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The Role of Tax Incentives in Innovation Policies: theoretical considerations and recent developments

O Papel dos Incentivos Fiscais em Políticas de Inovação: considerações teóricas e desenvolvimentos recentes

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Abstract: The objective of this paper is to discuss the role of tax incentives as part of national innovation policies from a theoretical perspective. Tax incentives are commonly interpreted as closer to a market failure rationale, but they can also play a role as part of a broad evolutionary policy strategy. The theoretical debate provides a conceptual framework to explain the increasing relevance of tax incentives in different countries as from the 2008 economic crisis. The Brazilian experience seems inconsistent with this trend, as the reduction of public budget to innovation was not followed by an upsurge of tax incentives.

Keywords: Brazilian innovation policy; innovation policy; tax incentives.
JEL Classification: O38. H25.

Resumo: O objetivo deste artigo é discutir o papel dos incentivos fiscais como parte das políticas nacionais de inovação sob uma perspectiva teórica. Os incentivos fiscais são usualmente considerados um instrumento de política associado ao argumento das falhas de mercado, mas eles também podem ser utilizados como parte de uma estratégia de política evolucionária. A discussão teórica fornece um quadro conceitual para explicar a maior relevância dos incentivos fiscais desde a crise econômica de 2008. A experiência brasileira parece inconsistente com essa tendência, pois a redução do orçamento público para inovação não foi acompanhada de um aumento dos incentivos fiscais.

Palavras-chave: política brasileira de inovação; política de inovação; incentivos fiscais.
Classificação JEL: O38. H25.

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1. Introduction

In 2005, the Brazilian Congress approved a new framework of tax incentives to promote business innovation in the country, as part of a broader industrial policy and tax reform. Law 11,196/05 (also known as the '*Goodness Law'*) established a horizontal innovation policy that allowed for the enhanced deduction of expenses in research and development (R&D) from the taxable income of beneficiary firms. Since then, tax breaks have gained increasing relevance within the country's innovation policy. The value of government support to business R&D granted through fiscal benefits increased from approximately 700 million U.S. dollars in 2005 to 2.3 billion U.S. dollars in 2018 (Brazilian Ministry of Science Technology and Innovation, 2021a).[1] Similar trends were observed in different countries (including France, Ireland, United Kingdom, Korea and Australia), where governments have resorted more intensively to tax incentives to foster business innovation (OECD, 2021a).

So far, the analyses on the Brazilian innovation tax policy have mostly adopted an empirical perspective, whether discussing the country experience with these incentives (Pacheco, 2003; Corder and Salles Filho, 2010), presenting data and descriptive statistics (Calzolaio and Dathein, 2012; Matias-Pereira, 2015), or estimating the impact of the policy (Avellar, 2008; Kannebley Jr and Silveira Porto, 2012; Colombo and Cruz, 2018; 2021). However, despite the relevance of these empirical studies to assess the impact and effectiveness of the policy, the international innovation policy literature poses a fundamental theoretical debate on whether state action should be limited to correct market failures or if policies should also aim at creating markets and achieving societal challenges (Mazzucato and Semieniuk, 2017; Borrás and Edler, 2020).

In light of such debate, the objective of this paper is to contribute to the understanding of tax incentives as part of a national innovation strategy by analyzing the role of such policy tool within these theoretical frameworks and considering the recent developments in the use of tax incentives in different countries and in Brazil. The main theoretical analysis of the subject in the country was presented by Avellar (2008), as a background to the empirical study. This paper favors a different approach, analyzing tax incentives according to the role ascribed to them by the 'market failure' and neoschumpeterian theories, and using such distinction to explain the increasing use of these benefits recently.

The second section below presents the theoretical debate and current international practice on innovation policies. The third discusses the concept of tax incentives, the different arrangements that can be adopted by governments and the international experience or how different countries have resorted to such benefits. The fourth part discusses how this policy tool can be interpreted, and its role according to the presented

[1] Values converted according to the exchange rate applicable at the last day of each year.

theories and policy context. The fifth section analyzes the Brazilian case, and the sixth concludes the paper.

2. The Theoretical Debate and Recent Developments on Innovation Policies

An advantage of researching innovation policies is that there is little disagreement at the theoretical level on whether they ought to be implemented or not. Both the neoclassical 'market failure' and the neoschumpeterian theories agree that there is a role for the government in promoting innovation. The consensus, however, does not go much further, as the appropriate scope and reach of the policy is subject to debate. Authors of the market failure theory understand government intervention should be limited to create the appropriate conditions for business innovation, minimizing distortions caused by this interference on market mechanisms. On the other hand, evolutionary or neoschumpeterian economists attribute a more prominent role to the state: it should lead the industrial development and directly pursue radical innovation or the development of strategic technologies necessary for economic growth (Mazzucato, 2011; Edler and Fagerberg, 2017; Borrás and Edler, 2020).

The market failure argument is currently the main justification of innovation policies (Edler and Fagerberg, 2017; Hall, 2020). It is based on the idea that perfectly competitive markets allocate resources efficiently, generating a social Pareto optimum. However, in the case of innovation or the production of information, a group of market failures does not allow such an outcome to emerge, and the private market is expected to underinvest in such activities in the absence of government intervention (Arrow, 1962; Van Reenen, 2020). The main market failure present in innovation-related activities is substantial positive externalities in the form of knowledge spillovers (IFS, 2015; Hall, 2020), which may be three to four times as large as the private returns that firms obtain from innovation (Lucking *et al.*, 2019). Other market failures suggested by the literature are indivisibility of results, asymmetric information, moral hazard, coordination failures, and imperfect competition (Hall and Lerner, 2010; Mazzucato, 2016).

Based on this reasoning, the aim of innovation policies is to correct or counteract these market imperfections to increase R&D spending and bring it closer to socially optimal levels (Martin and Scott, 1998; Appelt *et al.*, 2020). Governments should focus on policies that increase firms' R&D expenditures, human capital and productivity. Direct provision or public production of knowledge is only justified when positive externalities are too great, such as the case of basic research (Griliches, 1985; Edler and Fagerberg, 2017). Another agenda of the market-failure approach is to improve legal protection and strengthen intellectual property rights to increase private returns and incentives to invest in innovation

(Edler and Fagerberg, 2017). According to the Organization for Economic Co-operation and Development - OECD (2015), market failures are the rationale for 'well-recognized' innovation policy instruments, such as direct subsidies for business R&D, investment in basic research and infrastructure, and regulation of environmental externalities.

This policy agenda also finds its basis in the endogenous growth literature (Romer, 1990; Bloom *et al.*, 2020). By endogenizing technological development in firms' production function, these models allow for non-decreasing returns to scale that can lead to long-run growth. However, as ideas are non-rival and generate knowledge spillovers, firms underinvest in the production of new information, lowering the growth trajectory. Therefore, the aim of the innovation policy should be to increase factors affecting endogenous technology progress, thus raising long-run growth (Jones, 2005). Although the new growth theory did not explicitly present the argument in favor of innovation policies, it provided the theoretical grounds for government action by stressing the causality between R&D and growth (Mazzucato, 2011).

In this approach, a relevant constraint to innovation policies is the inefficiency created by government intervention. This topic was mainly developed by the public choice and government failure literature. These studies challenged both the intention and capacity of government officials to formulate and implement policies to correct market failures. Policies can be incorrectly timed, the magnitude may be excessive, and they may remain valid after they are no longer necessary because of rents (Tullock *et al.*, 2002). Wolf (1993) listed four main sources of government failures: redundancy and rising costs; "private" goals of public agencies; derived externalities or side effects; and distributional inequity. These public choice problems make the net outcome of innovation policies uncertain in terms of efficiency improvement (Chang, 1994).

The evolutionary theory presents a different model of the innovative process, including features such as uncertainty, heterogeneity of firms' behavior and Schumpeterian competition (Nelson and Winter, 1982). These authors criticize the traditional focus on market failures and knowledge spillovers, arguing that these are not major concerns of firms because their innovation capabilities are not easily copied (Edler and Fagerberg, 2017). The evolutionary theory favors a 'behavioral' approach, meaning that firms respond diversely to inputs from the environment according to a set of rules (Nelson and Winter, 1974). Dosi and Marengo (2007) emphasized the relevance of dynamics, bounded rationality and selection mechanism.

The Schumpeterian concept of 'creative destruction' is modeled through drastic innovations that render older technologies obsolete and change firms or countries in the knowledge frontier, affecting profits and chances of survival. In Nelson and Winter's (1982) simulated growth model, firms select between alternative production methods that are the product of new discoveries and the interaction and exchange of information among agents, thus blurring the concept of the production function. The maximizing behavior is replaced by search and selection, and the idea of equilibrium is no longer applicable, as the

historical process and uncertainties determine the outcome of the economy at each point in time.

The neoschumpeterian approach sees a different role for the state in the innovation process. These authors maintain that states have historically been responsible for more than simply 'fixing the market' (Mazzucato and Semieniuk, 2017). Mowery (1992) argued that government intervention has been central to the U.S. postwar innovation system, especially through the antitrust policy, public R&D expenditure and the national defense budget. Freeman (1988) suggested that the Ministry of International Trade and Industry (MITI) has shaped the structural change of the Japanese economy based on its assessments of the future of technological progress. Mazzucato (2011; 2016) criticized the market failure theory for ignoring the leadership the state has historically had in technological development. Especially in the case of developing or laggard countries, Dosi *et al.* (2020) argued that markets only 'cannot do the magic' of achieving technological 'catch-up'.

This approach has profound implications for the design of innovation policies. According to Nelson and Winter (1982), the main message is that the appropriate policy cannot be determined *a priori*, based solely on a theoretical model or on an ahistorical analysis. On the contrary, the state intervention should be outlined taking into consideration the particularities of the concrete case, including past experiences, the applicable institutional framework. Innovation policies should also be 'mission-oriented', meaning that they should aim at addressing clear challenges and achieving societal goals (Dosi *et al.*, 2021). The neoschumpeterian approach also emphasizes the 'trial-and-error learning process', and, for this reason, public support should target various formal and informal learning approaches (Seravalli, 2009). In this scenario, a policy is likely to include several distinct tools, each designed to tackle specific challenges of sectors and networks, an idea summarized by Mazzucato (2011) as 'R&D is not enough'.

Neoschumpeterian analysis favors the concept of system of innovation instead of individual policies. Such an approach emerged in the late 1980s and early 1990s as a comprehensive framework to discuss the interactions between firms and other actors necessary for innovation, along with the diverse role of public policy to support these connections (Edler and Fagerberg, 2017). An innovation system comprises the whole set of institutions (both public and private) that affects the funding, output and diffusion of new technologies (Mowery, 1992). And while parts of this system are predetermined by fixed country features (geography, size, natural endowments), Nelson (1993) argued that other characteristics can be the product of deliberate political decisions, including those aimed at economic development and creation of comparative advantages.

Based on such framework, Navarro *et al.* (2016) presented a set of policy guidelines specifically designed for improving the innovation system of Latin American countries. The region is described as having low technological intensity, a shortage of human capital and a weak innovation climate. Their recommendations included supporting capacity

building for policy-making, financing small and medium enterprises and investing in the development of effective innovation ecosystems.

Within the endogenous or new growth literature, a group of models included features of the Schumpeterian analysis into the neoclassical framework. These Schumpeterian growth models detail how the creation of knowledge, R&D investment and the 'creative destruction' affect the economy, concepts that are more familiar to the evolutionary approach. Their recommendations also point out specific policies that match the context of each economy. For example, Gerschenkron's (1962) notion of 'advantage of backwardness' was used to argue that growth-enhancing institutions may differ depending on the distance of an economy to the technological frontier (Aghion and Durlauf, 2009). Aghion and Akcigit (2017) concluded that stronger competition, trade openness and labor flexibility are important factors for advanced countries, while more intense competition may actually discourage innovation in 'non-frontier' firms.

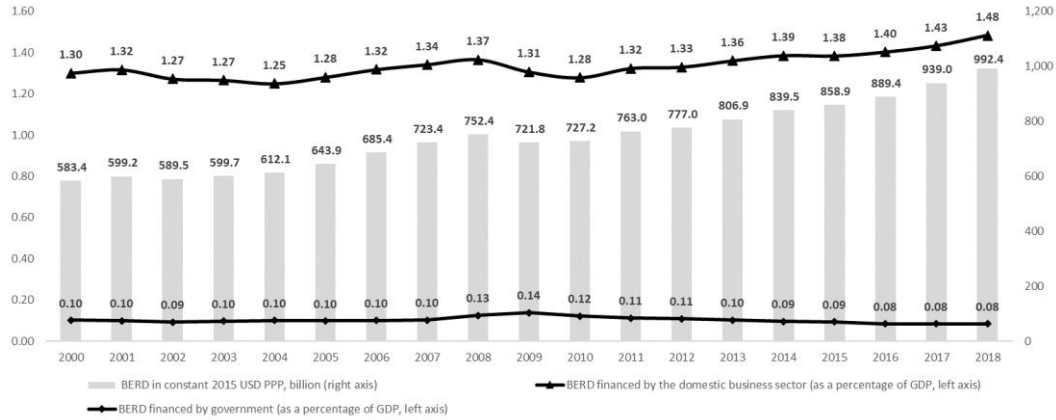
Until the financial crisis of 2008-2009, broad innovation policies were on the rise. OECD countries adopted comprehensive national innovation plans setting ambitious priorities, that responded to major challenges or technological opportunities identified by the government, such as environmental issues and nanotechnology (OECD, 2006). Government support to open innovation and partnerships between firms and universities tried to foster research collaboration and knowledge transfer and distribution. The OECD adopted and proposed a conceptual framework based on the idea of national innovation systems, using a model of innovation as an interactive process of transactions between firms, institutions and human resources (OECD, 2002).

A variety of policy tools were established to achieve different objectives, including tax incentives, early-stage capital funds and regional or sub-central policies (OECD, 2006). The World Bank (2010) guidelines for innovation policy made clear reference to the importance of collaboration and systemic perspective in an uncertain environment. Although it is not possible to frame such a policy description exclusively in a single theoretical paradigm, the presence of elements inspired by neoschumpeterian economics seems clear. Hartmann (2007) considered the approach adopted by the European Council in the 2005 version of the Lisbon Strategy as built upon and strongly influenced by evolutionary economics, as it relied on concepts such as the innovation system and the triple-helix (Ranga and Etzkowitz, 2013).

The global economic crisis of 2008-2009 has changed this landscape substantially. Although national strategies to face the crisis have acknowledged the relevance of innovation for resuming a growth trajectory, budgetary cuts have affected governments' capacity to offset the drop of business R&D, attract and lever knowledge-based capital and finance comprehensive policy schemes (OECD, 2016). As presented in Figure 1, the sharp decrease in business enterprise R&D expenditure (BERD) financed by the business sector in OECD countries in 2009 was only partially counterweighed by the increase of publicly-financed BERD, and the overall effect on business R&D expenditure was a decrease of

approximately 30 billion U.S. dollars. Since then, government expenditure in BERD (as a share of gross domestic product - GDP) experienced a gradual reduction after such period, while business-financed BERD increased steadily after 2010, surpassing its 2008 level in 2014.

Figure 1. Business Enterprise Research and Development Expenditure (BERD) financed by industry and by the government (as a percentage of GDP), and total value of BERD in OECD countries.



Note: government-financed BERD includes only direct public investment, excluding tax incentives.
Source: OECD (2021a).

The Lisbon Strategy failed to meet its main targets, including the increase in R&D per GDP ratio to 3% (European Commission, 2010b). It was replaced by a new plan - the Europe 2020 Initiative (European Commission, 2010a), that was based on the importance to protect and promote investment in innovation, but also to improve its performance, especially through integrated action by member countries. According to this document, public support to business R&D should be targeted and address well-identified market failures. The '*Strategy for American Innovation'* (U.S. National Economic Council and Office of Science and Technology Policy, 2015) followed the same idea: the main guideline to encourage business innovation was to address market failures and ensure friendly framework conditions. The United Kingdom (U.K.) "Plan for Growth" strongly emphasized the need to lessen the regulatory burden to encourage innovation (HM Treasury and B.I.S., 2011).

The previous emphasis on the variety of tools and coordinated groups of incentives was replaced by principles like rationalization of efforts, reduction of fragmentation and a 'no spending' approach (European Commission, 2010a; Meissner and Kergroach, 2019). Such a change of paradigm in innovation policy is subtle and should not be found in broad

aggregate indicators, as the modifications are mostly qualitative. According to the EC and OECD survey on innovation policy, the governance of science, technology and innovation policies became a major concern among policy-makers (OECD, 2016). The survey also pointed out that rationalizing public research, remodeling the policy mix for business R&D and improving policy governance with a focus on evaluation are relevant changes in the design of innovation strategies. A similar trend was suggested by Izsak *et al.* (2013), as funding and prioritization or targeting are described as top challenges for national innovation policies.

This scenario suggests that innovation policies leaned towards a 'market failure' rationale after the crisis. Budgetary constraints, excessive regulation and the lack of confidence in governments due to their inability to prevent the economic crisis (OECD, 2016) have reduced the attractiveness of the idea of a large public sector driving technological progress. This led to a change of focus towards firm-based innovation and policies with specific objectives aimed at boosting such potential. In the midst of the crisis, the OECD policy recommendation for innovation was based on the idea that the crisis had magnified acknowledged market failures in innovation financing (Guellec and Wunsch-Vincent, 2009). As suggested by Mazzucato (2011, p. 17), "across the globe we are hearing that the state has to be cut back in order to foster a post-crisis recovery, unleashing the power of entrepreneurship and innovation in the private sector".

3. Tax incentives: main concepts, institutional arrangements and summary of the international practice

Tax relief is any form of discount, credit or special treatment granted by the government to firms with positive innovation spending or implementing innovative projects (Köhler *et al.*, 2012; IFS, 2015). These incentives can have different arrangements or rates of tax breaks, depending on policy objectives and specific features of the tax system. Such arrangements can be divided into the following categories (Köhler *et al.*, 2012; IFS, 2015): (a) tax credits are subtracted directly from the amount of tax due after it has been calculated; (b) allowances are deducted from the tax base before liability is calculated; (c) accelerated depreciation or amortization of equipment or technology; (d) reduction or exemption of taxes levied on innovation inputs; and (e) reduction or exemption of taxes levied on innovation output.

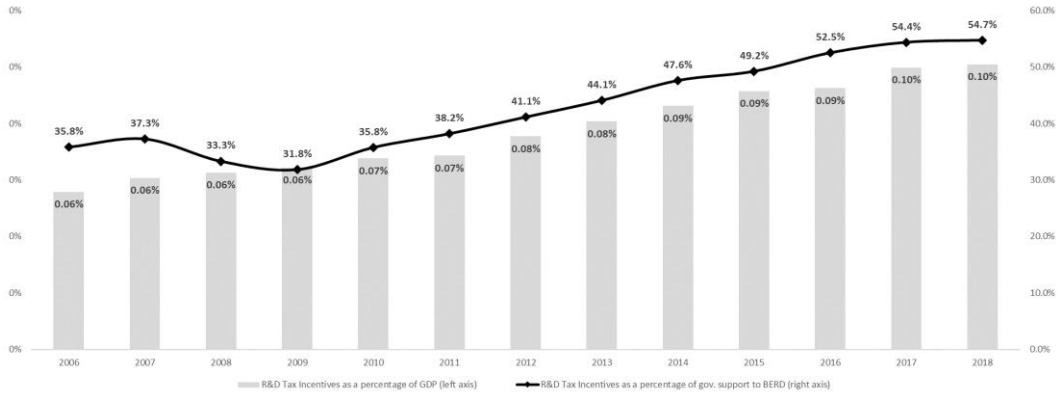
In addition to these basic categories, there is a set of secondary features or options distinguishing tax incentives in different countries, such as the definition of R&D; authorized deductible expenses; volume or incremental schemes; targeting; and carryforward or carryback provisions (IFS, 2015). Griffith *et al.* (1995) pointed out that the design of fiscal policy can substantially impact its results, generating inefficiencies or

distortions on economic incentives. As an example, Hall (1993) found that about 30% of companies benefiting from tax incentives in the U.K. actually had negative tax credit in 1989.

Since the first experiences in the second half of the 20th century, many countries have approved tax regimes that favor innovation and R&D-related activities. In 2018, around 80% of OECD member countries have resorted to some form of tax relief (Van Reenen, 2020), in addition to other important economies like India, China, Russia, South Africa and Brazil. The institutional structure of incentives varies significantly from one country to another (OECD, 2020). Köhler *et al.* (2012) emphasized that policy design impacts innovation spending and firms' behavior and productive structure, including their collaboration networks, making incentives' design even more relevant.

The upsurge in the values of tax waivers was influenced by the increasing importance attributed to innovation policies over the past decades, along with the rise of GDP, business R&D expenditure, and the diversification of countries and actors competing for innovation resources (OECD, 2008). But these general trends only partially explain the trajectory of tax incentives. Figure 2 shows the share of government incentives granted to business innovation through tax benefits in OECD countries from 2006 to 2018. Not only fiscal benefits increased in OECD countries (as a percentage of GDP), but they became relatively more important within national innovation strategies. Such increase was of such magnitude that the government support to BERD through tax incentives surpassed the value of direct public investment in this activity in 2016. Such trend is discussed in more detail in the next section.

Figure 1. Tax Incentives as a percentage of GDP and of total government support to Business Enterprise Research and Development Expenditure (BERD) in OECD countries.



Note: government support to BERD: direct investment plus tax incentives to R&D.
Source: OECD (2021b).

4. The role of Tax Incentives in Innovation Policies

Fiscal benefits reduce the tax cost of innovation projects, thereby increasing the number of economically profitable and viable projects and stimulating firms to undertake more R&D activities (Ognyanova, 2017). But tax reduction affects firms' economic incentives and business strategies differently than direct funding. The main advantage of this policy strategy reported in the literature is its 'market-oriented' nature, in the sense that the government does not decide the projects to be funded (Hall and Van Reenen, 2000; Agrawal *et al.*, 2020). Private decision-making is thus preserved, reducing allocative distortions arising from government intervention.

Moreover, tax incentives are less subject to the informational problem of public agents, as the state agent seldom is in a better position to identify projects or enterprises with greater profit or success potential (IFS, 2015). Exempting the government of such responsibility also reduces the size and cost of the administrative structure necessary to manage the incentives. Finally, this type of incentive tends to reduce uncertainty, favoring long-term business planning (Köhler *et al.*, 2012; Hall, 2020). Other positive features of tax incentives *vis-à-vis* direct benefits are: (a) neutrality and impartiality, for tax breaks apply to all firms indistinctly, without picking off winners; (b) a lower sensitivity to short-run political changes (Hall and Van Reenen, 2000; IFS, 2015); and (c) indirect subsidies through taxation are generally accepted in international trade agreements (OECD, 2013).

The economic literature has also identified the disadvantages of the fiscal approach. The leading downside is a possible low elasticity of R&D spending with respect to the reduction of tax costs due to a possible crowding-out effect (Hall and Van Reenen, 2000), although recent empirical analyses did not find evidence of such shortcoming (Czarnitzki and Hussinger, 2018). Additionally, the tax break may not induce an increase in R&D spending if firms report other activities or expenditures as R&D, as suggested by the relabeling argument (Chen *et al.*, 2018). Another drawback is the potential conflict of interests: public money should preferentially finance projects with high levels of knowledge spillovers; companies, on the other hand, would rather develop technologies with higher rates of appropriability and internalized returns (Hall and Van Reenen, 2000). Also, tax reliefs may not affect firms' perception of technological risks, and therefore not increase the base of innovative companies (Avellar, 2008). The neutrality argument may also be challenged, as tax incentives mostly benefit large corporations (Bastos, 2004). Finally, government competition to attract investment may lead to a zero-sum game at the international level, with budget reductions in all relevant countries (OECD, 2013).

It is not straightforward to interpret tax incentives in light of the theoretical framework and policy context discussed in the previous sections, as it is a measure that serves different purposes, depending on the adopted structure. Nonetheless, tax incentives are more commonly construed as a policy tool to correct market failures (Ognyanova,

2017), since the benefits partially compensate for the limited appropriability of the results of innovation (Köhler *et al.*, 2012), but at the same time, they do not interfere in the decision-making process of the firm, leaving limited room for further government intervention.

Following this rationale, these benefits are justified by externalities and knowledge spillovers, while their use is criticized if such market failures are not clear (Griffith *et al.*, 2010; IFS, 2015). Appelt *et al.* (2016) concluded that tax incentives are typically justified "as a means of overcoming these market failures". Besides positive externalities, OECD (2011) also pointed out the presence of high informational asymmetries between inventors and investors, which increases the cost of external capital and creates the possibility of efficiency-improving government intervention through tax incentives.

In addition, tax incentives are praised as an advantageous policy scheme because they reduce the chances of government failures arising from the selection of projects by public officials, and because they are neutral and not subject to the informational problem (IFS, 2015). These ideas follow the main message of the government failure literature that the public sector does not have the capacity to formulate and implement comprehensive policies efficiently, and that such problem can only be overcome usually has prohibitive costs.

Such reasoning is not consistent with a more active role of the government advocated by neoschumpeterian economists. As a horizontal policy, tax incentives may have the advantage of not 'picking winners', but such attribute also limits the use of the fiscal approach in mission-oriented policies. As the state's influence over firms' projects and decision-making is reduced, so is the government's capacity to direct innovation efforts to create new markets or achieve societal goals. For this reason, Edler *et al.* (2013) suggested that, unlike the majority of innovation policies or instruments that are grounded on a mix of different rationales, tax incentives are 'largely based on market failure'. Metcalfe (1994) argued that tax incentives are part of a group of policy instruments that take the innovation possibilities of firms as given and do not try to enhance them, not following an evolutionary perspective. Using a Schumpeterian agent-based model, Dosi *et al.* (2021) concluded that tax discounts do not improve output nor employment, and that the best outcomes are achieved by 'entrepreneurial-state' or 'mission-oriented' policies. And Mazzucato (2011) used a neoschumpeterian approach to recommend that fiscal credits in the United Kingdom should be replaced by direct commissioning.

But even considering these shortcomings, tax incentives can play a role in an evolutionary policy perspective, as long as they are part of a broader policy strategy instead of an independent measure to correct or compensate for market failures. There is an array of possible arrangements that governments can employ for the design of these benefits, and it is possible to combine a horizontal policy rationale with targeting and selection objectives typical of a neoschumpeterian policy setup. An interesting example is presented by Aghion *et al.* (2016): their model suggested that a system of carbon taxes and fiscal incentives can

negatively affect demand for more polluting vehicles, creating incentives for the development of cleaner technologies (electric or hydrogen cars) and contributing to fight climate change. Teubal (1997) analyzed innovation policies from an evolutionary perspective, and he concluded that tax breaks are important, mostly in the infant phase, where it is important to promote both variety and competitive systems of market selection.

This theoretical discussion provides a background to explain the rise of tax incentives within national innovation strategies since the last decade, as discussed in the previous section. According to Izsak *et al.* (2013), tax benefits gained popularity within Europe during the crisis, with several countries introducing or increasing incentive rates. Their design has also evolved, with simpler schemes and encouragement of technology transfer (OECD, 2016). The U.S. innovation strategy enacted after the crisis follows this pattern: the main proposals were to increase the R&D tax credit, simplify the incentive and make it a permanent national policy (U.S. National Economic Council and Office of Science and Technology Policy, 2015).

This is partially due to a 'no spending' approach adopted by countries after the crisis (OECD, 2016; Meissner and Kergroach, 2019). Facing strong budgetary constraints, governments favored policy instruments that do not increase expenditure in the short term. Another reason lies in the simplicity, low administrative costs and broad reach of tax incentives (Izsak *et al.*, 2013). Such benefits were also found to be more stable and less sensitive to economic downturns. The World Bank (2010) also emphasized the neutrality of tax incentives to explain why OECD countries adopted such policies, moving away from such grants. OECD (2016) also stated that in different countries (as the case of France) governments replaced direct subsidies for tax benefits.

Such explanations are in accordance with the evolution of innovation policies mentioned previously. After the crisis, governments adopted a more 'market failure' and horizontal orientation of innovation policies, trying to rationalize and eliminate redundancies of different instruments. In this context, tax benefits were an appealing choice for promoting business innovation because of their generality and neutrality. The firm remains with the decision of the direction and intensity of innovation investment, reducing the pressure on the government budget and leaving the public sector with a secondary role of ensuring the appropriate institutional conditions and correcting market imperfections.

To sum up, fiscal incentives gained importance as the scope of innovation policies was reduced to correcting market failures, for the properties of tax benefits make it particularly suitable for this role, limiting government intervention and reducing potential inefficiencies. Although these benefits can also be a valid tool in an evolutionary-oriented policy, the rationale and design of most innovation tax policies pursue goals strictly related to the increase of R&D spending.

5. The Brazilian Innovation Tax Policy

The main group of tax incentives for innovation currently in place in Brazil is the result of a favorable moment for industrial policy initiatives and for an active role of the government to foster innovation. The Industrial, Technological and Foreign Trade Policy (PITCE) of 2003 and the 'Innovation Law' (Law 10,973/04) espoused a neoschumpeterian policy view, with references to building competitive advantages, selection of strategic sectors to be championed and a national system of innovation that requires an articulated interaction of institutions and stakeholders (Brasil, 2003; Avellar and Oliveira, 2009).

Law 11,196/05 was approved within this context, establishing a comprehensive set of tax incentives for innovation. The country had limited experience with this policy tool, both as a horizontal policy and in targeted programs for sectors and regions. In general, the design and rationale of the incentives followed the international practice: firms with positive expenditure in R&D are entitled to an enhanced deduction of such spending from the tax base of income tax and social contribution to the net profit, up to the limits provided for in the law. This reduces the tax cost of innovating firms, offsetting part of positive externalities and correcting this market failure. The incentives can be higher if the firm hires more researchers, develop a patented technology or collaborate with public research institutions. There are also specific provisions for the purchase of research equipment or the acquisition of technology from third parties. Most of the incentives are input-related, but the law also provides for tax exemption for the registration of intellectual property rights.

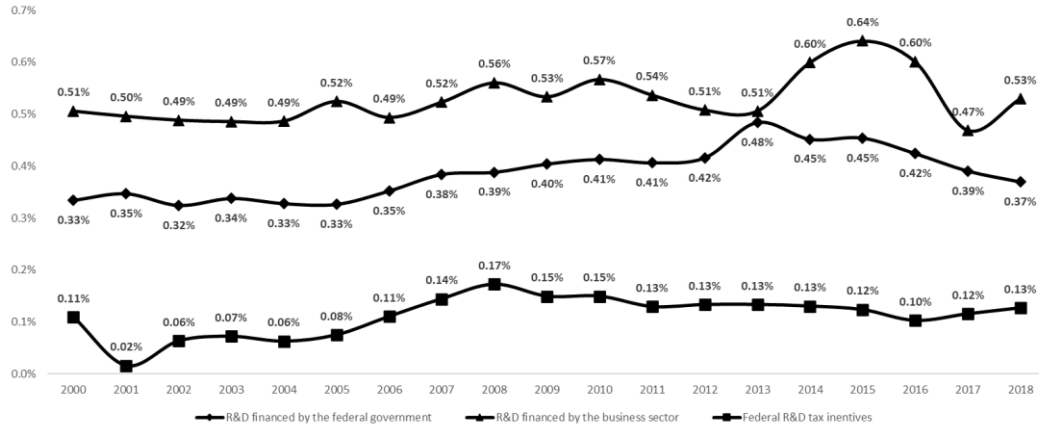
The structure of the Brazilian tax system also shaped the policy. A singular feature is that incentives are restricted to firms that operate under the real profit tax regime, which limits access to the great majority of Brazilian enterprises. Besides, the policy does not authorize firms to deduct expenses in future fiscal years (carryforward), again limiting the range of benefits.

In general, this policy was an improvement of the previous experience of the country with tax incentives. According to the Brazilian Ministry of Science Technology and Innovation (2021b), more than two thousand and two hundred companies applied for incentives in 2019. The total volume of tax breaks in the same year was around 0.9 billion U.S. dollars (3.58 billion Brazilian reais), and reported R&D spending by beneficiary firms was approximately 3.8 billion U.S. dollars (15,37 billion Brazilian reais).[2] The sectors with the greatest number of beneficiary firms were software, transportation equipment, food industry and chemicals. These data suggest this policy currently has an important role in the national innovation strategy.

[2] Values converted according to the exchange rate applicable at December 31st, 2019.

The international trend of downsizing of innovation policies arrived in Brazil in 2014. Since then, the federal government R&D budget shrank substantially, followed by a decrease in business sector R&D in 2016-2017, as presented in Figure 3. The '2016-2019 National Strategy for Science, Technology and Innovation' clearly expressed such a message, acknowledging that innovation policies are leaning towards a more focused-oriented approach, with government support becoming more specific and directed to start-ups and small firms (Brasil, 2012). Another evidence of this paradigm shift is the evolution of expenditure of the National Fund of Scientific and Technological Development (*"Fundo Nacional de Desenvolvimento Científico e Tecnológico"* - *FNDCT*), one of the most important sources for R&D funding, that experienced a reduction of approximately 70% (constant values) from 2013 to 2018.[3] The scientific community in Brazil has described such movement as the 'interruption of a cycle', referring to the expansion of the science and technology base in the last decade (ABC and SBPC, 2016).

Figure 3. Brazil: Research and Development (R&D) financed by the federal government and by the business sector, and R&D federal tax incentives (as a percentage of GDP).



Source: Brazilian Ministry of Science Technology and Innovation (2020; 2021a).

But, contrary to the international experience described above, the international crisis did not lead to a strengthening of the Brazilian innovation tax policy. As shown in Figure 3, the value of federal fiscal benefits to R&D as a percentage of GDP actually decreased as from 2008. Such a trend was observed even when business R&D experienced an upsurge between 2013 and 2015, suggesting that the fiscal benefits may not have been an important stimulus for private innovation investment in this period.

[3] Values readjusted by the IGP-DI/FGV index, considering the rate of the first month of each year.

While OECD countries relied more on the fiscal approach to compensate for the drop in direct innovation investment, the Brazilian federal government went in the opposite direction and tried to suspend the tax benefits in 2015 (Provisional Measure 694/2015) to overcome a budgetary crisis. After intense lobbying by the industrial sector (ANPEI, 2015) along with an unstable political environment, the suspension was not approved by the Brazilian Congress.

The Brazilian tax policy also does not follow internationally recommended practices by restricting the access to and use of fiscal benefits. The law not only does not target young companies as suggested by IFS (2015), but it actually makes it more difficult for these firms to benefit from the incentives, as only enterprises that operate under the real profit regime (adopted majorly by large firms) can deduct their R&D expenses from the taxable base. Also, firms without profit in a fiscal year cannot use the incentives in the future, not considering the maturation period necessary for innovation projects to generate results. Despite claims by industry representatives (MEI, 2016), the government so far has been resistant to eliminate these requirements.

Analyzing this scenario in light of the theoretical discussion presented in this paper leads to the conclusion that the recent development of the Brazilian innovation tax policy seems inconsistent both with the international practice and the set of ideas expressed by the government in the national innovation strategy (Brasil, 2016). Countries intending to reduce the size and rationalize their innovation policies are relying more heavily on the fiscal approach, by increasing the share of tax incentives on total government support and the introduction of more favorable schemes. As argued herein, such objectives are directly related to a 'market failures' approach of innovation policies. As Brazil currently experiences a similar scenario, one would expect that tax incentives to R&D would be enlarged and simplified to benefit a higher base of potentially innovative firms and projects. However, such a movement does not seem to be currently in the government agenda.

Although this argument on the inconsistency of the Brazilian policy is theoretically based, it has important practical consequences in terms of the results of the innovation system. The 'market failures' rationale requires that a restricted and well-defined set of innovation policy goals are pursued, as knowledge spillovers require the public sector to supplement inefficiently-low private investment or to compensate for these externalities. By not broadening the access and not strengthening the regulatory framework of its innovation fiscal policy, the country's innovation system becomes far from a neoschumpeterian perspective (Brasil, 2016) without properly adopting the neoclassical-oriented paradigm. Government action for industrial innovation is therefore not directed at neither of the objectives advocated by these theoretical frameworks, which may compromise the capacity to achieve relevant outcomes.

6. Conclusion

This paper discusses the theoretical foundations and recent developments of R&D tax incentives, analyzing their role under the light of the neoclassical and evolutionary economic theories. In general, the economic literature understands tax breaks as closer to a 'market failure' approach, although the diversity of possible arrangements also makes them a suitable strategy within neoschumpeterian policies aimed at overcoming societal challenges. The use of tax incentives has increased substantially in the last decades, gaining importance in the years after the 2008 crisis. After such an economic downturn, the budget and scope of policies were narrowed, focusing mainly on correcting market failures and placing the firm at the core of the innovation strategy. The approach of the Brazilian government presents an inconsistency, as the attempt to rationalize and focus the objectives of the innovation policy are not followed by efforts to enlarge the base of companies that can benefit from the tax policy.

The health and humanitarian crisis of recent years posed enormous challenges for governments and innovation systems worldwide (Sampat and Shadlen, 2021). This has profound implications not only for policy-makers, but also for the theoretical debate on innovation policies. On the one hand, it seems indisputable that the challenges of the COVID-19 pandemic cannot be tackled by adopting a market failure approach. On the other hand, the severe problems observed in government responses worldwide (and especially in Brazil) revealed that the state's capability to design broad and mission-oriented policies (as advocated by neoschumpeterian economists) might be overstated. The role of tax incentives in this new context of innovation policies seems even more unclear, suggesting that this might constitute an important and fruitful research agenda to be developed by future studies.

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