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The effectiveness of tax incentives for R&D+i in developing countries: The case of Argentina

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ABSTRACT

There is increasing interest in developing countries in granting tax incentives in order to encourage private investment in research, development, and innovation (R&D+i). However, evidence on the effectiveness of such schemes in achieving policy goals in weak innovation systems contexts is still very scarce. This paper aims at narrowing this knowledge gap by focusing on the effects of a tax credit scheme for promoting firm-level innovation investment in Argentina. The analysis applies dynamic panel data techniques to a novel dataset, merging several waves of the National Innovation Survey collected by the National Institute of Statistics and Censuses. The results suggest that the elasticity of R&D+i investment to its user cost of capital is a greater than 1 in absolute terms, which implies that the intervention has been effective in increasing firms' innovation efforts. However, effects vary depending on the type of innovation investment being subsidized, industrial sector, and size of the firm. Moreover, when innovation investment is divided into innovation related capital goods expenditures and only R&D, the results suggest that the absolute value of the elasticity for the R&D component of the innovation investment is less than 1. These heterogeneous effects should be exploited for further policy design.

1. Introduction

Ever since Solow's pioneering work, (Solow, 1957), technological change has been credited with explaining a substantial share of economic growth. Indeed, recent evidence in the United States shows that investments in research and development (R&D) made up 40 per cent of the productivity growth observed during the post-war era (Reikard, 2011). Argentina, however, is located in a region where investments in R&D have remained stubbornly low over time. Indeed, Brazil is the only Latin American country in which R&D efforts exceed 1 per cent of the gross domestic product (GDP). This percentage is much lower compared to countries such as Israel (4.3%), Finland (3.9%), and South Korea (3.7%) (IDB, 2014). In the case of Argentina, R&D spending experienced an increase in the last decade, from 0.38% in 2002 to 0.59% in 2009. However, while the private sector finances a large proportion of the R&D effort in top-performing countries, this figure is less than 25% in the case of Argentina, suggesting an important deficit in R&D investment, particularly in the private sector.

The investment deficit extends beyond R&D. Indeed, even when using a broader definition of innovation investment, which includes other complementary inputs such as training, purchasing of machinery and equipment, software licenses and royalties, a significant gap still remains. While the average firm in a developed country spends almost 4% of sales on innovation, the typical firm in Latin America spends around 2.5%. In the case of Argentina, innovation investment efforts are approximately 2.2% of sales (IDB, 2011). The gap, of course, is particularly large when focusing in intangible investments such as R&D. The pattern that emerges from these figures shows that technology embodied in machinery, mostly imported from abroad, is the main business strategy regarding innovation in the region. The evidence from successful catching-countries suggests that relying on imported technology is not necessarily bad if it leads to domestic learning (Lee, 2013). However, in order for this to happen, technology must be combined with absorptive capacities that allow for further adaptation

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and incremental improvements. At least some level of R&D might be needed to build such capacities (Cohen and Levinthal, 1989)

The innovation literature has pointed out that the deficit in innovation investment is a consequence of market failures. First, the “public good” nature of knowledge implies that a firm’s rivals may be able to free-ride on its investments. This problem creates a wedge between social and private returns to innovation. Second, innovation projects render results that are more uncertain and intangible than ordinary investments worsening the problem of asymmetric information at the moment of financing knowledge investments whenever the investor and financier are different entities. This second problem creates a wedge between the rate of return required by an innovator investing his/her own funds, and the return required by external investors, leading to liquidity constraints. In summary, imperfect appropriability and lack of financing would lead to private sector innovation investment that would fall short from the socially optimal point of view, creating the space for policy interventions such direct subsidies and tax incentives. Indeed, tax incentives could reduce the user cost of capital for innovation investments, inducing private companies to increase their innovation efforts, and thus at least partially closing the innovation investment gap. However, innovation investments are made not only of spending in intangible assets such as R&D, other complementary inputs are also important in order to reach the market with a novel idea. In other words, innovation investments are formed by a set of different inputs and it cannot be taken for granted that the above mentioned market failures will affect all these inputs with the same degree or intensity. In fact, the problems of incomplete appropriability and liquidity constraints are expected to be more severe in the case of the intangible components of these investments (such as R&D). By the same rationale, it is expected that these ailments will not affect to all innovative firms in the same way, indeed limited appropriability and liquidity constraints problems might be more important in the case of small and medium enterprises (SMEs) or firms operating in technology intensive sectors (where innovative investments are dominated by R&D).

Several Latin-American governments, including the Argentinean one, have increasingly adopted explicit business innovation policies in order to encourage domestic business innovation activities. Indeed, the legal framework that regulates Argentina’s innovation system experienced a major overhaul in 1990 when the federal government passed the National Law for the Promotion and Development of Technological Innovation (23.877), after which a series of policy instruments and programs were deployed. The Argentinean Technological Fund (FONTAR), one of the fundamental pillars under the new law, was created in 1992 to provide credit financing to private sector innovation projects. The rationale behind this early attempt was that the central problem hindering private sector innovation investment was basically financial constraints. However, since 1998 the government installed new instruments consistent with the idea that significant problems of appropriability and spillovers might also hinder private sector innovation, whose solution required some sort of subsidy. Thus, in 1998, the government introduced a tax incentive mechanism intended to stimulate private sector investment in innovation by subsidizing the user cost of capital of innovation-related investments. In contrast to the credit lines that operate through an ‘open windows’ system, the tax incentive operates under a ‘request for proposals’ mechanism.[1]

However despite that some time has already passed since Argentina’s R&D +i tax incentives were put in place, very little is known on whether they were effective at the moment of stimulating private sector innovation investment. This is worrisome as effectiveness is not something that can be taken for granted. Similar to R&D tax incentives in developed countries, the Argentinean scheme is a horizontal policy directed at all firms in the economy that might make investments in productivity-improving technological change. The principal attribute of a horizontal policy is that it can be more straightforwardly justified and, when appropriately designed, utilizes market mechanisms to provoke the self-selection of participants, sorting out those less likely to make good use of the subsidy (Steinmuller, 2010). Moreover, in the case of tax incentives firms can claim the tax credit only after they have invested in innovation and they can actually use the credit only after they have been able of generating taxable profits (so the investment should have materialized and had some private return). However, similar to other horizontal policies, tax incentives might suffer from a potential moral hazard problem consequence of opportunistic behaviors by firms. In other words firms can claim activities that they would otherwise conduct or have been conducting anyway as an expenditure qualifying for the scheme. Pervasive moral hazard could severally diminish the effectiveness of the policy in the extent that public resources could end-up crowding-out private resources. Controlling for this moral hazard problem requires policy implementing agencies with strong institutional capacities, capacities that are not abundant in the case of developing countries (IDB, 2014). Moral hazard and opportunistic behavior is not the only reason for crowding-out. The effectiveness of tax incentives for stimulating knowledge investment by firms will depend on whether they could get access to the critical inputs needed to implement their projects, in particular human capital (e.g. engineers) and infrastructure (e.g. for prototype testing). If these supply-side constraints are binding, the higher innovation demand by firms will trigger an increase in the price of these other inputs leading to the firms to potentially discontinue other innovation related investments (Lach, 2002). These supply side constraints are expected to be more pervasive in developing countries contexts. In summary, institutional weakness and supply side constraints might caution against the effectiveness of horizontal tax incentives schemes in innovation systems weak contexts.

This paper has several aims. The first goal is to provide new empirical evidence on the effectiveness of an R&D+i tax incentive policy implemented in Argentina since 1998. As it will be reviewed in the next sections, most of the previous literature on the effectiveness of such tax incentives has been inherited from developed countries, however findings cannot be linearly extrapolated to developing countries contexts as institutional capacities and supply-side constraints can be also more relevant. More specifically, empirical research on the effectiveness of R&D tax incentives, as inherited from developed countries, provides evidence regarding a class of innovation endeavors which is intrinsically different from the one in developing countries (e.g. frontier pushing innovation rather than catching-up), which uses a different mix of inputs (e.g. a bias towards R&D in developed countries versus machine embodied technologies in developing countries) and which focuses on a different class of innovators (larger vs small firms or firms operating in more traditional non-R&D intensive sectors). In other words, although the literature on the effectiveness of R&D tax incentives in developed countries is large, we believe that it has very little external validity for developing countries. Providing new empirical

[1] Together with the tax incentive the government also established a direct subsidy (matching grants) mechanism which became increasingly important during the following decade. The focus of this paper is on the tax incentive mechanism. At the moment of applying for support, companies have to choose which track they want to follow, companies that apply for the tax incentive cannot apply for the grant and otherwise. So the overlap among both types of instruments is very low.

evidence on the effectiveness of a similar scheme in a developing country such as Argentina helps closing this knowledge gap.

The second goal of this paper is to provide new evidence on the exact mechanism through which innovation investments are impacted by the tax incentive. In order to do this, the paper exploits a particular feature of the Argentinean design which allows subsidizing not-only a strict definition of R&D but also – up to some limit – the acquisition of capital goods needed for prototype development and technological modernization. This is the reason why we deem the Argentinean experiment as an R&D+i tax incentive policy. However, a question that naturally arises when a mixed mechanism like this is present is about the rationale for such arrangement. In fact, although innovation investments are composed of different inputs, some of them are intangible and appropriability is more uncertain – such as R&D – while others are more tangible and appropriability is safer, such as investment in capital goods. So, in order to properly assess the effectiveness of the policy, it is necessary to determine whether the tax incentive stimulates more those precisely more intangible or uncertain innovation investments that are more prone to suffer from market failures. In other words, is the subsidy targeting the right sort of innovation investment, the one a priori more affected by market failures?

The third aim of this paper is to contribute to proper policy targeting. Horizontal incentives, when broadly applied, discard potentially useful information about sectoral and firm level characteristics that might be used to narrow the definition of eligible candidates. In other words, targeting is not only about supporting the right sort of investments; it is also about supporting those types of innovators or economic sectors where market failures are expected to be more pervasive. At the current phase of innovation policy in Argentina most of the policy tools including tax incentives operate horizontally across firms and sectors. However, we believe that impact evaluations should be tools for policy learning supporting the transition of policy from horizontal to more targeted – or focused – approaches (Teubal, 1997). Most of the literature on the impact evaluation of innovation programs has used quasi-experimental techniques focusing mostly on average and static impacts (IDB, 2014). This helps answering the question whether a given intervention actually worked but it is of very little usefulness for policy re-design. The impact evaluation approach used in this paper aims at lifting some of these pitfalls by controlling for dynamic effects and by searching for heterogeneous impacts according to the type of innovation investment, size of the innovator and sector of performance.

Our findings show that R&D+i tax incentives in Argentina have been effective to encourage a larger firm level investment in innovation. Given that the size of the R&D+i demand elasticity with respect to the user cost of capital (adjusted by the tax incentive) is in absolute value higher than one, it is safe to infer that for every dollar that the incentive reduces the user cost of capital, investment in R&D+i increases more than one. So, it is not only that the subsidized dollar is actually invested by the firm; but that the incentive also crowds-in complementary private resources towards R&D+i. However, when spending on R&D+i is split into its components, capital goods and R&D, results are different. In fact, we found that the elasticity of innovation investment with respect to user cost of capital is greater than 1 only for capital goods investments, but that it is clearly less than 1 for R&D expenditures. This is worrisome because it is precisely R&D that should be targeted due to its expected lower appropriability and uncertainty. To the extent that capital goods are more appropriable and can be used as collateral, these investments should be better targeted by credit lines or guarantees, unless they have clearly identifiable demonstration effects.

At the same time we found that the effectiveness of the instrument is higher for larger firms and also for firms operating in low technology sectors, both results that are not completely in line with the expected results of policy. SMEs rather than large firms are a priori more affected by appropriability concerns in the extent that the later can use several strategies to protect the results of their innovation investments (e.g. they can afford the costs of patenting and litigation, they can also use distribution channels to protect their investments), options that normally are beyond the capabilities of SMEs. With regards to the technology sectors, high technology sectors are normally those more intensive in R&D and innovation. An effective policy should also help in mobilizing economic resources to those sectors contributing to production diversification and higher R&D investment overall. The finding that neither SMEs nor firms in high tech sectors are the ones more reactive to the policy is worrying and so we expect that these results could provide a solid base of policy redesign. Finally, although R&D+i tax incentives have been implemented in several Latin American countries, such as Mexico, Brazil, Colombia, and Chile, very little is known about the effects of similar schemes also in those countries. The innovation system in those countries share common features that are closer to Argentinean situation rather than developed countries contexts, making our finding also useful for them.

Our research is organized as follows in this paper: Section 2 summarizes the previous literature on R&D policy that inspires the current research. Section 3 presents the theoretical framework and the empirical model used to assess the effect of tax incentives on R&D investment. Section 4 summarizes the data, describes the main features of the legal framework existing in Argentina for the promotion and encouragement of investments in R&D and the main characteristics of our dataset. Section 5 presents the main empirical results. Finally, Section 6 concludes.

2. Literature review

The fundamental premise for innovation policies is that government intervention can be beneficial if profit-driven actors underinvest from a social welfare perspective (Steinmuller, 2010). Broadly speaking, the most widely accepted rationale for public policy in this field is based on the presence of spillovers and the 'public good' nature of knowledge. Since (Nelson, 1959) and (Arrow, 1962), knowledge has been regarded as a nonrival[2] and nonexcludable[3] good. If knowledge does indeed have these properties, then a firm's rivals may be able to free-ride on its investments. These spillovers may create a wedge between private and social returns and a disincentive against private investment in knowledge production. However, spillovers are not automatic, and should not be taken for granted under all circumstances, since not all knowledge has the properties of a public good with the same intensity. Certainly, the 'public good' rationale of knowledge pertains more strongly to *generic* or *scientific* knowledge than to *technological* knowledge, which is more applicable and specific to the firm. Furthermore, in order for the public good rationale to be valid, there should be some possibility of free-riding. To the extent that the originator can protect the results of the knowledge being generated (through entry barriers or the use of strategic mechanisms, for example), the potential for market failure declines.

On the other hand, knowledge generated through collaboration among different parties might be more difficult to protect and

[2] Many different firms can use new knowledge simultaneously once it has been produced, because the new 'blueprints' are not normally associated with physical constraints. This characteristic is an extreme form of decreasing marginal costs as the scale of use is increased. Although the costs of the first use of new knowledge may be large, in that it includes the costs of its generation, further use can be made at negligible, small incremental costs (Aghion et al., 2009).

[3] The nonexcludable nature of knowledge refers to the difficulty and cost of trying to retain exclusive possession of it, while, at the same time, putting it to use.

therefore more prone to spillovers than knowledge generated by individual entities. In other words, and as has been pointed out by (Yanga et al., 2012), there is broad consensus in the literature that private firms severely under-invest in R&D in terms of the socially optimal level, due to the imperfect appropriability of new knowledge (Yanga et al., 2012). This has generated different policy designs based on the idea that when an investment generates positive spillovers, some form of subsidy is needed to correct for this problem, giving place to matching-grants or tax incentive designs (David et al., 2000). Such designs are expected to encourage firm-level investment in innovation because they reduce the user cost of capital for undertaking innovation investments.

However, the 'public good' nature of knowledge is not the only rationale for policy intervention. Innovation projects have several peculiar characteristics that distinguish them from ordinary investments (Hall and Lerner, 2010), and that limit credit access. First, the returns on innovation investments are more uncertain and involve longer gestation lags. Second, innovators may be reluctant to disclose detailed information about their projects because of the danger that competitors will free-ride on their innovations. Third, innovation investments normally include a large proportion of intangible assets (such as human capital) that have very limited use as collateral. Although the problem of asymmetric information is always present whenever the investor and financier are different entities, this problem may be even worse in the case of knowledge investments. This creates a wedge between the rate of return required by an innovator investing her/his own funds and the return required by external investors. Sometimes these financial constraints imply that unless the innovator is particularly wealthy, privately profitable innovation projects will be postponed or never materialized. Financial problems have given place to different sorts of policy interventions, such as dedicated credit lines, guarantees, and venture capital support schemes.

Although developed countries have been experimenting with R&D tax incentives since the 1960s, the early empirical literature on innovation did not put much emphasis on assessing the efficiency of these incentives to encourage business sector innovation. R&D was mostly assumed to be inelastic to its user cost of capital (the variable on which the fiscal policy works). However, from the 1990s onward, empirical findings revealed that this elasticity was above one at least in the case of the US, suggesting that R&D tax incentives do, indeed, have power to promote business investment in innovation CITATION Blo02\l 1034 (Bloom et al., 2002). These results encouraged a new wave of studies in other developed countries. The findings were mixed, since in some countries the early results suggested that R&D tax credits schemes were not effective (Chirinkoet al., 1999), while in others positive effects were identified (Bloom et al., 2002). More recent results, however, tend to suggest that tax incentives have been effective in promoting private sector investment in countries such as Italy (Parisi and Sembenelli, 2003), France (Mairesse and Mulkay, 2004) and Canada (Czarnitzki et al., 2011). However, all this evidence is about frontier economies with developed innovation systems.

Although the rationale for R&D tax credits is clear, its effectiveness should not be taken for granted. As highlighted by previous research, private companies are more likely to use tax incentives to implement projects with high private returns (or projects with higher appropriability) inducing investment with a short-term horizon that would have been implemented by the firm in any case, leading to a potentially low additionality of the policy (David et al., 2000), and (Czarnitzki et al., 2011). An additional problem with tax incentives, in particular when their implementation is based on the volume of R&D, is that the subsidy will target both the marginal and infra-marginal R&D projects; however since infra-marginal R&D projects will be implemented in any case, the effectiveness of the policy instrument is not guaranteed (Crespi, 2013). Finally, it should be noted that if there are other supply side constraints such as lack of human capital or limited access to technological infrastructure, a single instrument may be unable to reach the objective of increasing e the investment in R&D (see for instance Bertonia and Tykvová, 2015). R&D tax incentives have, however, two nice design features that differentiate them from direct up-front subsidies. In order to use a tax incentive, the firms first should carry-out the tax exempted investments and second should have some taxable profit base (in other words, the supported investment should have produced some positive return).

R&D tax incentives are currently very popular innovation policy instruments in developed countries, where approximately 2/3 of the countries have some sort of scheme in place. They are less popular in Latin America, although an increasing number of countries are starting to experiment with this sort of instrument. As for any market intervention policy that transfers fiscal resources to firms under a situation of misalignment of incentives and asymmetric information, the potential for moral hazard is high, with possible unintended consequences for the effectiveness of the policy intervention (e.g. firms might label as R&D expenditures types that are not R&D, or that could have been incurred anyway). Thus, a proper assessment of the effectiveness of R&D tax incentives is a question of the first order. Contrasting with the situation in developing countries, impact evaluation studies of R&D tax incentives are still very scarce in developing countries.

Table 1 summarizes the most relevant works in the empirical literature that estimate the elasticity of the R&D investment to the user cost of capital. As shown, most of this literature provides evidence for developed countries with robust and closer to the technological frontier innovation systems. For these countries, the common finding is to obtain long-term elasticities in absolute terms higher than one, suggesting a positive impact of the scheme on R&D investment. Table 1 also includes three examples of studies in developing countries. The first is the work of Harris et al., 2009 who studied the effectiveness of an R&D tax scheme in a 'disadvantaged area' – Northern Ireland – finding that R&D is responsive to changes in the user cost of capital, but that this adjustment is slow over time, with a long-run elasticity of −1.4. The other two papers devoted to the study of the effects of tax incentives on R&D are about Argentina, finding a positive impact of the scheme on R&D investment. However, the two studies for Argentina only report standard static average treatment effects; they do explore neither the possible influence of heterogeneous effects nor the relevance of dynamic effects. In other words, these studies only focus on the effectiveness of the policy in *the short term*. Furthermore, given that they do not report the R&D user cost of capital elasticity, it is not possible to say anything else regarding the efficiency of the policy (e.g. they do not report whether the increase in the allocation of resources to R&D is proportionally greater than those resources subsidized by the state).

3. Conceptual framework and empirical strategy

The assessment of a public policy such as a tax incentive is challenging because the importance of solving the attribution problem. In other words, if a change in the variable of interest – in this case R&D+i investment – is observed after policy implementation, in what extent can this result be attributed to the policy itself or to something else? The holy grail of impact evaluation – randomization – is out of question at the moment of evaluating the impact of tax incentives, this because in the extent that the scheme is sanctioned by law, control firms cannot be excluded a priori from participation, and additionally because of those entitled to participate, actual participation will be the result of self-selection by firms, so non-participating firms won't be the right sort of control group to

Table 1
Summary of principal works estimating the R&D+i tax incentives elasticity.

References	Country	Industries	Elasticity (R&D+i)	Data
Baily and Lawrence (1992)	USA	Manufacturing	−0.75	Firm level data
Berger (1993)	USA	Manufacturing	−1.25	Firm level data
Hall (1993a,b)	USA	Manufacturing	−0.8 to −1.5 in the short-run, while the long-run elasticity ranges from −2.0 to −2.7	Firm level data
Hines (1993)	USA	Manufacturing	−1.2 and −1.6	Aggregated
ABIE (1993)	Australia	Manufacturing	−1	
McCutchen (1993)	USA	Pharmaceutical Industry	−0.29	Aggregated
Dagenais et al. (1997)	Canada	Manufacturing and Services	−0.4	Firm level data
Bloom et al. (2002)	G7	Manufacturing	−0.1 in the short-run, while the long-run elasticity is −1	Aggregated
Mairesse and Mulkay (2004)	France	Manufacturing	−0.41 in the short-run, while the long-run elasticity is −2.3	Firm level data
Baghana and Mohnen (2009)	Canada	Manufacturing	−0.1 in the short-run, while the long-run elasticity is −0.14	Firm level data
Wilson (2009)	USA	Manufacturing	−1.2 in the short-run, while the long-run elasticity is −2.5	Aggregated
McKenzie and Sershun (2010)	Australia, Canada, Italy, Spain, U.S., U.K., Germany, France, Japan	Manufacturing	−0.12 to −0.22 in the short-run, while the long-run elasticity ranges from −0.46 to −0.83	Aggregated
Lokshin and Mohnen (2012)	Netherlands	Manufacturing and Services	−0.25 in the short-run, while the long-run elasticity is −0.45	Firm level data
Harris et al. (2009)	North Ireland	Manufacturing	−1.4	Firm level data
Chudnovsky et al. (2006)	Argentina	Manufacturing	They not estimate elasticity. It is a ATT measurement.	Firm level data
Porta and Lugones (2011)	Argentina	Applied Scientific Research and Manufacturing	They not estimate elasticity. It is a ATT effect measurement.	Aggregated

solve the attribution problem. The standard approach to solve this problem is to use quasi-experimental techniques that statistically construct a control group. This could be implemented by matching firms from both groups (treated versus control) based on a large set of observable characteristics. The difference in R&D+i spending in the two groups could be attributed to the tax incentive. However, even using a comprehensive set of matching criteria – such as turnover, age, sector, geographic location, ownership, etc – perfect comparability between the two groups is not possible. There may always be some unobserved differences – such as managerial abilities – between beneficiaries and non-beneficiaries that also affect the policy outcome. Finally, quasi-experimental techniques also require a very careful identification of both participating and non-participating firms, and given that we are using a survey data this is not fulfilled in our case.

Given the limitations of quasi-experimental methods, in this paper we follow an alternative approach which is to evaluate the impacts of R&D+i tax credits schemes by means of structural econometric modelling techniques. This approach uses models of R&D+i investment behavior and assumes that R&D+i spending is a function of the cost to the firm of the capital used. The modelling first seeks to estimate the sensitivity of firms R&D+i spending to changes in the user cost of capital. In a second step, estimates are made of the sensitivity of the user cost of capital to the R&D tax incentive scheme (Coen, 1969; OECD, 2010). Following Lokshin and Mohnen (2012), it can be assumed that the firm's production function can be approximated by a CES form for firm i at time t:

$$Y_{it} = \gamma\left[\beta R_{it}^{-\rho} + \left(1-\beta\right) X_{it}^{-\rho}\right]^{-\frac{\nu}{\rho}} \tag{1}$$

where Y_{it} is the output, R_{it} is knowledge capital, X_{it} represents other inputs and γ (a scale parameter), β (a distribution parameter) and ν (a returns to scale parameter) are parameters that characterize the firm's production technology. While the elasticity of substitution between the knowledge capital and other inputs is defined by $\sigma = 1/(1+\rho)$. Under the assumption of profit maximizing agents and lack of adjustment costs, the first order conditions of profit maximization state that the marginal product of R_{it} must be equal the user cost of capital (P_{it}). In order words:

$$\nu\beta Y_{it}^{(1+\rho/\nu)}\gamma^{-\rho/\nu}R_{it}^{-(\rho+1)} = P_{it} \tag{2}$$

Solving this equation for the long-term knowledge capital and taking logs, we obtain a static linear version of the model to be estimated (3), where small letter means that the variables are in log.

$$r_{it}^{*} = \alpha + \left(\sigma + (1-\sigma)/\nu\right) y_{it} - \sigma p_{it} \tag{3}$$

However the above specification implies that knowledge capital adjust instantaneously to any change in its determinants; this is very unlikely to be true given the uncertainty and learning time that require knowledge investments. One way of relaxing this is to assume that the knowledge capital follows a partial adjustment mechanism, which could be formalized by an adjustment cost model such as:

$$r_{it} - r_{it-1} = \lambda\left(r_{it}^{*} - r_{it-1}\right) \tag{4}$$

where $0<\lambda<1$. Taking into consideration Eq. (4), Eq. (3) can after substitution be rewritten as:

$$r_{it} = \lambda\left[\alpha + \left(\sigma + \frac{(1-\sigma)}{\nu}\right) y_{it} - \sigma p_{it}\right] + (1-\lambda)\, r_{it-1} \tag{5}$$

The final econometric model derives from (5) where after parametrization we obtain the following estimating form:

$$r_{it} = \pi_i + \pi_1 y_{it} + \pi_2 p_{it} + \pi_3 z_{it} + \phi r_{it-1} + \eta_t + e_{it}, \tag{6}$$

In Eq. (6), r_{it} is the logarithm of R&D+i, p_{it} is the logarithm of the user cost of capital for R&D+i, y_{it} is the logarithm of firm size, z_{it} captures a vector of firm level observable characteristics (such as sector or ownership) and e_{it} is the error term. The coefficient of interest is the elasticity of the demand for R&D+i in relation to the user cost of capital (p_{it}). It is expected that this elasticity will be negative in order to be consistent with the model and to insure that a reduction in the user cost of capital (for instance, due to a fiscal incentive) could impact positively on investment in R&D+i. An absolute value larger than one for this elasticity would increase the effectiveness of fiscal incentives in stimulating investments in R&D+i. Finally, in the empirical implementation, the model also controls for firm fixed and time effects. This is important due to the severe recession that affected Argentina in 2002, a situation that led to an important decrease in firms' sales and innovation investment.

In other to empirically implement the model, we need an observable measure of the user cost of capital (p_{it}). In this regard, the seminal work of Hall and Jorgenson provides the basis for the empirical approach (Hall and Jorgenson, 1967). According to this research, the decision of a *marginal investment* in R&D+i depends on user cost of capital. The magnitude of which depends on the *effective tax rate*, *the depreciation rate* of the assets that will comprise the R&D+i investment, *the inflation rate*, and the *interest rate* of the market to which it is supposed the firm discounts its funding flows. Following (King and Fullerton, 1984), the user cost of capital p_{it} in its basic form is:

$$P_{it} = \left(n_t + \delta_{it} - \theta_t\right) \frac{1 - \mu_{it}\kappa_{it} - \xi_{it}\tau_{it}}{1 - \mu_{it}}, \tag{7}$$

where n_t is the instantaneous nominal interest rate, δ_{it} is the depreciation rate of R&D+i, θ_t is the inflation rate, μ_{it} is the nominal rate of income tax, κ_{it} is the tax deduction corresponding to investments in R&D+i applied on the taxable base of the income tax, τ_{it} is the tax credit corresponding to R&D+i investments applied to the payable income tax, and ξ_{it} is the income tax to be paid in the period. In the case of Argentina, the tax incentive can be applied only as a tax deduction on the payable income tax, so $\kappa_{it} = 0$. A further aspect to be taken into account is that formula (7) assumes that the firm deducts in full the fiscal credit for the period in which the expenditure is performed.[4]

A clear problem that arises with the empirical implementation is that the user cost of capital is an endogenous variable, and consequently traditional least squares methods may introduce a bias in the estimations of the coefficients. The user cost of capital p_{it} is a function of the fiscal incentives and of a series of other economic variables. One of these variables is the actual interest rate. This is generally pro-cyclic, and therefore it is possible that it will present a positive correlation with the expenditure in R&D+i. On top of this, the actual user cost of capital will depend on the composition of firm innovation investments (as the depreciation rate will vary across different innovation investments), a variable that is also under the control of the firm. Furthermore, the economic variation in the user cost of capital is probably measured with error, which could lead to an attenuation bias. In order to correct for all these problems, instrumental variables are needed. A natural instrumental variable is the tax component of the user cost. In fact, this tax component isolates the differences among companies due to variations in the fiscal credit actually used (Bloom et al., 2002). It can therefore be an appropriate instrument to control for the endogeneity of the p_{it} variable. For this reason the cost of the capital was instrumented with its fiscal component in Eq. (7), assuming a constant interest rate of 23.5% and also a constant inflation rate of 6.5% for all years and all firms.[5]

Finally, given that the model (6) is dynamic the lagged variable is correlated with the error term, so the estimation by least squares will produce an upward bias on the coefficients. In order to correct for this, the empirical implementation uses GMM techniques where lagged level and first difference values of the explanatory variables are used as instruments for the econometric model (Blundell and Bond, 1998). Additionally, the long-term partial elasticity of R&D+i investment with respect to the user cost of capital (Elp) can be obtained as[6]:

$$E_{lp} = \frac{\pi_2}{1 - \phi} \tag{8}$$

Based on this empirical approach, the analysis will seek testing for the following hypothesis that are critical for the assessment of the effectiveness of the tax incentive scheme. Our first hypothesis is that the fiscal incentives has been effective in triggering a higher investment in R&D+i at the firm level, this will occur in the extent that E_{lp} be statistically significant. Moreover, and as a rule-of-thumb, if this elasticity is in absolute value higher than one more likely will be that the incentive will also generate crowding-in effects in private investment. Our second hypothesis is that the fiscal incentive alleviates the market failures that affect innovation investment. In the extent that these failures are higher for pure R&D investments than for investments in capital goods (K) we expect that the long-term elasticity for the user cost of capital will be in absolute value larger for R&D than for K ($E_{lp,R\&D} > E_{lp,K}$). If this hypothesis is rejected, we interpret this as a signal that other supply side constraints might be hindering R&D more than capital goods investments and that these have not been properly internalized within the design of the scheme. Finally, and for similar reasons, as explained above our final hypothesis is that the user cost of capital long-term elasticity will be in absolute values larger for SMEs rather than large firms or for firms operating in high technology sectors. Rejecting any of these will be also interpreted as design flaw that would require careful policy rethinking.

4. Data description

The empirical implementation makes use of two waves of Argentina's Innovation Surveys, known as ENIT, from 1998 to 2004. Both surveys were conducted by the National Institute of Statistics and Censuses of Argentina (INDEC).[7] The first innovation survey (ENIT 01) covers the period 1998–2001, including in the sample 2229 companies, while the second survey (ENIT 04) covers the period 2002–2004, including a total of 2133 companies. Both surveys have response rates above 70%, and they are fully representative of Argentina's manufacturing sector. Firms were linked across the surveys using common identifiers provided by INDEC but with full respect to statistical confidentiality. Based on the Oslo Manual approach (OECD, 1992), the innovation surveys provide very detailed information at firm level regarding innovation activities, employment – both the number of employees and the composition of employment by education – and R&D+i expenditures and their components. Merging both surveys for the total period, we obtain that 1770 firms reported expenditures on R&D+i in at least one year, whereas 85 firms (4.8%) informed R&D+i expenditures throughout the period.

[4] The fiscal credit obtained by a firm is not necessarily computable in the period in which the investment in R&D+i is performed. This can take place whenever there are carry-forward provisions (for instance, if the fiscal credit consists of a deduction over the payable income tax, and the firm experiences losses in the tax year in which the investment in R&D+i is carried out).

[5] Mean values for the period 1992–2004.

[6] The *Delta Method* can be used to calculate the standard deviation of the long-term elasticity.

[7] R&D was deflated by using a weighted mean between the annual average of the National Wholesale Price Index (IPM) and the annual average of the Nominal Salary Index (ISN) per hour, discriminated by branch of Manufactured Products, at two digits. The mean was calculated by weighting the ISN by the relative importance of the average expenditure on personnel.

Table 2
Structure of the Panel.

Period	Frequency	Relative frequency	Cumulative frequency	ENIT01 1998	ENIT01 1999	ENIT01 2000	ENIT01 2001	ENIT04 2002	ENIT04 2003	ENIT04 2004
2002–2004	324	21.5%	21.5%					X	X	X
1998–2001	302	20.0%	41.5%	X	X	X	X			
1998–2004	266	17.6%	59.2%	X	X	X	X	X	X	X
2003–2004	69	4.6%	63.7%						X	X
1998–2001 and 2004	32	2.1%	65.8%	X	X	X	X			X
1999–2001	34	2.3%	68.1%		X	X	X			
Other patterns	481	31.90%	100%							
Total	1508	100%								

Source: ENIT 01 and ENIT 04.

Table 3
Number of Companies by Size of the Firm and Technological Intensity of the Sector.

Year	Fewer than 50 employees (Small)	More than 50 employees (Large)	Low Technology	High Technology
1998	196	609	517	288
1999	191	601	506	286
2000	204	613	525	292
2001	208	671	577	302
2002	153	564	437	280
2003	202	632	521	313
2004	252	701	599	354

Source: ENIT 01 and ENIT 04.
Note: The definition of high technology is according to the classification of the OECD, categories based on R&D intensities, ISIC REV. 3. While this classification is split into four categories, we use just two.

Table 4
Average Effort in R&D by Size of Firm.

Manufacturing Firms that Declared Expenditure in R&D		
Year	Fewer than or equal to 50 employees	More than 50 employees
1998	4.37	9.31
1999	3.87	8.34
2000	4.23	8.42
2001	3.13	6.21
2002	1.86	4.95
2003	2.97	7.06
2004	2.86	5.46
Total	3.34	7.08

Source: ENIT 01 and ENIT 04.
Note: Effort in R&D is calculated as the proportion of the expenditure in R&D in relation to total sales.

After some data cleaning and checking for data inconsistencies, the final working data set used for estimating the parameters of interest contained 1508 firms throughout the period. Table 2 describes the structure of this unbalanced panel. About 40% of the firms are present in more than half of the time period, i.e. four years or more, and over 60% of the firms appear for at least 3 consecutive years. Regarding to firm characteristics, the number of firms with fewer than 50 employees (small firms) is larger than the number of firms with more than 50 employees (large firms). Most of the firms operate in low technological intensity sectors. However, in both cases the sample size is adequate for the estimation of the elasticities of interest (Table 3).

For the average firm the total R&D+i effort as a proportion of total sales and for the total sample was 6.17% for the period 1998–2004. Regarding the size of the firm, it can be observed that there is a positive correlation between R&D+i and size (captured by total sales). Table 4 shows that the average R&D+i effort of the small firms was 3.34% (7.08% in the case of large firms). Assessing the time variation of the data is also important given the well-known volatility of the Argentinean economy. Indeed, during 2001 and 2002, there is a significant drop in the average R&D+i effort for all firms and sizes, during these two years the Argentinean economy went through a severe economic crisis caused by the collapse of the currency-board monetary system, where the GDP fell more than 9 percentage points in 2002.

Argentinean Innovation surveys also collect information by the type of innovation investment. Apart from R&D, the questionnaire allows for different types of innovation expenditures, such as capital goods, hardware, software, etc., to be part of R&D+i. Table 5 summarizes the average innovation expenditure per type of investment from 1998 to 2004 (see the definition in Appendix A). On average, expenditures in capital goods represent almost 66% of the total innovation expenditures during the whole period, 11.2% correspond to (both internal and external) R&D, while technology transfer acquisition represented 5.7% of total innovation spending. The remaining components do not exceed 5%.

In order to measure the elasticities of interest, we need to compute the user cost of capital, as in Eq. (7) which requires information on several key parameters. The information on corporate income tax (μ_{it}) was taken from the corporate income tax legislation (Law 20.628) and varies from 30% to 35% over the years. The information on the interest rate n_t was taken from the collateral loan interest rate for more than a year as provided by the Argentinean Central Bank (BCRA). Data on inflation (θ_t) was taken from INDEC, while the average depreciation rate (δ_{it}) was imputed at the firm level according to the composition of innovation investment. In order to calculate the user cost of capital for R&D+i, the following depreciation rates were used: 0.20 for R&D, industrial design and engineering activities; 0.10 for capital goods; hardware 0.33; 0.50 for software and training; and 1.00 for consulting. Hence, a weighted average rate was obtained for the years 1998–2004. The tax credit rate applicable to the payable income tax (τ_{it}) was set at a value of 30.05%, resulting from computing the average tax credit of projects granted for tax credit support by FONTAR between 2003 and 2010.[8] This rate was kept constant in the calculation of the user cost of capital for all firms, in all years, without distinguishing by type of innovation investment. As it was mentioned above, in the case of Argentina, the promotion regime for investments in R&D+i does not consider any deduction on the taxable income tax, so $\kappa_{it} = 0$.

As Table 6 shows, the user cost of capital of R&D+i (p_{it}) varies greatly over the years. In 2002, an important drop is observed in

[8] Given that the surveys do not inform whether or not firms have actually used the tax credit for R&D+i, in order to determine the tax deduction for R&D+i, information comes from the FONTAR website [http://www.agencia.mincyt.gob.ar/frontend/agencia/fondo/fontar]. We obtained data on projects that have applied for and have used tax credits to finance R&D+i, the amount of the project, the amount subsidized by tax credit, and the tax credit amount of each firm from that website. With this information, the rate was calculated as the percentage of the allowance for the tax credit.

Table 5
Percentage of total R&D+i expenditures per type of innovation investment.

Year	R&D	Capital Goods	Hardware	Software	Technology Transfer	Engineering and Design	Training	Consultancy
1998	7.49	70.35	4.07	2.88	6.80	3.42	3.54	1.45
1999	8.41	71.10	3.10	3.82	4.64	4.27	3.23	1.43
2000	8.84	68.36	3.35	4.43	6.10	3.45	3.62	1.85
2001	12.79	61.93	3.88	3.61	6.44	4.79	4.32	2.24
2002	16.38	59.66	5.36	3.31	6.34	1.06	6.06	1.83
2003	16.33	60.82	5.18	3.16	4.80	1.25	6.15	2.31
2004	16.87	57.39	5.10	4.13	5.58	1.31	7.33	2.30
Total	11.2	65.99	4.00	3.66	5.73	3.18	4.43	1.82

Source: ENIT 01 and ENIT 04.

Table 6
Cost of Capital for R&D.

Year	Low Tech	High Tech	Total
1998	0.53	0.59	0.55
1999	0.61	0.64	0.62
2000	0.62	0.67	0.64
2001	0.64	0.68	0.66
2002	0.36	0.38	0.37
2003	0.44	0.46	0.45
2004	0.47	0.50	0.48
Total	0.53	0.56	0.54

Source: Own.

Table 7
Estimation of Eq. (3) for Expenditure in R&D+i.

Log expenditure in R&D+i	(1) OLS	(2) FE	(3) System GMM
Log expenditure in R&D+i at t-1	0.581***	0.095***	0.246***
	(0.01)	(0.02)	(0.12)
Log p	−0.952***	−1.302***	−1.494***
	(0.05)	(0.12)	(0.16)
Log sales	0.358***	0.468***	0.638***
	(0.02)	(0.09)	(0.13)
Constant	−1.546***	1.666	−2.842
	(0.19)	(1.43)	(2.50)
Dummy year	Yes	Yes	Yes
Dummy industry	Yes	No	No
Fixed effect firm	No	Yes	Yes
Observations	4017	4017	4017
Number of firms	1273	1273	1273
R-Square	0.700	0.204	–
Sargan test			9.93
p value			0.445
t-Autocorrelation test. Order 1			−5.56
p value			0.000
t-Autocorrelation test. Order 2			−0.071
p value			0.943
t-Autocorrelation test. Order 3			−0.322
p value			0.742
Long-term elasticity			−1.981***
			(0.212)
Instruments			16

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors are in parentheses. Robust standard errors.

the user cost of capital for R&D+i, as a consequence of the increase in the inflation rate due to the devaluation of the Argentinean peso that occurred during that year. On the other hand, the user cost of capital between 2001 and 2003 experienced a significant decline close to 32% partially compensated by small growth by 6% in 2004, reaching a value of 0.50 which is far below the values observed prior to 1998, when the tax credit mechanism was implemented. The user cost of capital for R&D+i also varies substantially according to the economic sector. The activities with higher user cost are ‘manufacturing of tobacco products’, and ‘manufacturing of medical, optical and precision instruments, and manufacturing of clocks’, which exceed the value 0.65.

5. Empirical results

This section summarizes the results of the estimates associated with Eq. (6). First, we estimate Eq. (6) for the whole sample in order to measure the long run elasticity of R&D+i expenditures to the user cost of capital. Second, we estimate Eq. (6), but this time splitting the dependent variable into capital goods expenditure, and expenditures only in R&D. Finally, we estimate Eq. (6) once more but for different subsamples, i.e. small vs. large firms, and low vs. high technological firms; with these estimates we try to provide some empirical evidence on the heterogeneous effectiveness of tax incentives on different types of firms, in particular those that are in principle more affected by the market failures. Before moving forward one important clarification is needed. According to the conceptual framework the key dependent variable in Eq. (6) is knowledge capital rather than just expenditures. So before proceeding with the estimates a proxy for knowledge capital was built by accumulating yearly investments using the depreciation rate assumed in the user cost of capital formula.

Table 7 summarizes the results for Eq. (6), where column 1 contains the results of applying least squares methods, column 2 exploits the panel configuration of the dataset and control for firm level unobservable factors using fixed effects, and column 3 summarizes the results of estimating by using System GMM. Having these different estimates helps with cross-checking the validity of the System GMM estimates. System GMM estimates allows for controlling both for endogeneity and unobservable factors at the firm level, so it is the method with the strongest internal validity. However, it also rests on stronger assumptions (such as the instruments used during the estimates are valid and strong). Given the biases affecting both least squares and fixed effects methods when working with panel data, a rule-of-thumb approach to validate the System GMM results is that the estimated parameter for the lagged dependent variables should be located within the parametric interval provided by both least squares and fixed effects estimates (see Baltagi, 2008).

The results show that the short term elasticity for user cost of capital variable p_{it} is significant at 1% in all estimations, furthermore the results also point out toward an absolute value for this parameter which is larger than 1, except for the least squares estimates, where it is −0.952. The coefficient for lagged R&D+i is positive and significant in the three models, with a value for the System GMM method which falls in between least squares and fixed effects estimates. The result of the Sargan test does not reject the null hypothesis of exogeneity of the instruments, while the serial autocorrelation test,[9] does not reject the null hypothesis of order 1 autocorrelation, while it clearly rejects the null hypotheses for autocorrelation of order 2 and 3, discarding the presence of infor-

[9] See (Arellano and Bond, 1991).

Table 8
Estimation of Eq. (3) for Expenditures on Capital Goods and on Only R&D.

Log expenditure	(1) K OLS	(2) K FE	(3) K System GMM	(4) R&D OLS	(5) R&D FE	(6) R&D System GMM
Log expend. of BsK at t-1	0.475***	0.018	0.353***			
	(0.02)	(0.03)	(0.09)			
Log expend. of only R&D at t-1				0.807***	0.262***	0.638***
				(0.02)	(0.04)	(0.07)
Log p	−2.233***	−3.245***	−1.508*	−0.307***	−0.407**	−0.313***
	(0.11)	(0.22)	(0.81)	(0.08)	(0.17)	(0.10)
Log sales	0.460***	0.345**	0.662***	0.145***	0.245***	0.250***
	(0.02)	(0.17)	(0.09)	(0.02)	(0.09)	(0.05)
Constant	−2.845***	2.21	−5.693***	−0.774***	3.634**	−0.348
	(0.31)	(2.91)	(1.16)	(0.24)	(1.59)	(0.25)
Dummy year	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effect firm	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2113	2113	2113	2017	2017	2017
Number of firms	810	810	810	711	711	711
R-Square	0.679	0.317	–	0.801	0.131	–
Hansen/Sargan test			7.89		0.51	119.31
p value			0.246		0.131	0.161
t-Autocorrelation test. Order 1			−2.796			−6.26
p value			0.005			0.000
t-Autocorrelation test. Order 2			−1.57			−1.474
p value			0.128			0.141
t-Autocorrelation test. Order 3			0.605			0.828
p value			0.546			0.407
Long-term elasticity			−2.330***			−0.864***
			(0.514)			(0.162)
Instruments			14			13

Note: Standard errors are in parentheses. Robust standard errors.
* $p<0.1$.
** $p<0.05$.
*** $p<0.01$.

mation in the error term. The long-term elasticity of R&D+i to the user cost of capital suggested by the System GMM results is of −1.981 and significantly different from zero.

In summary the results in Table 7 suggest that a fiscal policy that reduces the user cost of capital through a tax credit incentive will significantly increase R&D+i investment. Indeed, based on the information provided by the firms for every $1 in subsidies to the user cost of capital, private investment in R&D+i will increase by nearly $2. Consequently, at first sight, we can conclude that in Argentina the tax incentive for investment in R&D+i is an effective policy for encouraging an increase in company investments in innovation, and furthermore the amount of the increase in investment suggest the presence of significant crowding-in effects.

However, a change in the tax incentive could also have a composition effect on overall innovation investment. As it was mentioned above Argentina, similar to other Latin-American countries, has a composition of the innovation investment biased towards the acquisition of capital goods. It would be important to explore if the policy has managed to rebalance the investment composition towards more intangible investments such as R&D which a priori are also the ones more affected by market failures. Table 8 presents the results of the estimates for Eq. (6), but comparing the effects on capital goods as the dependent value (BsK) with the results when the dependent variable is only R&D[10] for the period 1998–2004. The short-term elasticity of the capital goods expenditures to the user cost of capital (coefficient of the variable p_{it}) is significant and higher than 1 in absolute value (column 3). On the other hand, it can also be observed that the elasticity estimate for R&D is considerably lower (−0.313 in column 6). Because the lagged dependent variable coefficients are also statistically significant, the long-term elasticity for capital goods is significantly higher than for R&D. Indeed, the long-run elasticity for capital goods is 2.33 in absolute value, while it is just 0.86 for R&D.

These results call into question our previous earlier conclusion about the positive effect of this incentive policy in Argentina. Indeed, that the long run elasticity of pure R&D is lower than 1 in absolute value implies not only that the effectiveness of the policy for R&D is lower than for the case of investments in capital goods, but also that the actual increase in private sector R&D spending might be lower than the amount of the subsidy, in which case partial crowding-out might not be ruled out. These results are worrisome because the actual impacts are lower precisely for that sort of investment that at least on a priori basis is more risky and suffers from low appropriability problems (R&D). These findings point-out towards other sort of constraints that might be more binding for R&D rather than for capital goods investments and that are not fully integrated into the design of the scheme or within the overall policy mix. Natural candidates for these are supply side constraints such as lack of access to knowledge suppliers, technological infrastructure or human capital. One aspect that is consistent with this interpretation is that the estimated coefficient for lagged dependent variable for R&D is twice larger than for the case of capital goods investments suggesting a higher adjustment cost in the case of R&D investments. By observing the results of the survey ENIT, it is possible to highlight elements that support these results. Indeed, when firms are requested for enumerating those obstacles that prevent greater investments in R&D+i, firms enumerate three dominant factors, i.e.; difficulties in accessing funding, particularly in projects of technological innovation; failures in public policies that promote science, technology and innovation; and high costs of staff training; see INDEC-ENIT (2005).

[10] Only R&D is the sum of Internal and External R&D; see Table 5.

Table 9
Estimation of Eq. (3) for Expenditure in R&D+i according to the Technological Intensity of the Sector.

Log expenditure in R&D+i	(1) Low technology	(2)	(3)	(1) High technology	(2)	(3)
	OLS	FE	System GMM	OLS	FE	System GMM
Log expenditure in R&D+i at t-1	0.551***	0.065**	0.183***	0.628***	0.165***	0.273*
	(0.015)	(0.029)	(0.066)	(0.017)	(0.036)	(0.164)
Log p	−1.184***	−1.570***	−1.661***	−0.592***	−0.804***	−0.905***
	(0.072)	(0.159)	(0.142)	(0.080)	(0.181)	(0.147)
Log Sales	0.379***	0.651***	0.680***	0.336***	0.343***	0.659***
	(0.019)	(0.135)	(0.058)	(0.022)	(0.072)	(0.145)
Constant	−1.627***	(1.393)	−3.049***	−2.531***	3.583***	−2.895***
	(0.255)	(2.180)	(0.495)	(0.283)	(1.228)	(0.642)
Dummy year	Yes	Yes	Yes	Yes	Yes	Yes
Dummy industry	Yes	No	No	Yes	No	No
Fixed effect firm	No	Yes	Yes	No	Yes	Yes
7						
Observations	2 510	2 510	2 510	1 504	1 504	1 504
Number of firms	812	812	812	466	466	466
R-Square	0.674	0.212		0.768	0.229	
Sargan test			8.675			6.889
p value			0.371			0.549
t-Autocorrelation test. Order 1			−5.495			−2.760
p value			0.000			0.006
t-Autocorrelation test. Order 2			−1.243			0.920
p value			0.214			0.358
t-Autocorrelation test. Order 3			1.308			0.244
p value			0.191			0.807
Long-term elasticity			−2.033***			−1.245***
			(0.097)			(0.205)
Number of Instruments			16			16

Note: Standard errors of estimations are shown in parentheses. Robust standard errors.
* $p<0.1$.
** $p<0.05$.
*** $p<0.01$.

Table 9 shows the results of estimating Eq. (6) distinguishing firms by the technological intensity of the sectors they belong to.[11] The coefficient of p_{it} is significant and negative in both groups of sectors (−1.661 in the case of low tech and −0.906 in the case of high tech). In sectors with low technological intensity, the long-term elasticity is also greater compared to those sectors with higher technological intensity (−2.033 vs. −1.245). This finding can be explained by the fact that investment in R&D+i in sectors with low technological intensity is mainly focused on capital goods, and we already know from our previous results that capital goods investments respond better to the tax incentive. Indeed, while capital goods investments are 70.5% of total R&D+i spending in low-tech sectors, this share is 52.5% in high-tech sectors. On the other hand, the shares for R&D are 7.7% and 21.5% respectively. Ideally, we should have estimated separate equations for the different types of investment in each sector. Although this exercise was carried out, the number of finally available observations did not yield statistically significant results.

Table 10 summarizes the results by firm size for the period 1998–2004. The coefficient of p_{it} is significant for both small and large firms, but the short-term elasticity in absolute value is higher in larger firms (−1.679) compared to smaller ones (−1.188). This indicates that, in the short-term, tax incentives have a greater impact on large firms. In the long-run, however, the analysis shows that elasticities are similar to each other, i.e. still larger for larger firms, but much closer, −1.973 vs. −2.041, for small and large firms respectively. In other words, large firms respond quicker to the tax incentives (maybe due to their more favorable access to financial resources for innovation and other complementary assets such as human capital or technological infrastructure). In other words, they respond faster to the incentive because their adjustment costs are lower than in the case of small firms. Another reason for the delayed response by small firms could be due to the differences in the balance sheet profits in comparison with large firms. In other words, in the extent that audited profits are larger in the case of large firms, they are more likely to have larger tax liabilities that could be deducted through a tax credit than is the case for smaller firms. Another reason for this, and which is important for developing countries, is informality. In a context of weak tax systems, auditing mostly focuses on large firms. So small firms are many times semiformal entities that have an ample space to manipulate their tax returns. On this regards it is not that they have a lower reported tax liability but that by being semiformal they might opt-out from applying to any sort of tax incentive that could make them more visible to tax authorities. Although we do not have empirical evidence to confirm this conjecture, casual evidence from authors' interviews with users of the incentive point-out to this direction.

6. Conclusions

This paper presents new empirical evidence of the effects of tax incentives on increasing private investment in innovation in developing countries. Using two waves of Innovation Surveys, we find that the Argentinean tax credit scheme has reduced the user cost of capital for R&D+i from 0.61 in 1997 to 0.54 in 2004. This reduction in the "price" of innovation has had a significant effect on company decisions to invest in it, as indicated by the coefficients estimated by means of a structural econometric model. In fact, in most of the cases, the estimated coefficient for the user cost of capital is larger than 1 in absolute value, either in the short or long run. Therefore, the tax credit policy seems to have had a significant effect in promoting private sector investments in R&D+i.

However, we also found that the policy operates differently according to the type of R&D+i investment. Indeed the effective-

[11] As mentioned before, we used the OECD (ISIC Rev. 3) classification for this.

Table 10
Estimation of Parameters in Eq. (3) by Size of the Firms.

Log expenditure in R&D+i	(1) Small firms	(2)	(3)	(1) Large firms	(2)	(3)
	OLS	FE	System GMM	OLS	FE	System GMM
Log expenditure in R&D+i at t-1	0.593***	0.061	0.398***	0.575***	0.085***	0.191**
	(0.024)	(0.054)	(0.143)	(0.013)	(0.027)	(0.084)
Log *p*	−0.735***	−1.146***	−1.188***	−1.055***	−1.476***	−1.651***
	(0.107)	(0.240)	(0.327)	(0.063)	(0.140)	(0.170)
Log Sales	0.246***	0.361*	0.278***	0.361***	0.387***	0.649***
	(0.034)	(0.184)	(0.101)	(0.018)	(0.092)	(0.077)
Constant	(0.061)	(2.113)	(1.359)	−2.772***	3.197**	−2.543***
	(0.476)	(2.425)	(1.203)	(0.273)	(1.567)	(0.593)
Dummy year	Yes	Yes	Yes	Yes	Yes	Yes
Dummy industry	Yes	No	No	Yes	No	No
Fixed effect firm	No	Yes	Yes	No	Yes	Yes
Observations	862	862	283	3 115	3 115	2 083
Number of firms	152	151	151	890	890	890
R-Square	0.564	0.19		0.657	0.201	
Sargan test			9.842			11.975
p value			0.545			0.366
t-Autocorrelation test. Order 1			−2.651			−4.716
p value			0.008			0.000
t-Autocorrelation test. Order 2			0.227			0.145
p value			0.820			0.885
t-Autocorrelation test. Order 3			−0.703			0.244
p value			0.482			0.807
Long-term elasticity			−1.973***			−2.041***
			(0.413)			(0.142)
Number of Instruments			18			19

Note: Standard errors of estimations are given in parentheses. Robust standard errors.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

ness of the tax credit seems to be larger for investments in capital goods than for investments in pure R&D; in which case the probability of partial crowding-out of private R&D investment might not be discarded. This is worrisome because it is precisely R&D rather than capital goods investments the ones that should be the target of the policy because of their expected lower appropriability and higher risk. To the extent that capital goods investments are more appropriable and, at to some extent, can be used as loan collateral, these types of investments might be better targeted by credit lines or guarantees. Consistent with this, we also found that the effectiveness of the tax credit is higher in the case of low technology sectors, which is expected to the extent that capital goods make up a larger share of total innovation investment in these sectors. With regards to the size of the firm, we found that although in the long-run the effect of the tax incentive is similar across large and small firms, large firms respond quicker to the incentive suggesting that small firms face either liquidity constraints and adjustment costs that are more binding than in the case of large firms.

In conclusion, Argentina's R&D+i tax credit policy had an important effect on reducing the user cost of capital, leading to an increase in private sector expenditure in R&D+i. However, the policy did not have neutral effects on the composition of innovation investment in the extent that the impact has been higher for capital goods investments rather than to R&D. The share of R&D on total innovation investment will be actually lower because of the policy than it was before it. This is worrisome because it is precisely R&D the type of innovation investment more prone to suffer from market failures and the one where the gaps with developing countries are the largest. Based on the results, we believe that the effectiveness of the tax credit instrument could be improved if some features were modified in order to allow firms to deduct only R&D investments and to complement the policy with other instruments that could relax the constraints that affect SMEs R&D investment decisions. In particular, for SMEs with short term financial losses or insufficient profits, the tax credit certificate could be exchanged for a cash refund. Additionally, the tax credit could differentiate between intramural or extramural R&D in the extent that extramural R&D is more generic and more affected by transaction costs. Also extramural R&D is more likely to be carried-out by SMEs who lack enough internal research capabilities. A finally design feature could be to allow firms to partially deduct the labor charges that affect the hiring of skilled or advanced human capital. This will also allow firms, in particular SMEs, to start building their internal research teams and absorptive capacities.

To our knowledge, this is the first econometric study to use structural models for estimating the impact of tax incentives on investment in innovation in developing countries. Although the results suggest that, at least for the case of Argentina, these incentives have been effective, further research is still necessary to determine whether they have are efficient (in the sense that the supported projects have actually generated the externalities that ex-ante were expected) and to investigate the cost and fiscal sustainability of these measures. This is part of a future research agenda.

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[12] Taking the categorization by ENIT 2002 into account.

Appendix A. The components of the expenditure in R&D+i are defined as follows[12]:

- **Research and development (R&D)** is work performed systematically, that is, not only occasionally, in order to generate new knowledge (scientific or technical) or to apply or take advantage of knowledge which is already existing and has been developed by others. Within R&D, large categories can be differentiated as follows: basic research (to generate new knowledge, mainly abstract or theoretical, within a scientific or technical area, in a wide sense and without a previously defined goal or purpose); applied research (to generate new knowledge using the initial intended goal or purpose); and experimental development (manufacturing and testing of a prototype, i.e. an original model or experimental situation which includes all characteristics and performances of the new product or process, and organizational or marketing techniques). Software development is considered R&D since it involves scientific or technological advancements.
- **External R&D** is creative work not performed inside the firm or with personnel from the firm, but rather is provided by a third party which is either hired or financed by a team of researchers, the institution or the company. The agreement is that the results from the work will be owned totally or partially by the contracting company.
- **Acquisition of Capital Goods, Hardware and/or Software:** These are innovation activities that incorporate goods related to introducing improvements and/or innovations in processes, products, and/or organizational or marketing techniques. The replacement of a piece of machinery by another with similar characteristics or a new version of already installed software does not correspond to an innovation activity.
- **Technology Advance** includes every acquisition of rights of use of patents, non-patented inventions, licenses, trademarks, designs, know-how or technical assistance related to incorporating improvements and/or innovations in processes, products or organizational or marketing techniques.
- **Training**: This activity will be considered innovation as long as it does not aim to train new workers on methods, processes or already existing techniques or procedures in the company. Innovation Training can be internal or external for personnel in both soft technologies (management and administration) and hard technologies (production processes).
- **Industrial design and engineering activities:** All technical preparations for production and distribution not considered as R&D are included in this category, as well as blueprints, figures for the definition of procedures, technical specifications and operational characteristics, including installation of machinery, industrial engineering, and start-ups of production. These activities can be difficult to differentiate from R&D activities. In order to do so, it is useful to check whether or not it is new knowledge or an innovative technical solution. If the activity is related to the solution of a technical problem, it will be considered within the activities of engineering and industrial design. Ornamental or aesthetic activities are not innovation activities, except when they generate modifications that change the main characteristics or features of the products.
- **Consultants :** The hired use of scientific and technical services related to activities of Engineering or Industrial Design, or implementation of computing systems by third parties which are external to the company. It must be taken into account that if the activities contracted to third parties are related to R&D or training, they must be considered activities of external R&D and training, respectively.

Appendix B. The variables used in the estimations are defined as follows:

Expenditure in R&D+i	Logarithm of the expenditure in R&D by a company at the constant prices of 1992, using the index described in Section 4.
Stock of R&D+i	It is expressed in logarithms.
Cost of the capital in R&D+i	Described in Section 3.
Dummy Small firm = 1	Variable constructed with the size of the firm in the year in which the survey was performed, i.e. ENIT 92–96. The variable takes a value of 1 if the number of personnel in the firm was fewer than or equal to 50 employees in 1996.
Sales	Total sales of the firm at the constant prices of 1992. For the deflation of this variable, the consumer price index was used.
Effort in R&D+i	Ratio between the expenditure on R&D and the total sales of the firm.

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