can be powerful engines of job and output growth - and may create large spillovers for other businesses (Andrews et al.; 2016; Calvino et al., 2018; Grover et al., 2019).

[13] Further, some evidence indicates that innovation (product or process) can provide higher productivity returns to younger firms -especially in high growth firms- than incumbents, e.g., see evidence for Spanish firms by Coad et al., (2016) and Estonian firms by Masso and Tiwari (2022).

small firms tend to be more positively impacted by public R&D subsidies. This is consistent with the financial constraints' argument for small firms -i.e., being more severe in small companies and startups. In MICs there is some evidence of crowding-out in large firms. For China, some studies show crowding-in only in SMEs, with no impact or substitution effects prevailing in the group of (Chinese) state-owned enterprises (SOEs) (Boeing, 2016; Guo *et al.,* 2016 and Cheng and Cheng 2016) or large enterprises. For Uruguayan and Israeli firms, small firms also report a much larger multiplier effect (per dollar of subsidy) than large firms (see Berruti and Bianchi, 2020; and Lall, 2020; respectively).[14] In parallel, non-significant responses or even crowding out effects have been found in large firms in Argentina (Chudnovski et al., 2006).

In some studies, the largest effects are reported for young firms -those with less than 10 years old while in incumbents, responses are null or report a much weaker impact. For Argentinian firms, Binelli and Maffioli (2007) found that grants were effective in stimulating innovation investment only in the case of young and small firms, whereas in the case of incumbent firms crowding-out effects were reported. A similar finding is reported in a more recent study on the impact of FONTAR by Pereira *et al., (*2018) using a larger panel (2007-2013). They find evidence of additionality exclusively among small firms. Moreover, much larger effects are found in the sample of "young firms" (with 10 years or less), whereas no impact was found for "old firms".[15]

Similar findings are reported in the use of R&D tax incentives: they appear more effective in the most financially constrained enterprises and especially in young firms-. Small firms appear to be more responsive to changes in the user costs (of R&D) than large firms -despite their lower participation in the use of this incentive in most countries -see Crespi *et al.,* (2017) for Argentinian firms and Mercer-Blackman (2008) for Colombian firms, Romero-Jordan *et al.,* (2014) for Spanish firms, and Appelt *et al.,* (2019) for a group of HICs. Evidence also shows that young firms may display even larger responses: the elasticity response is two times larger (-1.08) for young firms (less than seven years) than to old firms (-0.57) (Appelt *et al.,* 2019; and Dechezleprêtre *et al.,* 2016). Despite these superior responses, tax incentives are often mainly used by large firms (see Brazil or Turkey) since some features in their design (e.g., not considering carry-forward use) and bureaucratic complexity prevents the participation of young and small firms (see Brazil-Lei do Bem). These questions on the response of large and incumbent firms demand further attention and research in both MICs and developed countries.

[14] In Mexico, subsidies have been found only impactful in fostering R&D investment in the group of SMEs (Calderon, 2009; see also Chavez, 2020) while in Poland, R&D subsidies only worked in the group of non-exporters (Zabłocka-Abi Yaghi and Tomaszewski, 2023).

[15] In this group of firms, both the innovative activities to sales ratio and R&D to sales ratio are substantially greater than the ratios that would have been registered in the absence of public support (+1.59 pp and +1.46 pp, respectively).

Yet, the findings here described call for careful attention to the design of programs, in a way to improve targeting of such firms and new entrants and better enable their participation in innovation programs and tax incentives. This should entail considering additional support to leverage their participation including for targeted funding programs (e.g., assistance in project definition and linking with partners and institutions; access to skills or mobility programs of researchers and technicians). Innovation support programs are often biased towards large firms as reflected often in the determinants of selection in counterfactual studies. More innovative firms (with experience in projects) and large performers are frequently more likely to be selected. This is due to governments' concern to minimize failure in policy programs by targeting the best although this may result in weak impacts or crowding-out effects (David et al., 2000). Evidence has also been reported that allocation subsidies can be subject to political interference -which hinders policy effectiveness (Fang *et al.,* 2018).

- The difficulty in R&D response and leapfrogging

Not leapfrogging over fundamentals and adapting direct support programs to the level of development and firms' capacity is key to their success in MICs. The evidence from MICs regarding R&D investment and patenting suggests that achieving a higher level of technological sophistication may require more than short-term co-funding of innovation projects. A major deficiency happens when innovation policies undermine the importance of other binding constraints key to the deployment of R&D and innovation activities. Among the most important barriers to the undertaking of innovation activities quoted by firms in MICs besides the lack of finance is the availability of skills (with similar scores in importance), which is closely followed by barriers (or rigidities) related to market demand and structure (Bogliacino e*t al.,* 2011; De Fuentes *et al.,* 2018) and uncertainty (macro instability). In southern European countries, the lack of domestic demand (including public sector demand) is among the largest obstacles to the undertaking of innovation activity as reported by firms (Radosevic, 2017). In Chile, the lack of demand and market structure have been found as much as important as lack of finance in explaining the lack of innovation engagement (Zahler et al., 2015; Kim and Lee, 2008).

A distinctive feature of innovation systems is that many of its components function in complementarity with others. A consequence of this is that piecemeal policy may not be successful, as one-dimensional policy prescriptions in isolation will not produce the desired impact. Addressing the different constraints (sunk entry costs) requires different policy interventions (i.e. lack of finance, human capital, and markets) and overcoming these barriers is crucial for enabling firm entry into R&D and innovation activities (Mohnen and Roller, 2005) - more than in the case of promoting investments in existing innovation performers. This is a key policy question for MICs given that a first policy challenge is how to induce firm entry into R&D and build a critical mass of innovators. According to the analysis of Mohnen and Roller (2005) for Dutch firms, in existing performers entry (innovation) barriers are surmounted and remaining obstacles are more likely to be handled with single interventions.

6. The Indirect Effects: The Importance of Knowledge Spillovers

The distinguishing feature of innovation policy interventions are their possible positive knowledge spillovers beyond beneficiary firms or how much policy interventions help spur innovation and efficiency in other firms and sectors (David *et al.,* 2000). It must be noted that the main purpose of public agencies is to induce a permanent change in firms' behavior and performance. As discussed by Takalo *et al.,* (2013), public agencies may be willing to support investment (and support firms to invest more) even if there were some crowding-out effects. The rationale is to encourage future positive spillovers through the expansion of the number of R&D performing firms (extensive margin), which may offset the short-term partial crowding out effects on the R&D intensive margin.[16]

Spillovers from policy interventions can spread from supported to other firms through different channels: within the same sector (horizontal spillovers) through market linkages and value chains (i.e. vertical spillovers), and mobility of employment (Moen, 2005; Foster-McGregor and Poschl, 2018; Castillo *et al.,* 2020).[17] There might also be negative externalities though through, for instance, business stealing effects from enhanced product competition (by supported firms), or higher prices in innovation inputs (e.g. highly skilled) due to potential increase in demands by beneficiaries.

Evidence of spillovers from innovation subsidies as reflected in productivity or other output measures has been reported recently for several MICs: Chilean firms (Crespi *et al.,* 2020), Argentinian firms (Castillo et al., 2016), and Chinese firms (Guo and Haochen, 2022). Evidence of knowledge spillovers from supported firms to other (non-supported) firms has been recently reported for Argentinian firms. In a panel study running 15 years and matching firm with employment level data, Castillo *et al.,* (2016) find that firms hiring workers from supported firms experience improvements in productivity, survival rate and exporting performance.[18] Moreover, workers directly exposed to innovation projects are found to receive higher wages, and this premium is highest for the high-skilled workers.

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[16] According to Crespi *et al.,* (2020), "it is the existence of spillovers -and not the potential impact of grants on beneficiaries- that is the main rationale for government intervention in these programs".

[17] Evidence from developed countries (see Foster-McGregor and Poschl, 2018) suggests that labor mobility can be a source of important cross-sectoral knowledge spillovers, especially from workers moving from high-tech and medium-high tech industries.

[18] Receiving firms increased their probability of survival (1.0 vs. 0.4 percentage points, respectively), probability of exporting (1.8 vs. 1.5 percentage points), employment (28.5% vs. 20%), and wages (28.5% vs. 12.7%).

Recent research shows that vertical spillover effects from supported firms in high tech services can be large. For China, Guo and Haochen (2022) analyzed the impact from the Inno-Fund -which targets high-tech SMEs and innovative startups in China- and found evidence of both intra and cross-sectoral spillovers on measures of regional entry rates, employment and output growth. They find very large vertical spillovers of subsidies from high-tech service sectors to manufacturing sectors. A similar finding has been reported for Japanese firms in the use of R&D consortia. Customers from participating firms are found to benefit from knowledge spillovers resulting from innovative projects being conducted in the consortium (Nishimura and Okamuro, 2016).

In addition, some recent research suggests that knowledge spillovers effects can be more substantial in funding programs of collaborative format linking public S&T institutions with private firms. In the case of Chilean firms, Crespi *et al.,* (2020) recently analyzed the FONTEC (e.g. co-financing program for internal firm R&D investment) and the FONDEF (R&D subsidy program for external (collaborative) R&D in association with universities and public S&T organizations). While both programs have had a positive impact on participants' productivity, only FONDEF-funded projects have generated positive spillovers on (other) firms' productivity. Moreover, spillover effects were found to occur only if firms were both geographically and technologically close -as proxied by a similarity index. This result is like the one recently reported by Dechezlepetre *et al.,* (2016) for British SMEs, in which spillovers from supported firms (tax incentives) are stronger when firms are technologically close.

As shown by Crespi *et al.,* (2020)- knowledge spillover effects from public support on other firms (performance) are not lineal; they have a threshold, probably due to a combination of (positive) spillover effects and (negative) business-stealing mechanisms. This non-linearity in spillover have important policy implications notably regarding the size and scale of programs: (1) there should be a critical mass in the number of treated firms that must be reached in order to generate these spillovers (i.e., small programs might not induce any spillovers) and (2) saturation points exist (i.e., programs that are too big might neutralize spillovers impacts through business destruction effects) (ibid).

Policy makers have different mechanisms to promote spillovers and maximize economic impact of productivity-enhancing policies beyond beneficiaries. Spillovers can be promoted through different channels including: (i) improving fluidity in markets (e.g. market reforms and private sector participation in the local economy is associated with large knowledge spillovers)[19]; (ii) inter-industry market (value chain) linkages[20]; (iii) decentralized of programs (i.e., program

[19] Guo and Haoche (2022) find that in regions where state owned enterprises represented a large share of the economy and marketization index was low (i.e. market reforms), spillovers were found lower in magnitude.

[20] In a theoretical paper, Liu (2019) highlights the role of government in supporting the sectors with higher distortion centrality, mainly the upstream sectors. Using a general equilibrium model of distortions, the author analyzed inter-industry input-output linkages in the context of developing economies.

support in regions; e.g. for Chile see Gonzalo Rivas, 2012; for China, see Chen et al., 2018), and (iv) interactions between different technology (industrial) and innovation policies (e.g. interaction between Inno-Fund and the Strategic Emerging Industries in China, which targets large technological projects in industries).

8. Leveraging Effectiveness: Some Policy Lessons

- Innovation skills: A key requisite for policy uptake

A major pre-condition for the effectiveness of R&D and technology diffusion policies is human capital. This refers not only to researchers but also engineers, technicians, and innovation management skills. Improving the pool of highly skilled personnel and supply of graduates and post-graduates in science and engineering (STEM) is key to R&D and innovation policies. In the long run, educational institutions have a crucial role in addressing skill shortages in S&T graduates and post-graduates (researchers) as well as in technical education and ensuring their supply and adequacy with industry demands. Both educational and labor policies also play an important role in the insertion of specialists in the private sector.

In the short run -if there is available supply pool of specialists, public support may take the form of tax incentives for the hiring of research personnel (and other specialists) or reductions of social contributions, (public) sponsorships of personnel or mobility programs (researchers in industry). Connectivity with S&T institutions is also key in getting firms into R&D projects, especially for SMEs. Countries also use immigration policies to attract highly skilled personnel and entrepreneurs. The attraction of talents through immigration policies and complementary measures such as tax incentives, can be an important way to address skill shortages. These policies can be an important instrument for MICs to tap into global talents to address short run needs in human capital and innovative entrepreneurship (e.g., Startup Chile and startup programs in France). In countries such as US and Canada, the participation of highly skilled immigrants in total STEM-labor and in domestic innovation can be quite substantial -e.g. about 26% of highly cited patents involve immigrants in the US (Shambaugh et al., 2017).

- Room for Potential Policy Complementarities

Important policy complementarities may exist when combining policy instruments that allow firms to address related constraints and develop synergies across different policy programs -which maximizes impact. This is particularly relevant for SMEs -which face multiple binding constraints in engaging in innovation and technology transfer (e.g. lack funding and skills). Complementarities between innovation policy instruments have been reported for firms in both developed and emerging countries, although of different nature. For instance, the recent cross-country study by OECD (Appelt et al., 2020) points out to complementarities between R&D tax incentives and subsidies; the former mostly promotes experimental ad market related activities (product introduction), while R&D subsidies are more effective in leveraging private R&D investments. Evidence on the joint reinforcing effects of policies has been reported for the use of innovation subsidies and loans (see Huergo and Moreno, 2017); the former promoting R&D and the second, financing of capital assets and equipment.

Complementarity effects have been found between research and innovation programs. For instance, larger impacts on firm productivity and innovation have been found for firms using business innovation programs jointly with collaborative programs (with public S&T organizations). This is the case of Chilean firms using the FONDEF (i.e. collaboration in research between publics S&T institutions and firms) jointly with the FONTEC program -i.e. which supports firm projects targeting more applied and developmental R&D and broader innovation activities (see Alvarez *et al.,* 2014). There is also evidence of policy complementarities in the use of supplier integration programs (e.g. supporting for instance certification and managerial skill upgrading) and business innovation funding in SMEs -as shown in an evaluation study for Costa Rican SMEs (see Monge-Gonzalez and Rodriguez, 2013).

There is also evidence of synergies in the use of innovation advisory services and the use of innovation vouchers for contracting R&D services by universities or other public S&T institutions. Caloffi *et al.,* (2020) examined the impact of these two instruments on firm innovation activities in a sample of Italian firms in Tuscany for the period 2011–2014. Innovation advisory services aim to help small and medium enterprises (SMEs) to gain a better awareness of their innovation needs and of how to address them, whereas innovation vouchers are used to subsidize SME purchases of knowledge-intensive services. Using matching methods the authors find that policy mixes are more effective than each individual instrument.

Finally, addressing market constraints in addition (or even jointly) to market failures can also leverage larger policy impacts of innovation support programs. Since the lack of demand is a major obstacle to the undertaking of innovation activities, funding may be insufficient in changing attitudes to innovation at a larger scale. Recent evidence suggests that combining "supply-side" support measures (funding) and "demand-side" interventions can have substantial impact in terms of leveraging private investment and impacting firm performance than individual funding mechanisms (e.g., Stojcica *et al.,* 2020). Larger additionality effects have been found for firms participating simultaneously in public procurement of innovation (PPI) and R&D subsidies in Eastern European countries -as opposed to firms using one single program.[21] Joint interventions

[21] Stojcica *et al.,* (2020) find that firms receiving public procurement for innovation contracts or financial support for innovation have a higher probability to innovate and achieve higher sales from new products than non-supported firms. The highest additionality is achieved when firms receive both financial support and innovation-oriented public procurement.

also promote innovation outputs, including radical innovation. This is due to combined synergies: public funding reduces costs of investing in innovation while procurement facilitates firm learning and enables innovation demand. Further, PPI programs (e.g. SBIR programs type) can help build collaborative relationships between public actors and firms, which can be a valuable opportunity for firms to take the first steps towards innovation in a coaching environment.

- The importance of Market Competition

Market competition matters to the effectiveness of public policies for innovation. R&D subsidies, for instance, can reinforce innovation incentives resulting from intensified trade competition (Lee, 2011; Akcigit *et al.,* 2018) and this effect increases with competition intensity up to a certain level (Kilponen & Santavirta, 2007). According to recent studies from emerging countries, innovation policies can be effective in fostering firm investment and sector productivity (e.g., Aghion *et al.* 2018; Benavente & Zuniga 2021) -only if instruments are allocated to competitive sectors or allocated in such a way as to promote competition.

Existing empirical evidence suggests that competition typically increases innovation, especially in markets that initially have low levels of competition and weakens with distance to the frontier (Aghion *et al.,* 2005; Bloom *et al.,* 2019). According to neo-Schumpeterian growth models, firms would invest in innovation face to stronger competition and competitive entry threats to "escape competition" (Arrow, 1962; Aghion and Howit, 1992; Aghion *et al.,* 2005) while at very high levels of competition these incentives reverse. For firms in MICs, this relationship has been found to be predominantly monotonic (e.g. Alvarez *et al.,* 2020; Benavente and Zuniga, 2020). Likewise, competition may help promote technology adoption of new technologies due to market rivalry and technology spillovers, e.g. see the case of cloud computing in MICs (Ben Youssef *et al.,* 2015) or solar panels (Hancevic and Sandoval, 2023).

In cross-country studies, empirical research tends to confirm the existence of complementarities between market competition (e.g., proxied by product market regulation or market concentration indicators) and innovation policies (e.g. Criscuolo *et al.,* 2014; Andrews et al., 2015). For Finland, Kilponen and Santavirta (2007) show that a proportional R&D subsidy accelerates innovation activity at all degrees of competition model, but less so at high degrees of competition: in line with the inverse-U shaped predicted by Aghion et al., (2005). Accordingly, the innovation grant reinforces the Schumpeterian effect: an increase in the R&D subsidy steepens the inverted U relationship when competition is fierce.

In the U. S, the introduction of the Research and Experimentation Tax Credit in 1981 was found an effective instrument to improving technological competitiveness of US firms face to increased competition by Japanese and European firms during the 1980s (Ackigit *et al.,* 2018).[22] This effectiveness is associated with three mechanisms influencing firm R&D decisions in open markets: (i) a "defensive" innovation motivation; (ii) market expansion effects (which increases returns to R&D), and (iii) technology spillovers. In a counterfactual analysis Chilean and Peruvian enterprises, Benavente and Zuniga (2022) examined the effectiveness of innovation subsidies or how much public support leveraged additional private investment -after two years of intervention. Accordingly, the impact of innovation grants on private investment in high competition sectors was found twice large the response in low competition sectors in Peru, whereas in Chilean firms, the impact was only significant in high competition industries.[23]

In addition, evidence suggests that industrial policies are more efective when they induce greater competition between firms -according to research by Aghion *et al.,* (2018). Using a panel of Chinese enterprises, the authors find that public support enhances sector productivity, its growth and average innovation when subsidies are more competitively distributed. By contrast, in sectors with a low degree of competition, the effects are negative. An important condition for this synergy to work is that sector policies should not provide selective advantages to specific firms (i.e., choosing leaders or winner) since this migth make interventions ineffective (e.g. risk of capture).[24] Instead, sector-wide policies -open to all firms- are expected to work better. However, in practice such approach may be difficult to implement.

Industrial policies can increase their effectiveness and improve on a purely equitable distribution by targeting firms most likely to engage in innovation (ibid). According to Aguion et al., (2018), measures to foster competition include policies that are more dispersed across firms in a sector or measures that encourage younger and more productive enterprises. In the Chinese case, targeting younger but not bigger firms (i.e. giving larger weights to young firms in the support concentration index) significantly increased the positive impact of industrial policies. The explanation is that young firms generally have higher productivity performance (ibid) -although evidence of this trend prevailing in other MICs is still lacking and deserves further analysis.

Recent evidence for European firms is provided by Murin and Samarin (2021) -which somewhat differs from previous research above discussed. Using conterfactual analysis (DID with PSM estimation), they find no difference in impact in terms of investment growth in intangible assets, employment, or patent applications -respect to the level of market competition in sectors

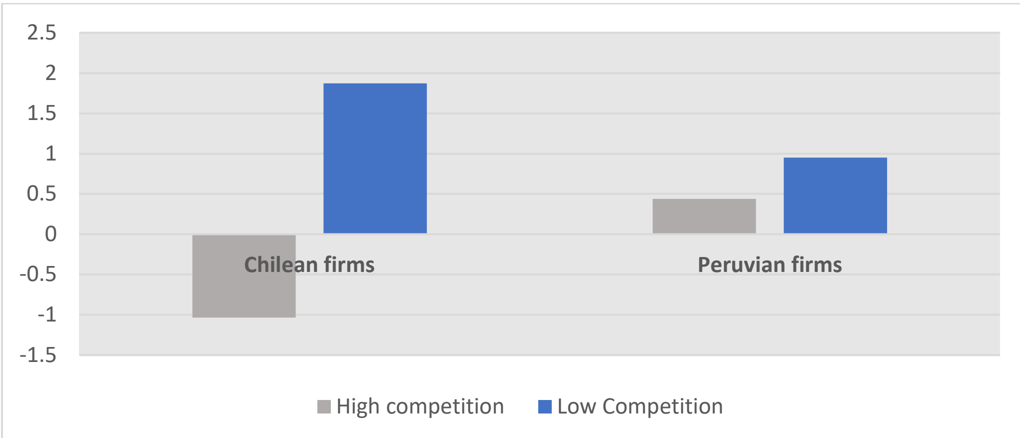
[22] Innovation subsidies were found to have substantial welfare gains in the medium and long-run, maximizing the welfare impact of trade -as opposed to protectionist policies which only work in the short run. According to their model, while statically the effects of trade (defined as reduced trade barriers) on welfare were found ambiguous, dynamically, intensified trade spurs domestic innovation through induced global competition.

[23] They distinguished high from low competition sectors by identifying (endogenously) the competition level at which a structural change in innovation response occurs (Hansen, 2000; Wang, 2015).

[24] Also, governments cannot (Ex-ante) identify market potential of innovation projects and what the leaders are, and should allow the market to follow the natural competitive process.

(high or less competitive). In contrast, subsidy impacts on tangible investment (machinery and equipment) and turnover growth are found only significant in sectors that were not too competitive.[25] Accordingly, pressures to innovate (escape competition) could be lower in these sectors, and thus firms would use public support to invest in existing capabilities (investment in machinery and equipment) rather than improving R&D capability.

Figure X.8: Innovation support programs (R&D and Innovation subsidies) are more effective in fostering innovation investment in industries with more intense competition



Source: Benavente and Zuniga (2021).
Note: Shaded (gray) colors indicate insignificant coefficients. Coefficient reports are ATT estimates from Differences-in-Difference estimation with PSM. The outcome is a logarithm of innovation expenditures per employee.

- The Role of (other) Framework Conditions

Research has shown the importance of coupling policies aimed at encouraging innovation and technological adoption with well-designed framework policies that ease entry costs into R&D and innovation and allow knowledge spillovers to proliferate (e.g., Mohen and Roller, 2005; Westmore, 2014). In addition to building human capital and research base (S&T specialists), these policies include improving the functioning of product and labor markets (e.g., flexibility in employment legislation), openness to trade and foreign investment, and access to finance (Andrews and Criscuolo, 2013; Andrews et al., 2018), as well as policies enabling business dynamics (e.g., easing regulations for firm creation and exit, see Rijkers *et al.,* 2014; Calvino *et al.,* 2020). Accordingly, dynamic efficiency gains (e.g. innovation) from market

[25] The authors used the HHI as indicator of competition in industries at the two-digit level of NACE Rev. 2. They split the sample of firms into two parts based on the value of the 20th percentile of the HHI distribution in the year prior to subsidization.

competition can hardly be achieved without well-functioning factor markets, which allow the reallocation of labor and capital of shrinking/exiting firms to entering/growing firm.

Intellectual property protection (i.e. which allows appropriating the returns to innovation investments) is also associated with innovative investments and R&D. In cross-country studies, intellectual property protection has been found to promote international technology transfer as reflected in trade in technology intensive goods (Chen, 2017) and international licensing contracting (e.g. Yang and Maskus, 2001). On the other hand, trade openness promotes innovation (especially in firms closer to the frontier), not only through its effect on competition, but also by increasing market size -which allows spreading the costs of innovation over a larger market (e.g., Grossman and Helpman, 1991; Aghion *et al.,* 2018). In parallel, trade facilitates access to higher quality inputs and diffusion of knowledge (e.g., Keller 2004; Atkin *et al.,* 2017).

Regarding technology (diffusion) policies, integrated public initiatives linking public-private efforts can help the process of technology adoption by targeting the ability of firms to access and exploit technologies in different dimensions (Shapira *et al.,* 2015; Teubal, 2006). Integrated programs mean combining access to finance and information (e.g. about technologies and demonstration), and support services, through for instance technology diffusion institutions under a private-public collaborative approach (Shapira *et al.,* 2015). On the other hand, regulatory reforms in transversal sectors are key to technology diffusion -e.g. digital and ICT. For instance, enhancing competition and liberalization of infrastructure has a strong potential for spurring innovation and diffusion in dynamic sectors such as ICT as well as in (downstream) mature sectors.

Finally, expanding sources of finance and financial markets is also essential to firm innovation and growth. In addition, equity markets can be a meaningful source of long-term financing, but they remain under-developed in many MICs. Early-stage finance through venture capital can also play a key role for scaling-up innovative startups. Promoting new financing channels not only spurs competition in the financial sector; it also helps improve the policy mix for supporting different innovation needs across the life cycle of firms.

Conclusions

Several policy implications stand out from this review. First, it is important to tailor innovation support to the level of development and innovation capacity of firms and address the different system-level binding constraints. Key to policy uptake and impact is human capital and access by firms to S&T specialists.

Policy directions to improve effectiveness of innovation support programs include targeting of firms towards those more-potentially responsive (financially constrained), notably young firms, and new entrants (new performers), and the use of complementary measures for market development, as well as promoting productive linkages among firms (improved local integration) to maximize knowledge spillovers.

The evidence on the impact of innovation policies on firm innovation activity in MICs suggests that achieving a higher level of technological sophistication as reflected in patenting may require more than short-term co-funding of innovation projects. Addressing the lack of investment in innovation in MICs, especially in R&D, requires not only tackling market failures in the funding of such activities, but also other binding constraints, notably the building of a domestic human capital base (and research expertise), the lack of demand and market competition. Improving competition -through business dynamics (entry and exit), competition law enforcement, and trade-- is key to improving allocation of resources and the effectiveness of innovation policy interventions -as recent research suggests.

The research discussed in this paper is without limitations. Most of the studies here reviewed focused on manufacturing sectors; yet services industries represent a largest share in MICs' economies, and the dynamics of innovation in these industries are less examined. Evidence on services should help provide a more complete picture of policy impacts and potentialities for intervention in MICs. Further evidence is however required to understand innovative behavior by incumbent and young firms, and how they respond to policy incentives including in terms of spillovers. Evidence is needed also regarding spillover effects from large firms and small firms; it is likely that large firms are more prone to diffuse knowledge spillovers through their (locally embedded) value chains.

References

Aboal, D., & Garda, P. (2015, April). Does public financial support stimulate innovation and productivity? An impact evaluation. *CEPAL Review*, 41-61.

Aboal, D., Rojas, G., Servín, B., & Queraltó, P. (2018). *How Effective are Innovation Support Programs to Stimulate Innovation?* . Asunción, Uruguay: CINVE (Centro de Investigaciones Económicas).

Aghion, P., Dewatripont, M., Du, L., Harrison, A., & Legros, P. (2015). *Industrial Policy and Competition.* NBER.

Akcigit, U., Ates, S. T., & Impullitti, G. (2018). *Innovation and trade policy in a globalized world.* London: Centre for Economic Performance, LSE.

Andrews, D., & Criscuolo, C. (2013). *"Knowledge-Based Capital, Innovation and Resource Allocation: A Going for Growth Report.* Paris: OECD Economic Policy Papers 4, OECD Publishing. doi:https://doi.org/10.1787/5k46bh92lr35-en.

Andrews, D., Nicoletti, G., & Timiliotis, C. (2018). *Digital technology diffusion: A matter of capabilities, incentives or both?,.* Paris: OECD Publishing.

Arrow, K. J. (1962). The Economic Implications of Learning by Doing,. *Review of Economic Studies, 29*(3), 155-173.

Becker, B. (2015, December). The effectiveness of R&D subsidies -A review of the literature. *Journal of Economic Surveys, 29*(5), 917-942.

Benavente, J. M., & Zuniga, M. P. (2021). *The Effectiveness of Innovation Policy and the Moderating Effect of Market Competition -Evidence from Latinamerican firms.* Washington, D.C.: Inter-American Development Bank.

Benavente, J., Crespi, G., & Maffioli, A. (2007). *Public Support to Firm-Level Innovation: An Evaluation of the FONTEC Program.* Inter-American Development Bank, Office of Evaluation and Oversight (OVE).

Binelli, C., & Maffioli, A. (2007). A Micro-econometric Analysis of Public Support to Private R&D in Argentina. *International Review of Applied Economics,, 21*(3), 339-359.

Bloom, N., Schankerman, M., & Van Reenen, J. (2013, July). Identifying Technology Spillovers and Product Market Rivalry. *Econometrica, 81*(4), 1347-1393.

Bloom, N., Schankerman, M., & Van Reenen, J. (2013). Identifying Technology Spillovers and Product Market Rivalry. *Econometrica, Econometric Society, vol. 81(4)*, pages 1347-1393, July.

Boeing, P. (2016, November). The allocation and effectiveness of China's R&D subsidies - Evidence from listed firms. *Research Policy, 45*(9), 1774-1789. doi:https://doi.org/10.1016/j.respol.2016.05.007

Bruhn, M., & McKenzie, D. (2019). Can grants to consortia spur innovation and science-industry collaboration? Regression-discontinuity evidence from Poland. *The World Bank Economic Review, 33*(3), 690-716. doi:https://doi.org/10.1093/wber/lhx014

Bukstein, D., Hernandez, E., & Usher, X. (2016). *Impactos de los instrumentos de promoción de la innovación empresarial -La Experience del ANII.* Washington, D.C.: Inter-American Development Bank, División de Competitividad e Innovación.

Calvino, F., Criscuolo, C., & Verlhac, R. (2020). *Declining business dynamism: Structural and policy determinant.* Paris: OECD Publishing.

Castillo, V., Figal-Garone, L., Maffioli, A., Rojo, S., & Stucchi, R. (2016). *The Effects of Knowledge Spillovers through Labor Mobility.* Munich, Germany: University Library of Munich, MPRA Paper 69141.

Cheng, H., Fan, H., Hoshi, T., & Hu, D. (2019). *Do Innovation Subsidies Make Chinese Firms More Innovative? Evidence from the China.* NBER Working Paper No. 25432, Boston.

Chudnovsky, D., López, A., Rossi, M., & Ubfal, D. (2006). *Evaluating A Program of Public Funding of Private Innovation Activities. An Econometric Study of FONTAR in Argentina.* Washington, D.C.: Inter-American Development Bank, Office of Evaluation and Oversight (OVE).

Cirera, X., & Maloney, W. (2017). *The Innovation Paradox.* Washington, DC: World Bank Publications, The World Bank Group.

Coe, D., & Helpman, E. (1995). International r&d spillovers. *European Economic Review, 39*, 859-897.

Cohen, W., & Levinthal, D. A. (1989). Innovation and Learning: The Two Faces of R & D. *The Economic Journal, 99*(397), 569-596. doi:https://doi.org/10.2307/2233763

Crespi, G., Figal Garone, L., Maffioli, A., & Melendez, M. (2015). Long-Term Productivity Effects of Public Support to Innovation in Colombia. *Emerging Markets, Finance and Trade*, 1–17. doi:10.1080/1540496X.2015.998080

Crespi, G., Figal Garone, L., Stein, E., & Maffioli, A. (2020). Public support to R&D, productivity, and spillover effects: Firm-level evidence from Chile. *World Development,, 130*, 104948. doi:https://doi.org/10.1016/j.worlddev.2020.104948

Crespi, G., Giulodori, D., Giulidori, R., & Rodriguez, A. (2016, December). The effectiveness of R&D+i tax incentives in developing countries: The Case of Argentina. *Research Policy, 45*(10), 2023-2035. doi:https://doi.org/10.1016/j.respol.2016.07.006

Crespi, G., Solis, G., & Taczir, E. (April 2011). *Evaluación del impacto de corto plazo de SENACYT en la innovación de las empresas panameñas.* Inter-American Development Bank, Science and Technology Division.

David, P. A., Hall, B., & Toole, A. A. (2000). Is public R&D a complement or substitute for private R&D? A review of the econometric evidence. *Research Policy, 29*(4-5), 497-529,.

De Negri, J. A., Borges Lemos, M., & De Negri, F. (2006a). *Impact of P&D Incentive Program on the Performance and Technological Efforts of Brazilian Industrial Firms.* Washington, DC.: Inter-American Development Bank, Office of Evaluation and Oversight (OVE).

De Negri, J., Lemos, M., & De Negri, F. (2006b). *The Impact of University Enterprise Incentive Program on the Performance and Technological Efforts of Brazilian Industrial Firms.* Washington, D.C.: Inter-American Development Bank, Oversight and Evaluation (OVE).

Dechezlepretre, A., Einiö, E., Martin, R., Kieu-Trang, N., & Van Reenen, J. (2016). *Do tax incentives for research increase firm innovation? An RD design for R&D, patents and spillovers.* London: LSE.

Eaton, J., & Kortum, S. (1999). International Technology Diffusion: Theory and Measurement. *International Economic Review, 40*, 537-70.

Elkomy, S., Inghman, H., & Read, R. (2021). The Impact of Foreign Technology and Embodied R&D on Productivity in Internationally Oriented and High-Technology Industries in Egypt, 2006–2009. *Journal of Industry, Competition and Trade*, 171-192, June.

El-Shal, A., & Morsi, H. (2020). *Innovation and Productivity in Developing Economies.* African Development Bank.

Freeman, C. (1987). *Technology and Economic Performance: Lessons from Japan.* London: London Pinten Publishers.

Gal, P., Nicoletti, G., Renault, T., Sorbe, S., & Timilioti, C. (2019). *Digitalisation and Productivity: In Search of the Holy Grail – Firm-Level Empirical Evidence from EU Countries.* OECD Publishing Paris. doi:https://dx.doi.org/10.1787/5080f4b6-en.

Gao, Y., Hu, Y., Liu, X., & Zhang, H. (2021). Can public R&D subsidy facilitate firms' exploratory innovation? The heterogeneous effects between central and local subsidy programs. *Research Policy, Elsevier, vol. 50(4)., 50*(4). doi:https://doi.org/10.1016/j.respol.2021.104221

Goh, C., Wei, L., & Xu, L. (2015). *R&D Returns, Spillovers, and Firm Incentives: Evidence from China.* Washington, DC: The World Bank Publications, World Bank.

Goñi, E., & Maloney, W. (2017). Why Don't Poor Countries Do R&D? Varying Rates of Factor Returns across the Development Process. *European Economic Review, Elsevier, vol. 94(C),* , pages 126-147.

Griffith, R., Redding, S., & Van Reenen, J. (2003, April). R&D and Absorptive Capacity: Theory and Empirical Evidence. (J. V. Stephen Redding, Ed.) *The Scandinavian Journal of Economics*, Rachel Griffith, Stephen Redding, John Van Reenen.

Griliches, Z. (1998). *R&D and Productivity.* National Bureau of Economic Research Books, University of Chicago Press, edition 1, number 9780226308869.

Guimón, J., & Agapitova, N. (2013, March). Why should governments of developing countries. *African Journal of Business and Management, 7*(12), 899-905. doi: 10.5897/AJBM11.1163

Guo, D., Guo, Y., & Jiang, K. (2016, July). Government-subsidized R&D and firm innovation: Evidence from China. *Research Policy, 45*(6), 1129-1144. doi:https://doi.org/10.1016/j.respol.2016.03.002

Guo, Y., & Haochen, Z. (2022, July). Spillovers of innovation subsidies on regional industry growth: Evidence from China. *Economic Modelling, 112*. doi:https://doi.org/10.1016/j.econmod.2022.105869

Hall, B. (2009). The Financing of Innovative Firms. *Review of Economics and Institutions,*.

Hall, B. L. (2010). *The Financing of Innovation.* Massachusets: National Bureau of Economic Research. doi:10.3386/w15325

Howell, A. (2017, July). Picking 'winners' in China: Do subsidies matter for indigenous innovation and firm productivity?," China Economic Review. *China Economic Review, 44*(2), 154-165. doi:https://doi.org/10.1016/j.chieco.2017.04.005

INE (Instituto Nacional de Estadísticas). (2018). *Encuesta de Innovación en Empresas (ENI 2017-2018).* Santiago, Chile.

Kilponen, J., & Santavirta, T. (2007). *When do R&D subsidies boost innovation? Revisiting the inverted U-shape.* Bank of Finland Research Discussion Paper No. 10/2007.

Lee, K. (2013). *Schumpeterian Analysis of Economic Catch-up.* Cambridge: Cambridge University Press.

Lundvall, B. Å. (2003). National Innovation Systems: History and Theory . In H. P. Hanusch, *Companion to Neo-Schumpeterian Economics* (pp. Hanusch, H.,). Edward Elgar.

Lundvall, B.-Å. (1992). *National Systems of Innovation. Towards a Theory of Innovation .* London: London Pinter.

Mazzucato, M. (2018). Mission-oriented innovation policies: challenges and opportunities. *Industrial and Corporate Change, vol. 27(5)*, pages 803-815.

Monge-Gonzalez, R., & Rodriguez-Alvarez, J. (2013). *Impact Evaluation of Innovation and Linkage Develoment Programs in Costa Ric.* Department of Research and Chief Economist. Washington, DC: Inter-American Development Bank.

Nelson, R. R. (1959). The Simple Economics of Basic Scientific Research. *Journal of Political Economy, 67*, 297-297.

OECD and European Comission. (2015). *Business Innovation Surveys.* paris, France: OECD Paris Publishing.

Oszcelic, E., & Taymaz, E. (2008, Marvh). R&D support programs in developing countries: The Turkish experience. *Research Policy, 37*(2), 258-275. doi:https://doi.org/10.1016/j.respol.2007.11.001

Petrin, T. (2018). *A literature review on the impact and effectiveness of government support for R&D and innovation.* Brussels: ISI Growth, European Comission.

Rijkers, B., Freund, C., & Nucifora, A. (2014). Which Firms Create the Most Jobs? Evidence From Tunisia. *Labour Economics, 31*, 84-102.

Romer, P. (1986). Increasing Returns and Long-run Growth. *Journal of Political Economy*, 1002-1037.

Romer, P. (1990). Endogenous Technological Change. *Journal of Political Economy, University of Chicago Press*, 71-102.

Rostow, W. W. (1959). The Stages of Economic Growth. *Economic History Review 12 (1), 12*(1), 1-16.

Teubal, M. (1996, March). R&D and technology policy in NICs as learning processes. *World Development,*, pages 449-460.

Teubal, M. (2002). What is the systems perspective to Innovation and Technology Policy(ITP) and how can we apply it to developing and newly industrialized economies? *Journal of Evolutionary Economics, 12(1)*, 233-55.

Zuniga, M. P. (2023). *Innovation Policy in Emerging Countries: Lessons from Impact Evaluation Studies.* Background Report to WDR (2023)., Washington, D.C.

Zúñiga-Vicente, A. A.-B., Zuniga-Vicente, J., Alonso-Borrego, A., Forcadell, F., & Galan, J. (2014, February). Assessing the Effects of R&D Subsidies on Firm R&D Investment: A Survey of. *Journal of Economic Surveys, 28*(1), 36-67. doi: https://doi.org/10.1111/j.1467-6419.2012.00738.x

ANNEX

Box 1: Innovation Policy Instruments

Innovation Policy Instruments take a large variety of support mechanisms depending on policy objectives and different schemes. Generally, they can be classified in two groups:

- *Direct Incentives:* Credit loans (subsidized rates) and subsidies for the purchasing of machinery and equipment; subsidies (e.g. vouchers) for partial or full reimbursement of expenses associated to technical assistance services and R&D investments; training support in the form of direct provision (by educational or S&T institutions) or subsidies (co-financing); subsidies or direct technical support for upgrading and technology adoption -either individually or through group of firms.
- For promoting young firms, public support can take the form of grants and loans for new business projects and prototype development (pre-seed investment), business development support services (such as incubation and mentoring), and through the form of equity participation and venture capital funds (public-private).
- *Indirect Incentives:* Lower tariff rates and tax deductions for the importing of new technologies, machinery, and equipment; tax credits, allowances or accelerated depreciation for R&D investment, ICT investment or the hiring of R&D personnel, and technology specialists.

Box 2: Examples of R&D and Innovation Support Programs

- In Brazil, one of the most important instruments to support firm innovation is credit lines. Launched in the early 1980s, the National Technological Development Support Program (ADTEN) was the first programas using this instrument. Today both BNDES and FINEPI (Brazilian Innovation Agency) have large credit programs in place to support firm innovation and technology acquisitions. Subsidized loans are well-fitted instruments to support incremental forms of innovation and the acquisition of technological equipment associated with technology transfer. Empirical studies show that credit lines can help improve firm innovation performance and capabilities in supported firms. Firms that benefited from credits over 1997–2005 had between 28% and 39% higher R&D investment than non-supported firms (De Negri et al., 2006a).
- Colombia's COLCIENCIAS co-finances grants for collaborative projects with universities and research centers—up to 50 percent of the project total amount for large enterprises and up to 70 percent for small enterprises, with resources transferred directly to the technology provider. After fiscal incentives, this instrument is the main mechanism to support university-industry collaboration and the need for technological solutions. The program allows companies to access advanced human capital and research infrastructure in public S&T institutions. A key feature is the provision of funding directly to research institutions which helps minimize misappropriation by firms. Nowadays, collaborative programs are an ancillary part of the innovation programs addressing innovation needs in priority areas or challenges (e.g., health and food), and challenges in regions (see "Alliances for Innovation").
- Poland's In-Tech, one of the two tracks of Innotech, run by Poland's National Center for Research and Development, provides grants to consortia of research entities and firms for proposed research projects. Applications receive a score based on peer reviewer ratings, and those with a score above a threshold are offered funding. This program promotes connectivity between science and industry to support the development of new technological competences in industry. The program was found to enable the implementation of R&D projects that would otherwise not take place due to the lack of funding and R&D competences in firms (Bruhn and McKenzie (2019). It was also found effective in leveraging patenting, new sources of funding and new collaborations.
- Innofund is one of China's largest R&D programs targeting small and medium firms in high-tech manufacturing. It provides appropriations, interest-free bank loans, and equity investments. Appropriations are provided as start-up capital for small firms founded by a researcher with scientific achievements. Partial subsidies are awarded for new products and pilot production, with firms providing dollar-to-dollar matching funding. Yet evidence is evidence about their effectiveness in fostering firm innovation investment and performance (e.g., Fang et al., (2023) and Guo et al., 2016).

Sources: Castillo et al., (2016), De Negri *et al.,* (2006a); Fang *et al.*, (2023), Guo et al., (2016), Bruhn and McKenzie (2019), and Wang *et al.,* (2017).