Policies for knowledge generation in the catch-up process: evaluation and lessons

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Abstract

Public intervention to support the knowledge generation is recognized as a fundamental strategy that enables the closing the gap between of latecomers and forerunners economies. Evaluations and academic studies have been conducted on a wide variety of interventions and rapidly expanded what we know about these policies instruments. However, much of the evidence report conflicting results and can lead to misunderstandings about the potential of these interventions. This article offers a systematic review and a critical discussion of what the literature has to say about the effectiveness of these instruments. It is argued that learning about the effectiveness of interventions requires a capacity to seize and interpret its effects. Specifically, it emphasizes two critical factors to understand the potential of these policies, which are their sequence of execution and the context dependence of interventions. Since none of these issues has been investigated in depth, some aspects are discussed to guide future evaluations.

Keywords: Catch-up; Evaluation; Policy instruments; Knowledge.

1 Introduction

An essential part of the catch-up process refers to the production of knowledge that enables the closing the gap between of latecomers and forerunners countries (Abramovitz, 1986; Lee, 2013b). These attempts are undertaken in a world characterized by cumulative polarization between rich and poor economies in terms of innovative intensity (Castellacci, 2011) and persistent heterogeneity in R&D intensities among firms in the same sector (Coad, 2019). Furthermore, in contexts of increasing returns and technological asymmetries the absence of public policies is enough to result in the intensification of this process of divergence (Cimoli, Pereima, & Porcile, 2019).

The catch-up framework argues that policies focused on correcting market failures are insufficient to generate the level of knowledge required to free latecomers from the middle-income trap given the existence of further failures in the catch-up process (Abramovitz, 1986; Lee, 2013b). The approach proposed by Lee (2013b, 2019) addresses three main flaws, namely: the "capability failure" due to the intrinsic difficulty of building innovation capabilities; the "system failure" which results from missing or weak connections among actors; and the "size failure" caused by the lack of world-class businesses.

Once the existence of these failures is recognized, evaluations need to inform what works in policy making and be more efficient and effective in designing future instruments[1]. Nevertheless, the multidimensional nature of the catch-up phenomenon makes the evaluation of these instruments notoriously challenging. There are three issues that hinder the undertaking of these evaluations. First, there are several possible outcomes and effects are strongly context-dependent, which means that the impacts tend to appear only under certain conditions. Second, the relevant criteria used in assessing the effectiveness of these policies have changed over time and the locations where they are applied[2]. Third, the complex combination of policy instruments necessary to deal with the various dimensions of capabilities of firms and industries. The reasoning of this combination depends on the targets to be achieved and vary according to the stage of income status in the transition.

Although recent evaluations have expanded what we know about policy instruments, systematic attempts to take advantage of these advances are remarkably thin. Moreover, much of the evidence report conflicting results and can lead to misunderstandings about the potential of these interventions. This article fills this gap by offering a review of what the literature has to say about the effectiveness

[1] This article uses "evaluation" in a broad sense, including commissioned studies to conclude on the effectiveness of policies and academic investigations on intervention-specific issues.
[2] Korea is an illustrative example shifting its emphasis from tariffs to R&D subsidies, in the late 1980s (Lee, 2013a).

of policies for knowledge generation and critically discusses the potential of evaluating these instruments in the catch-up process. Therefore, this article does not provide an exhaustive review of the literature which is significantly wide and comprehensive. Rather, it focuses on recent literature sourced mostly from leading journals.

The rest of the paper is structured as follows. Section 2 describes the policies instruments and review of the empirical literature. Section 3 presents the key findings of the review of the existing empirical literature. Some remaining questions and challenges for future research are examined in Section 4. Section 5 summarises the conclusions and discusses the implications.

2 Scope of policies, rationale, and evidence

According to traditional economic rationale, the needed policies for knowledge production is due to the existence of market failures. In these situations, given the public good character of knowledge, firms are prohibited from fully appropriating the returns to innovation and tend to underinvest in R&D compared to a socially optimal level.

In parallel with this stem of research, the catch-up framework has made significant advances in a conceptual framework that addresses additional obstacles that arise when latecomers attempt closing the knowledge gap with forerunners (Lee, 2013b, 2016, 2019). These advances represent a portion of an emerging body of work committed to finding "binding constraints" of countries according to their income levels and structural differences (Rodrik, 2006), in contrast to attempts of the mainstream to find a universal factor for economic growth.

This article addresses three failures in the knowledge generation in latecomers and that radically differ from this conventional view (Lee, 2013b, 2019). In this contexts, policies for knowledge generation are justified by the presence of capability failure that hinders the enhance the innovation capabilities, the system failure caused by the lack of collaboration between members of an innovation system and the size failure that results from the lack of large firms in the generation, market introduction and diffusion of innovation. Despite the wide variety of classification of policy interventions, this section reviews the instruments according to these failures and organises the set of studies into logical subsets through a classification of innovations instruments proposed by Edler *et al.* (2016)[3].

[3] For the sake of objectivity, many auxiliary interventions are absent, for example, the demand-oriented policies.

2.1 Policies for capability failure

The main obstacle facing by latecomers in the upward transition is the need to building innovation capabilities of firms, sectors, and nations. This limitation is so-called "capability failure" and is the consequence of the lack of opportunity for effective learning and capability building (Lee, 2013b). In the latecomer context, firms are endowed with extremely weak levels of capacity, which limits their ability to search and lead in-house R&D. In the absence of incentives, undertake R&D becomes an unsafe investment and with high uncertainty about its return (Lee, 2019). Thus, the public intervention in promoting the raise the capabilities needs to observe the different methods to be provided over their dynamic course of learning. The usual government activism to address the capability failure are divided into two main groups: the incentives for *private R&D investment* and the policies for *human capabilities*.

2.1.1 Fiscal Incentives and Direct Support

The incentives for private R&D are based on the rationale that activities related to R&D generate knowledge spillovers, a critical phenomenon for latecomers countries where firms have a low R&D capability. Accordingly, the incentives are required due to the chance of underinvestment in R&D, which is caused by the scarcity of capital, the predominance of imperfectly competitive industries and obstacles to the diffusion of knowledge (Lee, 2013b, 2019). In these economies, private efforts in R&D are required not only for the further absorptive capacity of advanced technologies but also for building own capacities.

There are two main instruments to encourage private investment in R&D. The *tax incentives* that consist of an indirect mechanism to support R&D and the *direct government funding* for private R&D that are undertaken through grants and contracts. The former is a more market-oriented approach because the firm chooses the moment and the level of investment.

The provision of tax incentives to stimulate private R&D has become an increasingly popular policy in the past decade[4]. Developed countries have a long tradition of operating these instruments, but they are also widely adopted in emerging countries such as Brazil, Russia, India, China and South Africa. Given that building innovation capabilities through R&D involves uncertainty of results and asymmetries of information, financial institutions tend to avoid committing operations to this type of effort. Accessing tax incentives changes the incentive structure faced by firms by lowering the costs

[4] Among OECD members, R&D tax incentives is adopted by more than 20 countries.

of private R&D (tax burden or other types of mandatory contributions by law) and is delivered only after the R&D activity has been undertaken (Hall, 2002; Larédo, Köhler, & Rammer, 2016).

Regarding the effectiveness of R&D tax incentives, there is a large amount of evidence that tax credits have a significant positive effect on R&D expenditure both short and long term[5]. The extent of these positive input effects varies according to the country, estimation method and model specification. Table 1 lists some relevant studies consulted for this review.

Table 1 – Overview of some key contributions on input additionality of R&D tax incentives.

Autor	Period	Industry	Country	Main results
Duguet (2012)	1998–2006	Manufacturing and services	France	Each € 1 of tax credit generate € 2.33 of private R&D
McKenzie and Sershun (2010)	1979–1997	Manufacturing	9 OECD countries	In the short-run elasticity ranging from -0.15 to -0.28 and the long-run elasticity from -0.58 to -0.83
Lokshin and Mohnen (2012)	1996–2004	Manufacturing and services	Netherlands	In the short-run elasticity is the order of 0.2–0.5 and the long-run elasticity of the order of 0.54–0.79
Mulkay and Mairesse (2013)	2000–2007	Manufacturing and services	France	Dynamic R&D demand function with a preferred estimate of -0.4 for the long run elasticity of the user cost of R&D capital
Guceri (2013)	1998–2006	Manufacturing	UK	Treatment group increased their R&D spending by more than 18%, implying a user cost elasticity of 1.35
Westmore (2013)	1983–2008	Manufacturing and services	19 OECD countries	There is a positive relationship between R&D tax incentives and private R&D spending in the short and in the long term
Kobayashi (2014)	2009	SMEs in construction, manufacturing, services	Japan	R&D tax credits induce an increase in SMEs' R&D expenditure in 100% compared to control group
Dechezleprêtre *et al*. (2016)	2006–2011	Universe of SME firms	UK	The elasticity of R&D with respect to its tax-adjusted user cost of about 2.6. The policy stimulates £1.7 of R&D for every £1 of taxpayer subsidy
Freitas *et al*. (2017)	2004–2008	Manufacturing	Norway, Italy and France	Industries with high R&D orientation have higher propensity to apply to R&D tax incentives and stronger input and output additionality effects.

Source: Own elaboration.

This evidence is the main source of information that supports a framework for design and implement policies to knowledge generation in of latecomers. However, this overview reveals some caveats when moving from these results to policy. First, these incentives are usually implemented at the national level in the context of national taxation laws, which restricts the evaluation of its effect under the specific legislative situation in that country. Second, the tax incentive is not a guarantee of effects on innovation as firms can re-label existing activities as R&D to take advantage of tax credits or just

[5] Similar conclusions are observed in recent literature reviews (Becker, 2015; Larédo et al., 2016).

expand very low-quality R&D projects (Dechezleprêtre et al., 2016). Regarding the latter limitation, evaluations of *input additionality* – the effect of the tax incentive on increasing private R&D expenditure – must be supplemented with *output additionality* – the contribution to tax incentives on innovation and economic impact[6].

Evaluations of the effects of R&D tax incentives on output additionality show that these instruments increase the probability of introducing new-to-the-firm products and new processes (Cappelen, Raknerud, & Rybalka, 2012); new-to-the-market products (Falk, 2009); and new-to-the-world and a new-to-the-market product (Czarnitzki, Hanel, & Rosa, 2011). Positive effects of tax incentives on output additionality are also found when are measured by turnover from new products (Freitas et al., 2017); patenting value (Dechezleprêtre et al., 2016); and flow of patents in the short and in the long run (Westmore, 2013).

In addition to the indirect incentives, many direct instruments for promoting private R&D fill the toolkit of policy makers and are related to a long tradition in public policies. The rationale for direct subsidies to private R&D is to stimulate innovation that leads to the production of new marketable products, processes, or services. The literature on the effectiveness of direct R&D support is extensive and covers a wide range of topics. One of the main surveys of the body of available studies accumulated over 35 years states that econometric evidence is ambivalent and there are crowding-out effects (David, Hall, & Toole, 2000). García-Quevedo (2004) meta-analysis finds similar results and argues that the relationship between R&D public funding and private R&D expenditure are difficult to reconcile since its fundamentally empirical and descriptive nature.

However, the post-2000 empirical literature generally finds positive effects of public R&D subsidies on private R&D investment. One explanation for this revision is the effort to overcome the problems of sample selection bias using new econometric techniques for this purpose (Becker, 2015). Another possible explanation is the improvement in the effectiveness of this policy tool over time (Klette & Møen, 2012).

Accordingly, this growing literature finds additionality effects and rejects the hypothesis of crowding-out effects (Bloch & Graversen, 2012; Bronzini & Piselli, 2016; Carboni, 2017; Cerulli & Potì, 2012; Choi & Lee, 2017; Huergo, Trenado, & Ubierna, 2016; Le & Jaffe, 2017). A survey on the effect of public subsidies on firm R&D investment reveals limitation since the most available data come from studies performed in the short term, at the firm level and focused on the manufacturing sector (Zúñiga-

[6] Despite the scant evaluation of output additionality, the topic has received increasing attention from the literature in the recent period (Larédo et al., 2016).

Vicente, Alonso-Borrego, Forcadell, & Galán, 2014). A further limitation, and critical for the scope of this article, is that most of these studies are the result of experiments conducted in developed countries[7].

The scant evidence from developing countries shows that public support is efficient tools to better innovation performance of firms in Turkey and Poland (Szczygielski, Grabowski, Pamukcu, & Tandogan, 2017); generate significantly higher technological and commercialized innovation outputs in SME firms in China (Guo, Guo, & Jiang, 2016); reduce the probability of abandoning an R&D project due to economic crisis of 2008 in Latin America (Paunov, 2012). However, evidence from Brazil reveals that the adoption of a very wide variety of instruments could compromise the effectiveness of government support and raises doubts about the complementary character of government resources to support R&D (Rocha, 2015).

The overview of evidence regarding fiscal incentives and direct support reveals that the effectiveness of these instruments can be enhanced when they are implemented in a coordinated manner since the former is more effective as a short-run intervention and the latter is more effective in medium to long-run strategies (Becker, 2015).

2.1.2 Incentives for human capabilities

There is an apparent consensus on the rationale that the skilled workers (also in the public sector), are a critical element for creation and diffusion of the knowledge that fosters the catch up with their forerunners. In latecomers, overcoming the capability failure requires the design and performance of effective policy instruments for the accumulation of human capabilities.

The literature review shows that the use of a wide range of notions (i.e. “in-house capacity”, “know-how” and “human capabilities”), rather than more real-world notions as training and skills, difficult the generalization of their results. Moreover, the analytical interconnections between skills and innovation capability remain under-theorised (Jones & Grimshaw, 2016).

Despite these shortcomings, the evidence confirms the significant positive effects of skilled workers on R&D at various levels. The R&D effect is found when measuring the number of scientists and engineers (Adams, Chiang, & Jensen, 2003; Adams, Chiang, & Starkey, 2001; Becker & Pain, 2008); years of formal schooling (Kanwar & Evenson, 2003); the ratio of workers with higher education in

[7] For an expanded overview of this evidence, see Cunningham *et al.* (2016).

the total (Garcia & Mohnen, 2010); and the ratio of the population having tertiary education to the working age population (Wang, 2010).

Nevertheless, the effect of skilled workers needs to be put into perspective since the level of human capabilities required varies according to the stage of development of the nation. In terms of the firm growth, developing countries are mainly fostered by a low level of human capacity – measured by primary or secondary education – and the contribution of tertiary workers is not significant (Lee & Temesgen, 2009). Meanwhile, the high level of tertiary education in advanced countries are significantly and positively related to firm growth when measured by job growth (Laursen, Mahnke, & Vejrup-Hansen, 1999).

2.2 Policies for system failures

System failures occur when missing or weak connections (and synergies) among actors produce a poor performance of an entire national innovation system (NIS) (Lee, 2013b, 2019). According to the Schumpeterian tradition, this system is defined by firms, universities, public research laboratories, government agencies and financial institutions that interact in the generation, diffusion, and use of new and economically useful knowledge.

These system interactions have been extensively investigated in advanced countries but still need to be fully understood in emerging and less developed countries, given the specifics of their firms and universities (Albuquerque, Suzigan, Kruss, & Lee, 2015; Romijn & Caniëls, 2011). In the initial stages of development, there is a lack of interaction between scientific and technological knowledge and institutions that catalyse this interaction are required to overcome specific thresholds (Bernardes & Albuquerque, 2003). Accordingly, given the immaturity of the NIS for the mutual transformation of scientific and technological knowledge, evidence shows that the latter rather than the former matters directly for economic growth in latecomers (Kim & Lee, 2015).

The system failure is also described as the situation in which nations build up a certain level of capacity and the virtuous circle related to the functioning of dynamic complementarities is not able to work. This arises from the mismatches or misalignments in the accumulation of tacit knowledge among the NIS agents, which result in an increase in their cognitive distance and a vicious circle of low interaction and learning (Lee, 2019; Nooteboom, Van Haverbeke, Duysters, Gilsing, & van den Oord, 2007). In order to tackle this failure, the policy makers claim instruments both within an established system that is in the process of transformation and for an entirely new system. These instruments are designed to improve systemic capabilities and complementarities between the NIS

components and aim to change their behavior, encouraging more university-industry interactions, or between large and small firms (Edler, Gök, Cunningham, & Shapira, 2016).

A systematic review of studies investigating public interventions aiming to enhance collaborative activities reveals a positive relationship between government subsidies and collaborative R&D between firms (Cunningham & Gök, 2016). These studies are heterogeneous in terms of scope and results, but a careful analysis reveals three main groups. First, are the studies that identify the effects of government subsidies on the design of collaborations and encourage firms to undertake domestic upstream and downstream partners (Kang & Park, 2012); expand their external collaboration breadth (Chapman, Lucena, & Afcha, 2018); and work with a heterogeneous range of partners (Ahn, Lee, & Mortara, 2020).

The second deals with the mismatches among the NIS agents and its results reveal that the supporting collaboration is associate with academic researchers' industrial activity (Bozeman & Gaughan, 2007); the higher probability of firm cooperation with a public research organisation (Busom & Fernández-Ribas, 2008); and increase the rate of agreements between manufacturing firms and universities or technological centres (Afcha Chávez, 2011).

The third group of studies output effects and report the collaborative R&D on firm increasing R&D spending (Arranz & Arroyabe, 2008; Mothe & Quelin, 1999); increasing the probability to patenting (Czarnitzki, Ebersberger, & Fier, 2007; Miotti & Sachwald, 2003); and greater propensity to establish R&D agreements (Segarra-Blasco & Arauzo-Carod, 2008). The increase in spending also generates spillovers effects given the increase in R&D spending in other firms (Watanabe, Kishioka, & Nagamatsu, 2004). According to Hottenrott and Lopes-Bento (2014), public subsidies are even more effective in generating R&D spending in cases of international collaboration. Caloffi *et al* (2018) show that the expected results of public subsidies over time depend on the characteristics of the beneficiaries. SMEs with some prior R&D experience increase the amount of spontaneous R&D investment and firms with modest R&D experience produce and an increasing number of R&D-performing SMEs.

2.3 Policies for size failure

The lack of world-class businesses in developing countries is conceptually defined as "size failure". Within these contexts, the market space that would be occupied by large companies (as in developed countries) is filled by small and medium-sized firms, which are perceived as an insufficient organizational form in leading a transition from middle- to high-income status. The Schumpeterian

legacy states that large and quasi-monopolistic firms are the businesses model capable to exploit economies of scale and scope. Thus, the need for large companies in this transition is due to their ability to achieve high levels of knowledge production and capacity to undertake R&D and marketing activities with higher value-added (Lee, 2019; Lee, Kim, Park, & Sanidas, 2013; Lee, Park, & Krishnan, 2014).

Despite this rationale, the benefits of big business are a controversial topic and its results in terms of social welfare are far from a consensus among scholars. For instance, Fogel *et al*. (2008) find faster economic growth in countries where big business is less stable over time. Moreover, the big business stability occurs where governments are larger, civil codes hold sway, red tape is denser, banks are more dominant, and the global economy less immanent.

A critical issue in this debate is the lack of well-established toolkit for this policy goal, which result in a relative scarcity of evaluations of its effectiveness. Generally, the instruments to encourage the growth and consolidation of large companies are designed and implemented within the scope of trade, competition and regulations policies and their public intentionality is not clearly observed. For the purposes of this article, this section reviews the effectiveness of policies designed to building capacity, especially in promoting R&D through *fiscal incentives* and *direct support*.

Guceri (2013) study on R&D tax incentive scheme in the UK shows that large firms increased their R&D spending by more than an additional 18 percent in comparison to the SME control group. In a similar study, Bond and Guceri (2012) found effects of the UK R&D Tax Relief for large firms in increasing the intensity of R&D, albeit almost wholly concentrated in high tech sub-sectors of manufacturing.

The effectiveness of R&D tax incentive schemes requires special attention when the time dimension is included in the analysis since the effects and outcomes of these activities are of a long-run nature. Lokshin and Mohnen (2012) examine the effects of the Dutch scheme and finds that input additionality diminishes over time, hence the crowding out of private R&D can only be averted for small firms, while the scheme becomes ineffective in large firms.

As in the case of fiscal incentives, the evidence of direct support is mixed and not clear cut. According to some, the additionality effect is observed differently depending on the size of the company. Lach (2002) using data from Israeli manufacturing sector shows increased R&D spending for small firms and decreases for large firms. Lenihan and Hart (2006) develop an approach to estimate the net additionality and discover a higher deadweight for larger domestic firms, that is, the amount of subsidies that which can be deemed to have occurred anyway.

Another stream of research reports positive effects of direct support for large firms, although the effect on R&D intensity is more significant for small firms (Alecke, Mitze, Reinkowski, & Untiedt, 2012; Özçelik & Taymaz, 2008; Paunov, 2012). Cerulli and Poti (2012) firm-level study suggest that the Italian R&D policy instrument has been successful in promoting both input and output additionality and firms with higher performances are generally larger.

In cases where the policy outcomes are measured by new products and services, Hujer and Radic´ (2005) study of the German Federal Employment Office shows a significant effect for large firms. Herrera and Bravo Ibarra (2010), when comparing R&D subsidies according to firm size, conclude that large firms only show a positive and significant effect on in-house technology generation and R&D subsidies have a positive, significant effect only on the tendency to patenting of large firms.

3 Summary and discussion

Arguments in defence of evidence-based policies have proliferated in the past decades and have had a profound impact on government bureaucracies, academic institutions, and the media. According to this movement, evidence matters for public policymaking and perform a critical role in demonstrating "what works". However, science-based policies are threatened by the "politicisation of science", where political interests appear to drive the corrupt to shape or cherry-picking the evidence (Parkhurst, 2017). In order to deal with these problems, scholars have proposed a toolkit that aims to guide policymakers in various aspects of interventions, based on existing evidence (Bloom, Van Reenen, & Williams, 2019).

Despite this apparent consensus, another strand of academics is critical of the notion that public policymaking can somehow simply be 'based' on evidence alone. These critical voices argue that social policies involve trade-offs between several competing social values and only a minor group of political decisions can be limited to decisions based only on technical evidence of the effects of interventions. In contrast, these scholars are concerned with "depoliticisation of politics" given that the emphasis on evidence-based can obscure or marginalize social values (Parkhurst, 2017).

In terms of policies for catch-up, although practices in forerunners usually provide a model, the needs of latecomers countries inevitably differ in various and important ways from the existing templates (Mazzoleni & Nelson, 2007). This can be illustrated by the paradox that states "to be similar, you've got to be different" (Lee, 2019) which means that long-term success requires a different path from that adopted by developed countries.

According to Parkhurst (2017), these views are not seen as mutually exclusive since they are based on normative rather than on epistemological differences. Thus, a pragmatic view tends to recognize that both sets of values are important goals to deal with initiatives to improve the use of evidence within the catch-up process.

Despite the deeper implications of both sets of values, a first conclusion from the extant literature is that much of the evidence is invariably context-dependent, and lessons for latecomers contexts need to be in perspective. However, this fact does not prevent this evidence from being a basis for guiding the efforts for catch-up policy efforts in latecomers. Table 2 condenses these judgements according to the failure and reveal the identified variations in terms of quality and conclusiveness.

Table 2 - Summary of instruments and evidence judgements.

Failure	Instrument	Time frame	Availability of evidence	Accuracy of evidence
Capabilities	Tax incentives	Short run	●●●	●●●
	Direct funding	Medium run	●●○	●●○
	Incentives for human capabilities	Long run	●●○	●●○
System	Subsidies to collaboration	Medium run	●●●	●●○
Size	Fiscal incentives	Medium run	●●○	●○○
	Direct support	Long run	●○○	●○○

Source: Own elaboration. Note: ●●● = major presence, ●●○ = moderate presence and ●○○ = minor presence.

Policies for handle with capability failure are the interventions most supported by evidence from policy instruments. Evaluations show that R&D tax incentives and direct funding increased business R&D expenditure over time (input additionality). There are positive effects of R&D tax incentives on output additionality, especially for products and processes, but the evidence for direct funding is limited and contradictory. In both cases, these effects vary greatly depending on the country, sectors, period and method used. Therefore, this context-dependent characteristic of the instruments makes careful examination necessary before their implementation in latecomers since most of the evidence comes from developed countries.

System failures are overcome by instruments such as subsidies to collaborative R&D and reviewed studies present significant evidence of their effectiveness. In terms of input additionality, government subsidies have strong effects on collaborative R&D between firms. The evaluations also report a wide range of output additionality from these subsidies, which are broadly defined and measured. Policymaking based on this evidence requires caution since the evidence comes from developed innovation systems and the effects are clearly limited to the target group, not to broader populations of firms.

The instruments to tackle the size failure are the most contradictory among the groups investigated. Despite some studies finding positive input additionality, most reveal that fiscal incentives and direct

support to large firms become ineffective when the time dimension is included. These results impose a dilemma for policy makers since small firms seem to respond more positively to government support than large companies (Criscuolo, Martin, Overman, & Reenen, 2019). However, the focus on small firms can limit the emergence of large companies since entrepreneurs are discouraged from expanding beyond thresholds that disqualify them from these subsidies (Bloom et al., 2019).

The R&D activities undertaken by large firms when compared to SME have characteristics that modify their performance in response to government support. First, since R&D is characterized by indivisibilities and a minimum size, projects of all types and complexities are more likely to become feasible in the context of large firms. Second, R&D activities also involve high fixed costs and large firms are better able to absorb the spreading effects of fixed costs due to their larger scale of production. Third, large firms are more capable to capture the spillovers from R&D activities given the effectiveness of protecting their intellectual property. Ultimately, large firms are endowed with a structure that enables to secure funding for risky projects given capital market imperfections.

3.1 Interaction between instruments

This summary leads us to question the consequences of the interplay between instruments and their effects on the outcomes of the policy intervention. The question that arises is whether there are effects from the combination of policy instruments since forms of interaction can assume the form of "complementarities", where the presence of one instrument increases the effectiveness of another, or "trade-offs", where one instrument attenuates the effectiveness of another (Edler, Shapira, Cunningham, & Gök, 2016).

During policy enforcement, it is evident to assume that both possibilities for interaction often occur. Meanwhile, the evaluations of policy instruments are largely done in isolation and extant evidence on the interplay of policy instruments is exceedingly rare. Accordingly, little efforts have been devoted to producing meta-evaluation of these country evaluations. A comparative study commissioned by the European Commission's Research Directorate-General found no analysis concerning the overall effects of policy mixes and interplay of instruments (Cunningham, Edler, Flanagan, & Larédo, 2016).

The extent to which these instruments can achieve synergies and positive complementarities and the mechanisms to minimise negative interactions between instruments are a topic with increasing attention among policy makers. The discussion on this phenomenon has been organized around the

so-called “policy mix” and refers to the combination of policy instruments, which interact to influence the quantity and quality of interventions in public and private sectors.

The main idea is that a policy mix is more than simply a portfolio of instruments and the appropriate understanding of the evolution of policy mixes is a precondition to any evaluation. The conceptual mechanism proposed by Flanagan *et al*. (2010) argues that policy mix interactions can occur across the policy space, which is embodied by different policy sub-systems, between different levels of governance, across geographical space and over time. From this framework, the policy makers take advantage of potential complementarities or address potential sources of tension by efforts at improved coordination or design a coherent policy mix.

4 Challenges and lessons for evaluations

A usual conclusion in the reviewed studies on the effectiveness of instruments is “the evidence is mixed”. Some argue that when we recognize the complex and multidimensional nature of the catch-up process, it should not be surprising that quantitative evaluations achieve this type of results. However, a critical reflection on the limits and possibilities of contemporary methods that are emerging could guide the future directions of evaluations.

A challenge of evaluations is the adequate treatment of causal interpretations. Generally, the policies for catch-up is based on a relevant causal argument that there is a better outcome that would not have occurred in the absence of the intervention. Although it appears this would be fertile ground for causal inference, the review shows that this has not been the case until recently. Nevertheless, the causal inference has been at the centre of the concerns of quantitative policy assessment in several areas. The counterfactual evaluation aims to estimate the magnitude of this specified causal effect, using appropriate econometric techniques.

The use of counterfactual in policies has been the subject of disagreement among scholars. Some believe that steps to build this counterfactual are excessively arbitrary and suggest that analysis is impossible. According to others, using contemporary econometric tools, questions and research designs, it is possible to conduct useful counterfactuals comparisons for policies (Lane, 2020). In other words, the counterfactual evaluation methods cannot answer many relevant questions since that important effects cannot be quantified, however, still many issues for which causal inference would be feasible and useful (Bravo-Biosca, 2019).

In the case of policies to knowledge generation, a relevant question in the counterfactual language is: “Would firms underinvest in R&D, or be less innovative, if they had not received a public incentive?”.

Since most of the incentives for knowledge generation are related to R&D promotion, one of the challenges to be overcome in the evaluations is lacking experimental evidence in this area.

This experiment-based evaluation format is contextualized in a research environment increasingly dominated by randomized policy evaluations (Duflo, Glennerster, & Kremer, 2007). To exemplify this method, we can imagine a randomly partitioning a population of firms into a treatment and a control group. Whereas the former receives financial support and to latter funding is denied, the differences in performance between the two groups could be directly attributable to the grant. The main obstacle to this experiment is that policy makers and taxpayers are unwilling, without extensive due diligence, in randomly handing amounts of financial incentives among firms (Hünermund & Czarnitzki, 2019b). Alternatively, the evaluations are conducted mostly based on data ex-post observed data collected from subsidy schemes where firms have been hand-selected from a list of applicants. This method renders the econometric policy evaluation task even more complex.

Attempts to overcome these obstacles arise when it is recognized that these policies can be employed more effectively if one knows if the combined net effects of a treatment exceed those of the combined costs of the treatment. Although the quantitatively analyse the net effects of interventions can be particularly useful for policy makers, the studies that demonstrate these effects are exceedingly rare.

Ex-post policy evaluation also needs to handle technical difficulties such as the so-called confounding problem (Bareinboim & Pearl, 2016). Following the reasoning of the previous example, differences between funded and non-funded firms resulting from the selection process, if not carefully considered, can significantly affect the outcomes of the evaluation. However, a successful assessment requires that all confounders be observed, and as can be imagined, this rarely occurs. For instance, the survey on the effectiveness of public subsidies of private R&D spending shows that very few studies adequately take the confounding problem into account (Zúñiga-Vicente et al., 2014).

The evaluation of a policy tool without controlling for simultaneous public programmes aiming at the same objective can also result in procedural confounding due to hidden treatments (Guerzoni & Raiteri, 2012). Put differently, the results of the target treatment are distorted when only one particular treatment is observed without controlling for other treatments. In order to deal with these problems, emerging studies have proposed the use of rankings, thresholds, and Regression Discontinuity Design (RDD) to provide more convincing causal evidence (Bronzini & Piselli, 2016; Dechezleprêtre et al., 2016; Howell, 2017; Hünermund & Czarnitzki, 2019a). Therefore, research designs are planned in detail to confront endemic endogeneity and tackle the confounding problem.

Since these frontiers of evaluation tend to be undertaken at the level of specific policy programs and schemes, challenges for their use during catch-up process become evident. A first challenge is imposed by the system complexity, their multiple interactions over time and, essentially, the needed data to support assessments[8]. In order to handle these obstacles, governments should become more open to the use of experiments in policy evaluations and there is a need to increase cooperation with researchers.

4.1 Sequence and context of policies

This article advocates that evaluation of policies for knowledge generation in latecomers could improve interventions to deal with failures during the catch-up process. Therefore, it needs to consider the effectiveness of a range of instruments in order to achieve an increasing improvement in the design of the intervention. This presupposes learning about these interventions and capacity to capture and interpret its effects. Yet, the evidence is invariably context-dependent, and caution is needed when drawing lessons for latecomers' contexts.

In view of the current literature, evaluations have led to a perspective that isolates individual instruments from their overall policy context. Since the instruments do not emerge in a vacuum, studies increasingly need to demonstrate how contexts can affect the overall results. The interventions need to put it in perspective the existence of unobservable forces such as government capacity, market imperfections, and the targets of policy makers. These forces can confound the relationship between instrument performance and policy interventions. For instance, the empirical relationship between private R&D spending and endogenous politics cannot distinguish between the impact of intervention and unobserved political forces behind the policy. In the absence of context analysis, is difficult to determine whether the evaluation is testing the practical aspects of the policies per se or the interaction of these policies with broader political forces[9].

The role of the political context requires attention since technocratic policies may not be as salient in the time frame of evaluation. While instruments such as tax incentives are well established in terms of evidence, this is not the case for other incentives such as incentives for human capabilities that given its nature their effects may not be properly captured by evaluations. In some cases, the measure

[8] An example is the methods to measure and compare costs and benefits over time. The current toolkit makes it difficult to capture both sides of the cost-benefit ledger since many of the benefits are based on future hopes for benefits and are fully captured only in the long run.
[9] See Rodrik (2012) for a detail discussion of these evaluation failures in the industrial policies context.

of the impact requires more granular evidence and richer institutional context than the present generation of empirical studies.

The political context is also crucial since the instruments are embedded in institutions that shape their performance over time. Suzigan *et al*. (2020) demonstrate how the general political context was decisive in determining the results of policies to encourage the generation of knowledge in Brazil (based on R&D indicators). Thus, evaluations of instruments need to consider the intention of policy and recognize the existence of unobserved forces shape the scope of the policy.

A further challenge arises when the evidence is properly captured only as a sequence of events is observed. The incentives for knowledge generation is highly dependent on the time dimension and the verification of many outcomes depends on the succession of different instruments over a significant period. A study on Danish and Norwegian wind industry reveals a cumulative impact on permanent technical change when different policy instruments are coordinated over time (Buen, 2006)[10]. This study shows that the cumulative impact of the interventions is influenced by the succession of different instruments designed for specific needs and is captured by the combination of supply and demand measures. In other words, the evaluation of incentives to knowledge generation must be followed up by further tailored supply or demand measures.

When it is recognized that the evidence on theses interventions tends to be nuanced and poses challenges for emerging evaluation methods, a possible consequence is that methodological advances are to render a large portion of current methods impotent. These limits and shortcomings have led scholars to reinforce the importance of qualitative reviews, among conventional quantitative analyses when seeking to capture the effectiveness of instruments in policies such as catch-up.

In view of the proliferation of new studies and methods, the combination of approaches can prove especially useful to deal with the challenges discussed. In particular, the studies focus on specific case studies and natural experiences to estimate the impact of catch-up policies. Although there are limitations to this approach, it can still provide valuable information about these policies. An example is the return of studies that adopt traditional historical investigations that rigorously detail specific political cases, institutional schemes, and specific projects (Lane, 2020). Since the successful upward transition rarely occurs, this approach allows the extraction of empirical lessons from specific episodes and is crucial for shaping the way we understand the complex relationships between government action and its broader effects.

[10] For discussion of sequencing policy interventions in the case of energy agencies, see Cunningham *et al*. (2016).

5 Concluding remarks

This study proposed a review of studies about the effectiveness of policies for knowledge generation and discusses the potential of evaluating these instruments to address failures in the catch-up process. The results show that instruments for tackle failures are heterogeneous and the availability and accuracy of evidence vary significantly. The policies for capability failure and size failure are interventions that are more evidence-based and less controversial than policies for size failure. Moreover, much of the evidence report conflicting results and can lead to misunderstandings about the potential of these interventions. The lessons for latecomers are that evaluations tend to isolate individual instruments from their overall policy context and given its characteristic of strong dependence on the context, caution is needed when drawing lessons for policies.

Emerging studies and their attempts to adequately address the problems of causal evidence, endogeneity and confounding problem are relevant initiatives for the improvement of evaluation of catch-up policies. However, these evaluations require more granular evidence which poses challenges for methods of analysis. This article argues that an adequate understanding of catch-up policies also requires a rigorously detail specific political cases, institutional schemes, and specific projects. In general, our understanding of these interventions is enhanced if emerging approaches have been enriched by specific policy case studies, institutional details, and policy contexts. Put differently, the combination of approaches, with appropriate caveats, represent a significant potential to improve the future production of evidence of policies for the catch-up and learning about policy design.

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