Tax incentives and firm size : effects on private R&D investment in Spain

UNU-MERIT Working Paper Series

#2014-081

Tax incentives and firm size: effects on private R&D investment in Spain

José M. Labeaga, Ester Martínez-Ros and Pierre Mohnen

Maastricht Economic and social Research institute on Innovation and Technology (UNU-MERIT)
email: info@merit.unu.edu | website: http://www.merit.unu.edu

Maastricht Graduate School of Governance (MGSoG)
email: info-governance@maastrichtuniversity.nl | website: http://mgsog.merit.unu.edu

Keizer Karelplein 19, 6211 TC Maastricht, The Netherlands
Tel: (31) (43) 388 4400, Fax: (31) (43) 388 4499

UNU-MERIT Working Papers

ISSN 1871-9872

Maastricht Economic and social Research Institute on Innovation and Technology, UNU-MERIT

Maastricht Graduate School of Governance MGSoG

UNU-MERIT Working Papers intend to disseminate preliminary results of research carried out at UNU-MERIT and MGSoG to stimulate discussion on the issues raised.

Tax incentives and firm size: effects on private R&D investment in Spain

José M. Labeaga
UNED
Ester Martínez-Ros
UC3M and UNU-MERIT
Pierre Mohnen
UNU-MERIT and Maastricht University

Abstract

The use of fiscal policy instruments to stimulate private R&D is widespread and important in some countries like Spain. In this paper we explore the effectiveness of R&D tax incentives on knowledge capital accumulation in Spanish manufacturing firms using an unbalanced panel and compare the estimates based on claimed and claimable tax reductions. We find that while large firms use the programme more than small ones, the impact of the programme measured by the price elasticity is smaller for large firms than for SMEs. The price elasticities are higher when the ex-ante claimable tax reductions rather than the ex-post actually claimed tax reductions are used to compute the user cost of R&D.

Keywords: tax incentives, effective user cost, panel data, sample selection

JEL Class.: H25, H32, O32

1. Introduction

In spite of the efforts of national, regional or local governments to foster private R&D during the last 15 years, Spain has not really progressed as expected and as much as other countries. Spain continues to lag far behind neighbours from EU and OECD countries both in private spending and in the success of developing innovations. According to OECD data, Spain is located in 2010 at the 29th position out of 34 countries as regards innovation effort, with a volume of internal R&D relative to GDP of 1.38% far away from the OECD average of around 2.40% or the EU27 average of 1.90%. Although we have to consider that most OECD countries departed from higher initial values, the evolution of the innovation effort in Spain during the period 2003-2010 increased by 39% while OECD exhibited a 6% of growth.

The Lisbon Strategy created the fundamentals of growth and employment based on knowledge. However, two features of the Spanish economy, a huge unemployment rate and a low level of innovation, have been exacerbated during the current crisis. On one hand, public policies have not stimulated innovation activities sufficiently, and on the other hand, private investments have not complemented enough public efforts to create added value for job creation.

Table 1 offers a description of the percentage of R&D financed by industries or governments by country. We can observe a huge difference between Mediterranean and other EU countries. While for the EU27 and most of its northern countries (with the exception of the UK and the Netherlands) have more than 50% of their R&D funded by industry, southern countries permanently remain at the bottom of the distribution.

Table 1. Percentage of R&D financed by Industry or Government -2010

Country	Industry	Government
UE27	53.3	35.3
UK	45.1	32.1
Germany	66.1	29,7
The Netherlands	45.1	40.9
Greece	31.1	46.8
Italy	44.2	42.1
Denmark	60.3	27.7
Belgium	58.6	25.3
France	51.0	39.7
Portugal	44.0	45.3
Spain	43.4	47.1

Source: OCDE Report (2012)

Spanish Governments at any time and any level have traditionally helped firms in their innovation activities by overcoming the typical problems associated to market failures such as financial constraints or imperfect appropriability of the returns. At one time Spain was considered one of the most generous countries in the OECD in tax treatment of R&D (Warda 2001 and 2002). Tax incentives, acting either on the tax base (free depreciation) or on the corporate income tax liability (tax credits for R&D and technological innovation), have the effect of decreasing the price of doing R&D. These instruments should in theory stimulate innovation activities and correct for suboptimal R&D funding in firms. Moreover, they apply to all firms that carry out R&D activities, a known advantage of this instrument.

However, empirical evidence (Marra 2004, Heijs et al. 2006) reveals that these generous tax incentives are rarely used by Spanish firms: only around 30% of the firms make use of them (Corchuelo and Martinez-Ros, 2008). The success of this tax policy is based on the government's ability to design it and on the firms' willingness to make use of it. Therefore, since these aids are not conditional on success in innovating, it is very important to understand their design and the characteristics of the firms that use them in order to be able to propose alternative policy options.

In the literature there are two main approaches to explore the evaluation of the effect of tax incentives on private R&D investment. The first estimates the treatment effect by constructing counterfactuals, instrumenting the treatment, comparing experimental and treatment firms before and after the introduction of a policy change, or by comparing firms that are close to a discontinuity in the treatment design (Czarnitzki et al. 2011, Duguet 2008 and 2012, Cappelen et al. 2008, Corchuelo and Martínez-Ros 2008). The second approach is based on the estimation of a structural model that also permits simulations of the effects of future tax incentives distinguishing between short-run and long-run effects of the user cost on R&D investment (Bloom et al. 2002, Mairesse and Mulkay 2004, Marra 2004, 2008, Corchuelo 2006, Romero and Sanz, 2007, Baghana and Mohnen 2009, Harris et al. 2009, Lokshin and Mohnen 2012).

Our paper focuses on the effectiveness of R&D tax incentives in affecting the evolution of the volume of internal R&D. We use a structural approach deriving a dynamic demand for R&D equation depending on the user cost of R&D inclusive of R&D tax credits, and we propose to include additional variables in order to analyse the capacity of a public policy to incentivise private action through different channels, such as the use of several technological networks. We depart from previous studies in several directions. First, we use firms that spend on R&D but that do or do not use the tax incentive instrument. In this sense, we estimate the average effect of the treatment on the treated (ATT) although we are aware of several sources of endogenous sample selection, which we will try to overcome. Second, we compare the results obtained using the effective and the legal user cost. The effective user cost of R&D is measured on the basis of claimed deductions while the legal user cost is based on eligible tax deductions according to legislation. Third, we compare the responsiveness of R&D to the user cost for small and for large firms. Fourth, we propose that private R&D investments depend also on the flows of external information, that is spillovers that condition the effectiveness of public policies in terms of appropriability of R&D returns (Griliches 1992, Audretsch and Feldman 1996, Cohen et al. 2002).

In order to test for the effectiveness of tax programmes we use data provided by the SEPI Foundation on behalf of the Spanish Ministry of Industry, Tourism and Trade. This is a survey containing information on manufacturing firms with more than 10 employees. It provides some information about the knowledge and use of tax incentives for R&D from 2001 onwards, it allows us to distinguish between firms that are merely aware of these incentives and firms that actually use them, and it reveals the amount of those funds. Although the information on the variables related to the tax incentives programme is available in the survey from 2001 onwards, we build an unbalanced panel from 1998 to 2008 in order to be able to use initial conditions and instruments for solving potential endogeneity problems. We are aware that the ATT could be affected by decisions about spending on R&D or using the tax credits that we do not take into account, but we'll be able to conduct a test for endogenous selection.

Concerning the determinants of R&D spending, previous R&D efforts explain an important variation of current investment. The effect of the user cost of R&D expenditures is more than double for SMEs than for large firms. As expected, the legal user cost shows more influence on R&D investment than the effective user cost because we observe that a number of firms entitled to R&D tax credits do not make use of it. Moreover, the influence of the legal user cost is not statistically different in large firms and SMEs because the tax scheme does not establish differences among them (except in the ceilings, which are rarely binding). Financial constraints are only important for SMEs in some specifications. Regarding the other channels of influence on R&D, we observe different patterns by size. For large firms, the participation in technological firms is more relevant whereas for SMEs the use of technological consultants helps them to invest in R&D. Definitely, firm size matters in terms of investment in R&D since the access to knowledge using technological networks is more affordable for large firms than for small ones. The acquisition of external knowledge being absorbed inside the firm confers the possibility to increment the efforts devoted to R&D. However, SMEs consider the use of technological consultants as a way of making more effective the tax incentive relative to their investment. Finally, having subsidies in the past positively influences current spending on R&D for large firms although our suspicion that its inclusion could affect the elasticity of the user cost of R&D is not confirmed.

The paper contains four sections in addition to this introduction. In section 2 we revise the literature on innovation incentives with special reference to models where effectiveness is tested in the context of a production function. In section 3 we describe the data and the characteristics of the tax credit programme in Spain. Section 4 is devoted to present the economic model, the econometric methods and the main results. Our main conclusions and some policy implications are in section 5.

2. Empirical related literature

In the public programmes and policies supporting R&D activities there are several alternatives ranging from promoting basic research for the production of knowledge to launching new products on the market. There are two main ways in which government can directly influence the level of R&D spending within firms, by directly subsidising such expenditure through grants or loans or by offering fiscal incentives. In all cases, those instruments try to overcome market failures due to appropriability problems, financing constraints or indivisibilities.[1] Quite a number of studies have tried to assess the effectiveness of public funds in stimulating private R&D in terms of competitiveness, productivity and social welfare.[2]

We essentially focus on the fiscal incentives policy. Fiscal incentives are one of the most used instruments by governments to lower the user cost of R&D and thereby stimulate business investment in research and development. Market failures due to R&D externalities and asymmetric information between lenders and borrowers for financing R&D projects are often cited to justify the existence of such government programmes, which involve substantial tax burdens (OECD, 2007). The effectiveness of R&D fiscal incentives programmes, however, continues to be the object of intense debate among economists (Mohnen and Lokshin, 2010). These instruments are articulated through the fiscal law (Corporate Tax) with the object of reducing the cost of investment and increasing private profitability, trying to achieve a balance between social and private production of R&D. However, as the European Commission (2003) recognises, an important issue is the existence of numerous country-specific designs implying the need to compare their effectiveness at the EU level. The goal of R&D tax credits is then to reduce the cost of an innovation project, and its main characteristic is that it can be applied without conditions to any firm dedicating investments to R&D. So, the decision on its use is left to the firm at the expense of fulfilling a form (Duguet, 2012). A drawback of tax credit programmes is the impossibility to select R&D projects by independent institutions or to boost R&D on desired lines of research.

The methodology used in the literature on R&D fiscal incentives combines event studies comparing behaviour before and after a change in the policy (Collins 1983), questionnaire surveys and interviews attempting to determine how individual firms respond to a policy change (Mansfield 1986), and econometric estimation using two kinds of parametric methods: impact models (Berger 1993) in which a binary variable proxies the impact of the tax incentive, and demand models (Bloom et al. 2002; Baghana and Mohnen, 2009, Harris et al. 2009) that directly yield the price-elasticity of R&D investment. Although results are mixed, most of the evidence shows that firms respond to the R&D tax incentives, although the effect of social welfare when costs and benefits are taken into account are less clear-cut (see European Commission, 2014).

The efforts of governments to provide incentives for firms either to initiate R&D activities (extensive margin) or to expand the range of development activities that they undertake (intensive margin) have not produced the expected results in Spain. A priori, the Spanish tax system is one of the most generous but the evidence of the impact of this tax policy is scarce, with a few exceptions. Marra (2004, 2008) concludes that tax incentives affect the firm cost structure and increase the private demand for R&D. Corchuelo (2006) finds that incentives increase the probability of innovation and R&D effort. Heijs et al. (2006) get that, on average, firms receiving fiscal incentives are 1.14% more intensive in R&D than those

[1] It is difficult to imagine private initiatives dedicating funds from the early stage on to the study of DNA 25 years ago, since profitable discoveries have not provided benefits to the society until now. We ask public policies to promote research and development at both basic and applied levels especially in the presence of high levels of uncertainty in the returns.

[2] For the effectiveness of direct grants or loans see Duguet (2004), González et al. (2005), Busom (2000), Blanes and Busom (2004), Czarnitzki and Toole (2007), Gelabert et al. (2009), Arqué-Castells and Mohnen (2012), for the evaluation of tax credits see Bloom et al. (2002), Baghana and Mohnen (2009) Harris et al. (2009), Mohnen and Lokshin (2010), and for studies regarding the use of both instruments see Lhuillery et al. (2013) and Busom et al. (2014).

without them. Romero and Sanz (2007) show that each monetary unit spent on fiscal incentives generates approximately 1.2 units of gross R&D investment by firms. All these papers compute the user cost under conditions of eligibility following the legislation and none of them calculates the effective user cost of R&D.

In 2003 a report from IDETRA and CEIM exposed to the Ministry of Economy and Finance the existence of difficulties of applying for R&D tax deductions by the firms in terms of interpretations and required conditions. Corchuelo and Martínez-Ros (2008) analyse the participation of firms in the tax credit system and conclude that despite knowing the advantages of the programme, firms frequently prefer not to make use of such incentives because of administrative costs, lack of information and lack of resources. The percentages of use are around 20% for SMEs and 40% for large firms. Behind different arguments about non participation in this programme, they conclude that what is crucial for non-participation is the volume of information firms should provide to the Tax Agency that could increase the probability of further or future inspections. However, to our knowledge, the most important barrier to the entry into these programmes is the complexity of the rules and the design of the tax scheme for the Spanish business network (Ministry of Science and Technology Report, 2009) composed of around 60% of SMEs, the majority of which are family businesses or micro firms. Corchuelo and Martínez-Ros (2010), using matching methods, show that firms with a high capacity for innovation, a stable financial position, and benefiting from R&D subsidies (especially SMEs) are more likely to take advantage of the tax benefits. SMEs encounter important obstacles to using them. As to the effect of tax policy, it is a significant and important only for large firms and firms that belong to high-technological intensity sectors.

In 2009, the Ministry of Science and Technology ordered a new report on the comparison of different systems of R&D tax incentives in OCDE countries. From this report, we can infer that many R&D intensive Spanish firms cannot apply for tax credits. Those are small innovative firms, technological start-ups or large firms with huge amounts of R&D investments. Using the Spanish CIS, Busom et al. (2014) found that financially constrained SMEs are less likely to use R&D tax credits and more likely to obtain subsidies. SMEs with legal methods to protect their intellectual property are more likely to use tax incentives. So, one important aim of our present analysis should be the evaluation of the design of the instrument and how changes in it could affect firms' decisions to make use of it.

We argue here that firms that permanently use the tax credit (TC) programme develop specific capabilities that lead them to superior performance (Clausen et al. 2011). This argument is a result of the very nature of knowledge itself, which is cumulative and used as an input to generate new knowledge. This particular effect is often important in sectors where the knowledge base is very cumulative; implying that experience in R&D makes firms more efficient in innovating (Malerba and Orsenigo, 1996; Martinez-Ros and Labeaga 2009; Huergo and Moreno, 2011; Cappelen et al. 2011). R&D is not an activity to conduct with discontinuity since investment in knowledge, for instance, skilled workers and new technological equipment that entail sunk costs are difficult to amortise in a short period of time.

As a final aim, we would like to know which other public incentives are in place to complement the tax credit in stimulating R&D. Little evidence exists regarding those channels. The complementary channels that we have in mind could reinforce the effectiveness of the tax credit programme: one is using the employees dedicated to R&D tasks, others could be the share of knowledge via innovation, geographical or technological networks; the use of external services like fiscal or economic consultants to help firms understand better the corporate tax system.

The ability of firms to appropriate at least some of the value created by their innovations is essential if there is to be an incentive to innovate. On the other hand, the economy-wide benefits from an innovation depend to a considerable degree on the extent to which the new knowledge associated with it becomes available to others to use and build on. Cohen et al (2002) report the results of a research study that compares the ability of the US and Japanese firms to appropriate the returns to their innovations, how these firms protect their innovations (by using, e.g. secrecy, patents, lead time advantages) and the magnitude and channels of intra-industry R&D information flows in the two nations.

Innovation, learning and technological development are now seen as systematic activities involving many diverse actors throughout the economy. Innovation networks imply R&D alliances among companies. As Goyal and Joshi (2002) claim, firms form bilateral relations to reduce costs and then to compete on the product market. Empirical studies on alliance formations state that accumulated joint experience between partners generates both trust and shared cognitive past (García-Pont and Nohria, 2002, Powell et al. 1996). The current state of the network is an important variable for explaining future link formations. Innovation networks are a way to manage necessary knowledge interactions because knowledge spillovers can be internalised. It is a way of choosing the appropriate partners and the suitable modes of cooperation. It allows seeking a strategic position within the network structure.

We can separate different types of networks: those related to geography and those related to technology. In Spain, we have regions with different ways of organising R&D and regions with different schemes of fiscal policy regarding the corporate tax and the R&D tax incentive system. What would like to capture both types of networks: those associated with the participation of, or collaboration with, universities and technological centres and those more related with different tax schemes according to geography. Our guess is that such proxies for technological and geographical networks will generate some impact on the investment on R&D.

3. Data and the Spanish tax credit programme

We use data provided by the SEPI Foundation on behalf of the Spanish Ministry of Industry, Tourism and Trade. The ESEE (*Encuesta Sobre Estrategias Empresariales*) is a survey that contains data since 1990 on manufacturing firms with more than 10 employees that are questioned about their strategies in the short and long run, including their R&D decisions. In the ESEE, SMEs are firms with less than 200 employees and large firms are for those more than 200 employees. We adopt this classification of firm size for our analysis. Since 2001, this survey has included some questions about the knowledge and use of tax incentives for R&D that allow us to distinguish between firms that merely are aware of these incentives and firms that actually use them. According to the availability of tax credit information, our period of study goes from 2001 to 2008, although some key variables could enter the model using all the available periods, for instance 1997-2008. This fact helps us to take into account the pre-sample information that could serve as appropriate controls for individual effects and firm size.

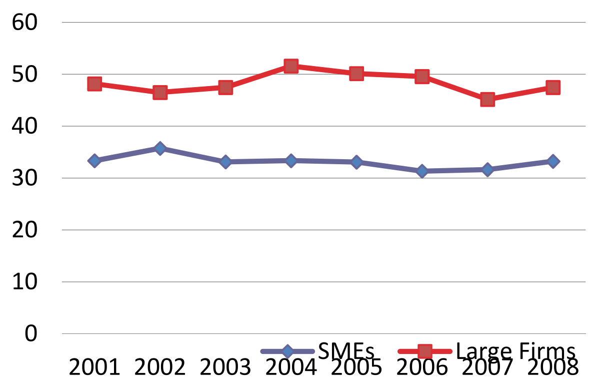
3.1. A preliminary look at the Spanish data

The evidence shows that R&D is more of an intermittent activity than an ongoing one for most firms. Large ongoing corporate R&D labs are rare. Firms do R&D for a specific purpose: to update a product or process; to imitate competitors; or to work through a new innovation. They do this for many reasons, but mostly for competitive ones – if they don't, their competitors will take over their market share and so their profits.

The tax implications of these investment decisions are typically fairly low on the list of important decision factors. However, a better tax treatment does make justifications for R&D investments easier: a fact which partly drove the change from the R&D tax concession scheme to the R&D tax incentive scheme, as some large firms (typically mining) structured massive investments to reap the concession on investments that were regarded as R&D under the old scheme but maybe not under the new scheme.

In Figure 1, we report the share of innovating firms with tax credits by firm size. 30% of SME and 45% of large innovating firms use tax credits during the period of our estimating sample. Its use goes down to around 5% and 29% for SMEs and large firms, respectively, in the whole sample. In the current scheme, there is a cut off among firms using this instrument in terms of an entrance barrier because to apply for it you need to report a significant amount of R&D expenditure and profits as well.

Figure 1. Share of R&D performing firms using Tax Credits



Notes:
1. Innovating firms are firms with positive internal R&D expenditures.
2. Contract research is not taken into account.

Source: ESEE and own calculations.

We are not able to explain the reasons why such a big percentage of firms spending on R&D do not use the programme because we even observe that their effort is in some periods as large as the effort of persistent users or entrants. But we can explore which channels firms use as complements to the Tax Credit Programme.

Since the introduction by the Spanish Government in 1995, the Tax Credit instrument has attempted to encourage firms to increase their private R&D investment. When we look at the aggregated data, the distribution of the public – private effort (as measured in terms of GDP and reported in Table 1) has not completely gone in the expected direction. There are several studies trying to evaluate the effectiveness of tax incentives in encouraging additional R&D spending by firms. The most common evaluation is to conduct tests of R&D additionality (or on the contrary crowding out effect of private funding by public help). Since the instrument is a universal one and a number of firms do not use it as a complement (or substitute) for their own investments, we will analyse the reasons behind their behaviour.

Since we have a panel, we can follow information provided by firms for a number of years. Unfortunately, the survey only asks for this information from 2001 onwards while the TC started in 1995.

When tax credits are applied to the corporate tax liability, they may be considered as an ex-post prize for successful innovation outcomes conditional on having profits. If they are reimbursable they act as a prize for R&D effort regardless of the outcome. This particular characteristic may affect firm's decisions since the ability to claim the prize does not depend on the firm's tax position. So, the tax credit should provide increases in private R&D investments.

Table 2. Number of R&D performing firms and number of TC applicants

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
LARGE								
Firms with R&D expenditure	353	355	276	285	347	339	330	295
Firms applying for Tax Credits (TC)	154	153	121	130	157	151	128	124
Firms with Profits[1] and R&D expenditures and not applying for TC	167	168	129	123	142	145	157	139
SMEs								
Firms with R&D expenditure	192	196	148	156	248	265	253	301
Firms applying for Tax Credits	58	62	45	48	73	68	63	84
Firms with Profits[1] and R&D expenditures and not applying for TC	111	108	73	77	135	152	144	162

Notes.

1. Profits are not accounting figures; they have been proxied as the difference between total firm revenues and total gross cost from the balance sheet information.

3.2. Main characteristics of the Spanish tax incentive system

Almost every country within the OECD and EU has its own system of tax incentives related to R&D. Warda (2006) shows that 19 out of 27 OECD countries examined have specific tax incentives in place for R&D investments. There are countries in which national tax-based innovation policies seem to be more holistic, in particular, Austria, France, Japan, the Netherlands, Spain, and perhaps Korea. The driving force behind this trend appears to be the recognition by governments that R&D does not operate in a vacuum and as such is not sufficient to bring new products or services to the market and increase industrial productivity. Other key factors that shape business innovation but lie outside the realm of R&D include investments in intellectual assets such as patents and patent rights, a skilled workforce and organisational flexibility.

In Spain, tax incentives for R&D investment have been in place since 1995, when a new law on corporate taxation was introduced. The definition of eligible R&D expenses follows the OECD Frascati Manual guidelines. In 1999, under Law 55/99, some non-R&D technological innovation expenditures were included as eligible for tax credit at a 10% rate. In the Law 45/95, tax credit rates were initially 20% of R&D volume, and 40% of the excess on the average R&D expenditures of the two preceding years, with a cap of 35% of tax liability. It contained an increase of 10% on the labour cost of employees assigned exclusively to R&D tasks and R&D cooperation with technological institutions. In the Law 24/2001 an additional 10% deduction for investments in physical assets (excluding buildings) was included. Later with the Law 62/03 and the RDL4/04 the rates were increased (from 20% to 30% and from 40% to 50%, and 20% of the labour cost of employees assigned exclusively to R&D tasks and R&D cooperation since 2004 and up to 2007). It also increased the cap RD-L3/00 (to 45% for SMEs when the credit was greater than 10% of the tax liability) and the number of years one could carry forward the deduction not applied due to the excess or the absence of tax liability was increased from 5 to 10 years. In 2007, in the Law 35/06 firms could use the alternative option of deducting from the social security tax liability and the deduction for tax credit was multiplied by 0.92 in 2007 and by 0.85 in 2008, so the tax credit rates allowed for deductions since 2008 are: 25% of R&D volume, 42% of the excess on average R&D expenditures of the two preceding years, and additionally 8% for physical assets (excluding buildings) and 16% for R&D personnel (the additional deduction for R&D cooperation is eliminated). Unused tax credits can be carried forward up to 15 years.

The eligible base for deduction includes personnel costs, materials, outside services and depreciation of assets used for R&D. It excludes investment in buildings affections (3.6% of total R&D), and tax credits can be claimed on all R&D expenditure remaining after subtracting 65% of the subsidies received. In Table 3, we summarise the evolution of different changes in legislation during the period of our exercise.

Table 3: Evolution of tax credit in Spain in the analysed period (2004-2008)

Tax Credit	**2001/03 (Law 24/01)**	**2004/06 (Law 62/03 and RDL 4/04)**	**2007 (Law 35/06)**	**2008 (Law 4/08)**
Current R&D expenditures	20%	30 %	27,6%	25%
Current R&D expenditures > R&D expending during the previous 2 years	45%	50 %	46%	42%
Expenditures on R&D personnel	10%	20 %	18,4%	16%
Cooperation with universities and Technological Centres	10%	20 %	18,4%	0%
R&D capital expenditures (assets except buildings)	10%	10 %	9,2%	8%
Expenditures in innovation	10%-15%	10%-15%	9,2%	8%
Cap in tax liability[2]	30%/50%	35%/50%	35%/50%	35%/50%
Carry-forward excess	5 years	10 years	15 years	15 years

Notes.

1. Alternative option of deducting from the social security tax liability
2. Splitting in SME and large firms respectively.

4. Model and variables

In this paper we consider a simple model of R&D investment that expresses the long-run equilibrium equality of the marginal productivity of R&D capital and R&D user cost for a profit-maximising firm. In particular, we wonder about the existence of additionality as well as about firm's characteristics improving the efficiency of the programme. We estimate the elasticity of R&D with respect to its user cost using the Mulkay and Mairesse model (2013). The model is derived under the assumption of a CES production function with a constant elasticity of scale (θ) and a constant elasticity of substitution (*σ*) between R&D capital and all other factors of production and it can even accommodate the hypothesis of imperfect markets with a constant mark-up. Then, we can write the demand function for R&D as:

$$R_{it} = \alpha_0 + \theta \text{Output}_{it} + \sigma \text{User Cost}_{it} + \gamma_0' X_{it} + \alpha_i + \alpha_t + \varepsilon_{it} \qquad (1)$$

where R, Output and User Cost are, respectively, the log levels of firm R&D capital in real terms, output in real terms and R&D capital user cost in real terms, and where α_i and α_t stand for the firm and year individual effects. Moreover, we include in the expression other controls for firm characteristics X. We assume that X contains *alternative channels* that could affect the demand for R&D investment. For instance we use the technological networks including the participation in technological firms and collaboration in joint ventures as well as the use of technological assistance.

We want that expression (1) be more realistic hence, we need to specify the dynamics of R&D investment and, in particular we have to approximate firm expectations of demand and account for the costly adjustment process of R&D capital. A straight way is to insert the long-run relation (1) into an Autoregressive Distributed Lags (ADL) equation, or an ADL linear model with two lags:[3]

$$\mathrm{R_{it}} = \alpha_0 + \alpha_1 \mathrm{R_{it-1}} + \alpha_2 \mathrm{R_{it-2}} + \beta_0 \mathrm{User\ Cost_{it}} + \beta_1 \mathrm{User\ Cost_{it-1}} + \beta_2 \mathrm{User\ Cost_{it-2}} +$$

$$\xi_0 \mathrm{Output_{it}} + \xi_1 \mathrm{Output_{it-1}} + \xi_2 \mathrm{Output_{it-2}} + \gamma_0' \mathrm{X_{it}} + \alpha_i + \alpha_t + \varepsilon_{it} \qquad (2)$$

In this ADL model, coefficients β_0, ξ_0, and γ_0 represent the short-term dynamic adjustment of R&D capital to its user cost, to the product demand to the firm and to other determinant of R&D capital, while the long-run elasticity of R&D capital with respect to its user cost is given by (β_0 + β_1+β_2)/(1-α_1–α_2).

An alternative representation of the ADL equation (2) is the equivalent form of an error correction model (ECM, see again Mulkay and Mairesse 2013), which can be expressed as:

$$\Delta \mathrm{R_{it}} = \delta_1 \Delta \mathrm{R_{it-1}} + \pi_0 \Delta \mathrm{User\ Cost_{it}} + \pi_1 \Delta \mathrm{User\ Cost_{it-1}} + \sigma_0 \Delta \mathrm{Output_{it}} + \sigma_1 \Delta \mathrm{Output_{it-1}} +$$

$$\phi_1 (\mathrm{R_{it-1}} - \mathrm{User\ Cost_{it-1}} - \mathrm{Output_{it-1}} - \mathrm{X_{it-1}}) + \rho_1 \mathrm{User\ Cost_{it-1}} + \tau_1 \mathrm{Output_{it-1}} + \theta_0' \Delta \mathrm{X_{it}} + \alpha_i + \alpha t + vit \qquad (3)$$

In (3), the coefficients $\pi_0, \sigma_0, \text{and } \theta_0$ characterise the short-term elasticities of R&D capital to its user cost, product demand and all other factors included in X_{it}, while the long-run elasticity to the user cost is $(1 - \frac{\rho_1}{\phi_1})$, and the long-run elasticity to the product demand is $(1 - \frac{\tau_1}{\phi_1})$.

4.1. Definition of variables

We define our dependent variable as the log of R&D internal expenditures in real terms (taking 2001 as the base year). It is important to notice that as Harris et al. (2009) stated, the preferable measure of R&D investment is the stock instead of the flow. However, when data do not permit the use of a proper R&D stock variable, R&D spending could be a good proxy. In that case, we assume that in the steady-state R&D stock is proportional to the flow of R&D investment (in equilibrium ΔR&D=0, thus the net R&D spending equals to δK, where δ is the depreciation rate of the R&D stock, K).

As explanatory variables, we include, in addition to one year lag of the dependent variable, the log of deflated sales and the log of the user cost of R&D, which is measured as in Bloom et al. (2002) and for which we provide details of its calculation in Annex II. We use two measures of the user cost of R&D: the effective user cost, which is measured on the basis of claimed tax deductions, and the legal user cost,

[3] We depart from the models of Bloom, Griffith and Van Reenen (2002), Baghana and Mohnen (2009) and Lokshin and Mohnen (2012) by generalising their partial adjustment models to ADL models. Of course, we can express the process using additional lags of the variables as in Mulkay and Mairesse (2013).

which is based on eligible tax deductions according to legislation. As additional incentives for R&D investment we differentiate those related to networks from those related to technological consultants. For the former, we have whether firms collaborate with other technological firms and whether firms participate in joint ventures. For the latter we employ a dummy variable whether firms use those agents as advisors of their R&D decisions. We also include a dummy controlling for the use of R&D subsidies in the past to avoid overestimating our price elasticity.

According to the literature, there exists evidence that financial constraints could impede or condition the engagement in innovations, hence we introduce a binary variable equal to 1 if the firm is seeking without success external funds. As well, the firm experience measured by the age of the firm (in logs) is considered a good indicator and determinant of innovation activity. We also consider industry and time dummies as controls of common industry and macroeconomic shocks. Finally, we include also regional dummies as controls for different regional tax programmes.

Table 4. Descriptive statistics

Variable	**Measure**	**Mean (Standard Deviation)**	
		SMEs N = 1516	Large N = 2430
R	Ln R&D: log of R&D spending deflated by the retail price index	11.23 (1.47)	13.17 (1.67)
Effective User Cost	Ln effective user cost based on actually claimed R&D tax incentives	-1.95 (0.32)	-1.98 (0.38)
Legal User Cost	Ln legal user cost based on claimable R&D tax incentives	-2.00 (0.23)	-2.01 (0.26)
Output	Ln sales: log of sales deflated by the retail price index	15.90 (1.17)	18.44 (1.15)
Control variables:	Ln age: log of number of years since the firm was founded	3.18 (0.70)	3.42 (0.76)
	Financial constraints: dummy variable equal to 1 if the firm searched for external funds without success	0.11	0.08
Past R&D Subsidies	R&D Subsidies: dummy variable equal to 1 if the firm has obtained a R&D subsidy from the Government	0.13	0.30
Alternative Channels	Participation in technological firms: dummy variable equal to 1 if the firm collaborated with technological organisations	0.06	0.19
	Joint Ventures: dummy variable equal to 1 if the firm had joint ventures	0.06	0.16

	Use of technological assistant: dummy variable equal to 1 if the firm used technological consultants.	0.38	0.51

Although we have a complete sample of 3112 SMEs and 1806 large firms (see columns 1 at top and bottom parts of Table 2), we present descriptive statistics for samples of 2430 SMEs and 1516 large firms since they are the most common samples where we estimate the model taking into account all control variables and dynamics. Anyway, the statistics for both sample sizes are rather similar. Our sample shows some interesting characteristics regarding firm size. Large firms dedicate more effort to R&D than SMEs. In contrast their user cost of R&D is very similar. The experience of firms, measured as the age, is on average the same while the lack success in obtaining external funds is slightly higher in SMEs. Finally, large firms use more frequently networks and technical consultants to develop R&D projects.

5. Econometric issues and results

5.1. Econometric issues

The main advantage of using panel data is the control of unobserved heterogeneity and more specifically correlated heterogeneity. Firms are very different and some unobserved factors could affect their behaviour in many respects and particularly concerning R&D decisions. Panel data allows controlling for factors such as managerial ability, which in short time dimensions can be assumed to remain fixed but is with a high probability correlated to observable controls. Since data at several points in time are available, transforming the model (first differences, within-groups, orthogonal deviations, etc.) allows ruling out the factors remaining constant. There are several important implications of proceeding in this way. First, we do not only drop from the specification unobserved heterogeneity but also observed variables which are non-time varying and whose effects are sometimes of interest. Second, it is sometimes difficult to find adequate instruments for some variables in transformed equations (see Blundell and Bond, 1998), and in our model it particularly affects to the user cost as well see later on. In this context, the proposals of estimating the models combining equations in levels and equations in differences could be an option to consider. Although we are going to estimate the model at the first stage without worrying about selection, a third implication is that unobserved heterogeneity poses additional difficulties in adjusting non-linear models even for the possibility of making any transformation of it (see for instance Arellano and Bover, 1997).

But dealing with models that contain heterogeneity, which also include lagged dependent variables, complicates the methods to be applied for several reasons. First, we need the time dimension tending to infinity for getting consistent estimates in fixed effects settings (see Nickell, 1980). Second, when we assume random heterogeneity the random components are by construction correlated with at least the lagged regressor. There are several approaches, different to the within-groups transformation of the model, which allow obtaining consistent estimates but every method relies on the existence of adequate instruments, and it is not an easy task in some circumstances. In a model in first differences, the heterogeneous components do no longer appear in the specification but the mixed error adopts a moving average structure correlated with the lagged regressor. Instruments in first differences are, sometimes, inadequate in the sense of exhibiting low correlation with the regressors to be instrumented or their variation across firms is not enough to properly identify its effects. In this case, Arellano and Bover (1995) or Blundell and Bond (2000) provide procedures (as system Generalised Method of Moments estimation) to improve the degree of adjustment and the identification of their effects.

A usual concern when estimating R&D type equations either for innovations, expenditures or patents is the selection of the sample. In the case under study we are interested in the effects of the cost of capital on the evolution of R&D expenditures, and we use firm level data. We face two potential selection problems. First, a number of firms in our information set do report zero R&D expenditures over the whole period and we can think that they are true non-innovating firms (after checking that pre-sample information allows us to classify them as true-non-innovators) so that removing the observations from our final sample does probably not create the usual endogenous sample selection problem. However, we do also have firms entering and exiting from innovation activity (in the sense that they spend in some periods while not in other periods) and excluding them from our sample could generate such a problem. So, we wonder whether missing time periods for some firms (periods where firms report zero R&D expenditures but whose complete information set is a mix of zeros and positives) produce inconsistencies in the estimates. We use proposals by Semykina and Wooldridge (2010, 2013) to test and correct for endogenous selection. Second, some firms spending on R&D and then entitled to use the programme do not finally use it for any reason. If the decision to use it is correlated to observables or unobservable in our equation of interest, the estimates obtained would be inconsistent. So, we will estimate the models after taking into account the effect of the decision to use the programme on the volume of R&D expenditure that firms do.

On the other hand, firms make simultaneous decisions about inputs and output and, as a result, our measure of the output is potentially endogenous. Moreover, the economic component of the user cost is also potentially endogenous. A usual approach is using GMM since in panel data we have available a number of instruments within the information set (see Arellano and Bond, 1991). Of course, the critical issue is whether the instruments are robust in levels, differenced or combined levels-differenced equations. In this context, the papers by Arellano and Bover (1995) or Blundell and Bond (2000) contain some proposals to fully exploit the available instruments. Finally, these methods can also be used even allowing for sample selection while controlling for endogeneity of some explanatory variable. So, we first test for exogeneity and, based on the results of the diagnostics, we use alternative procedures.

In any case, since instruments in transformation of variables (within-groups, first differences, etc.) are likely to perform worse than instruments in levels, we also opt for adjusting the ADL equation [2] by two-stage least squares in the levels specification. The main problem is the presence of the correlated unobserved heterogeneity terms. We solve this problem by modelling them. We opt for specifying a distribution for the effects on the averages of a set of strictly exogenous variables.[4] So, if we take equation [2], the error can be expressed with its components as:

$$u_{it} = \alpha_i + \varepsilon_{it} \qquad [4]$$

with the conditional mean of the effects as:

$$\alpha_i = \lambda'\overline{X}_i + \gamma R_{i0} + \mu_i \qquad [5]$$

where vector $\overline{X}_{i.}$ contains the individual mean of the variables entering the conditional mean of the effects and the error in [5] (μ_i) is uncorrelated with any variable in [2]. Moreover, we include (as suggested by Wooldridge, 1995) initial conditions for the dependent variable, which correspond to log of R&D expenditures in the initial period. Since we use the period 2001-2008 for estimation purposes because the tax variables are only available for those years but we have information for previous years, we can use pre-sample information as initial conditions for R&D expenditures. So, our final specification to estimate the ADL model using this method is:

$$R_{it} = \alpha_0 + \alpha_1 R_{it-1} + \beta_0 \text{ User Cost}_{it} + \beta_1 \text{ User Cost}_{it-1} + \xi_0 \text{Output}_{it} + \xi_1 \text{Output}_{it-1} + \gamma_0 X_{it} + \lambda'\overline{X}_{i.} + \gamma R_{i0} + w_{it} \qquad [6]$$

with w_{it} collecting the errors in [4] and [5], R_{i0} being the initial value of R_{it} and where User Cost_{it} and Output_{it} are potentially endogenous variables. Since the function of the random effects [5] is included in [6], we expect there is not additional room for firm unobserved heterogeneity, but we perform a test for it. The ECM model [3] can also be adapted in an equivalent form to [6], given [4] and [5], since the ECM equation contains an individual component of the error. We can get consistent estimates of the parameters on the level specification by two stage least squares (TSLS) or GMM.[5] We estimate the ECM model by GMM and system-GMM. Since [3] contains variables in first differences and levels, we will also try additional estimations enriching the instrument set using a combination of equations in levels and first differences with instruments in first differences and levels to deal with the correlated effects problem. Finally, we present tests for the two types of endogenous sample selection and results that correct for it when necessary.

5.2. Results

Tables 5, 6 and 7 contain the results. We begin presenting baseline results of the ADL model based on OLS (Table 5) where we do not account for any of the econometric problems previously explained. We then move to estimate the same model taken into account each problem sequentially to end with a set

[4] Following Mundlak (1978) we can include averages of all variables strictly exogenous in the model. We could also follow Chamberlain (1984) and include lags and leads of all time varying exogenous variables.

[5] Note that the ECM representation of the model is a specification that mixes variables in levels and first differences, and then the main task is the adequate choice of the instrument set.

of results that considers all of them simultaneously (Table 6). Finally, Table 7 presents GMM estimates of the ECM model while tests and comments about checking different assumptions and commenting diverse alternatives are explained through the text. Columns 1, 3, 5 and 7 in Table 5 report results using the effective user cost of R&D while we present in columns 2, 4, 6 and 8 the same specifications but substituting the effective by the legal user cost. We estimate the model separately for large firms and SMEs.

Clearly, baseline results are very robust across specifications for the main determinants of innovation effort and for both samples. Previous efforts in R&D explain an important variation of current investment. The legal user cost shows more influence on R&D investment than the effective user cost. How can we explain this? On average during the sample period only 30% of SMEs and 44% of large firms used the programme. This does not preclude those firms to do R&D. It is just that they do not want to apply for R&D tax credits. The effective R&D tax credit is thus a mixture of claimable tax credits and propensities to apply for tax credits. It is an imperfect measure of the ex-ante cost of doing R&D and resembles therefore an error in variables problem. And indeed all estimated price elasticities (short-run and long-run) based on the effective R&D user cost are systematically lower in magnitude than those based on the legal user cost and, as we shall see later when correcting for endogeneity, the former are also often insignificant. There are significant differences between the impact of the effective user cost in big firms and SMEs, but there are also differences in the influence of the legal user cost in large firms and SMEs because although the tax scheme does not establish differences among them, except in the ceilings, the use of the programme is different among them.[6] Financial constraints are only important for SMEs[7]. Age has a positive effect for large firms and a negative effect for small firms, but it is hardly significant.

Regarding the other channels of influence on R&D, we observe different patterns by size. For large firms, the participation in technological firms is more relevant, whereas for SMEs, the use of technological consultants helps them to invest in R&D. Definitely size matters for investment in R&D since the access to a better knowledge using technological networks is more affordable for large firms than for small ones, the acquisition or benefitting from the external knowledge being absorbed inside firms and conferring the possibility to increment the efforts devoted to R&D. SMEs consider the use of technological consultants as a way of making best use of the tax incentive relative to their investment. Finally, having subsidies in the past positively influences current spending on R&D for large firms, but our suspicion that its inclusion could affect the elasticity of the user cost is not confirmed.

Although we shall comment more on long-run elasticities later on, there is a pattern emerging from these baseline results. First, long-run elasticities are always greater for SMEs than for large firms. Second, figures are very different when the legal user cost instead of the effective one is used. However, we should be cautious for at least three reasons. Individual heterogeneity is not taken into account and makes the inertia of R&D expenditures capture the confounding effects of dynamics and heterogeneity.

[6] Since the expression for the long-run elasticity presented in Section 4 is non-linear in the parameters, we have calculated its standard error using the delta method.

[7] The counterintuitive positive sign found is often encountered in the literature and it could be associated to endogeneity problems of this variable.

Second, we do not correct for the potential endogeneity of sales (or even of the user cost), which could be correlated with the mixed error term. Third, potential endogeneity of any of the types considered could also affect the results.

Table 5. OLS estimation for R&D performing firms (ADL model)

	Baseline[1]		With controls[1]		With Networks[1]		With past subsidies[1]	
LARGE FIRMS[2, 3]								
Nº observations	2426	2426	2426	2426	2228	2228	2158	2158
Ln $R\&D_{t-1}$	0.63 (30.70)	0.63 (30.75)	0.63 (30.64)	0.63 (30.69)	0.64 (29.70)	0.64 (29.73)	0.64 (29.00)	0.64 (29.05)
Ln $R\&D_{t-2}$	0.18 (8.64)	0.17 (8.44)	0.18 (8.60)	0.17 (8.41)	0.17 (7.89)	0.17 (7.70)	0.17 (7.52)	0.16 (7.35)
Ln effective user cost	-0.07 (3.10)		-0.07 (3.04)		-0.06 (2.52)		-0.07 (2.64)	
Ln effective user $cost_{t-1}$	-0.005 (0.19)		-0.00 (0.14)		-0.01 (0.25)		-0.00 (0.09)	
Ln effective user $cost_{t-2}$	-0.02 (0.62)		-0.02 (0.57)		-0.01 (0.49)		-0.01 (0.30)	
Ln legal user cost		-0.12 (5.61)		-0.12 (5.55)		-0.11 (5.03)		-0.12 (5.10)
Ln legal user $cost_{t-1}$		0.03 (1.13)		0.03 (1.16)		0.03 (1.11)		0.03 (1.15)
Ln legal user $cost_{t-2}$		-0.02 (0.68)		-0.02 (0.66)		-0.01 (0.59)		-0.01 (0.39)
Ln sales	0.31 (4.44)	0.31 (4.36)	0.31 (4.42)	0.31 (4.35)	0.41 (4.63)	0.41 (4.55)	0.41 (4.45)	0.40 (4.36)
Ln $sales_{t-1}$	-0.11 (0.98)	-0.11 (0.94)	-0.11 (0.97)	-0.11 (0.93)	-0.18 (1.38)	-0.17 (1.33)	-0.18 (1.38)	-0.18 (1.32)
Ln $sales_{t-2}$	-0.04 (0.45)	-0.04 (0.44)	-0.04 (0.46)	-0.04 (0.45)	-0.09 (0.95)	-0.09 (0.94)	-0.07 (0.72)	-0.07 (0.70)
Ln age			0.03 (1.28)	0.03 (1.17)	0.02 (0.78)	0.02 (0.65)	0.01 (0.56)	0.01 (0.44)

Financial constraints			-0.09 (1.48)	-0.09 (1.51)	-0.08 (1.33)	-0.08 (1.34)	-0.07 (1.13)	-0.07 (1.12)
Participation in technological firms					0.06 (1.23)	0.06 (1.26)	0.05 (1.10)	0.06 (1.15)
Joint Ventures					0.02 (0.42)	0.02 (0.41)	0.03 (0.60)	0.03 (0.58)
Use of technological consultant					0.02 (0.67)	0.02 (0.57)	0.01 (0.39)	0.01 (0.29)
R&D subsidies$_{t-1}$							0.05 (1.14)	0.05 (1.09)
Long-run elasticity of user cost[4]	-0.50 (2.63)	-0.55 (3.24)	-0.47 (2.47)	-0.53 (3.12)	-0.43 (2.47)	-0.50 (2.78)	-0.40 (2.11)	-0.48 (2.67)
Long-run elasticity of sales[4]	0.82 (8.20)	0.81 (8.10)	0.81 (8.10)	0.80 (8.00)	0.77 (5.92)	0.76 (5.85)	0.80 (6.15)	0.79 (6.08)

	Base line[1]		**With Controls[1]**		**With Networks[1]**		**With past subsidies[1]**	
SMALL MEDIUM FIRMS[2, 3]								
Nº observations	1280	1280	1280	1280	1221	1221	1208	1208
Ln R&D$_{t-1}$	0.67 (21.84)	0.67 (21.85)	0.67 (21.88)	0.67 (21.89)	0.69 (21.94)	0.69 (21.96)	0.68 (21.22)	0.68 (21.21)
Ln R&D$_{t-2}$	0.16 (5.01)	0.15 (4.97)	0.15 (4.90)	0.15 (4.87)	0.12 (3.74)	0.12 (3.66)	0.13 (3.88)	0.13 (3.83)
Ln effective user cost	-0.09 (2.46)		-0.09 (2.37)		-0.09 (2.46)		-0.11 (2.80)	
Ln effective user cost$_{t-1}$	0.00 (0.06)		0.00 (0.04)		0.02 (0.44)		0.02 (0.60)	
Ln effective user cost$_{t-2}$	0.01 (0.18)		0.00 (0.09)		0.00 (0.00)		-0.00 (0.04)	
Ln legal user cost		-0.13 (3.79)		-0.12 (3.69)		-0.13 (3.69)		-0.13 (3.69)
Ln legal user cost$_{t-1}$		0.02 (0.61)		0.02 (0.62)		0.04 (0.97)		0.03 (0.89)

Ln legal user $cost_{t-2}$		0.01 (0.30)		0.01 (0.24)		0.00 (0.08)		0.00 (0.07)
Ln sales	0.09 (0.90)	0.08 (0.86)	0.09 (0.91)	0.08 (0.86)	0.13 (1.30)	0.13 (1.27)	0.14 (1.38)	0.14 (1.39)
Ln $sales_{t-1}$	0.02 (0.12)	0.02 (0.13)	0.01 (0.11)	0.01 (0.12)	-0.03 (0.25)	-0.03 (0.26)	-0.03 (0.20)	-0.03 (0.23)
Ln $sales_{t-2}$	-0.00 (0.04)	0.00 (0.01)	0.00 (0.06)	0.01 (0.08)	0.03 (0.36)	0.03 (0.38)	0.01 (0.14)	0.01 (0.16)
Ln age			-0.01 (0.24)	-0.01 (0.15)	-0.01 (0.16)	-0.00 (0.09)	-0.01 (0.20)	-0.01 (0.14)
Financial constraints			0.17 (2.23)	0.16 (2.12)	0.15 (2.06)	0.15 (2.00)	0.17 (2.20)	0.16 (2.13)
Participation in technological firms					0.11 (1.08)	0.11 (1.13)	0.10 (0.95)	0.10 (1.00)
Joint Ventures					0.01 (0.09)	0.00 (0.05)	0.01 (0.08)	0.00 (0.04)
Use of technological consultant					0.08 (1.63)	0.07 (1.47)	0.07 (1.52)	0.07 (1.38)
R&D $subsidies_{t-1}$							0.03 (0.46)	0.03 (0.40)
Long-run elasticity of user cost[4]	-0.47 (1.47)	-0.53 (1.77)	-0.47 (1.52)	-0.51 (1.76)	-0.40 (1.38)	-0.45 (1.55)	-0.44 (1.52)	-0.46 (1.70)
Long-run elasticity of sales[4]	0.57 (2.19)	0.55 (2.04)	0.60 (2.40)	0.58 (2.32)	0.66 (3.14)	0.65 (3.10)	0.64 (3.05)	0.63 (2.86)

Notes.

1. Annual, industry and regional dummies are included in all specifications.
2. In columns (1), (3), (5) and (7) we use the effective user cost while in columns (2), (4), (6) and (8) we use the legal user cost.
3. Asymptotic t-statistics are in parentheses. The standard errors of the long-run elasticities have been computed using the delta method.

The second set of results, which we present in Table 6, aims to control for some of the econometric problems previously mentioned, again in an ADL specification. In the first column we only take into account unobserved heterogeneity, which seems to have very important implications for the dynamic adjustment towards the optimal R&D stock and also for the impact of our measure of output. A difference in Sargan test for exogeneity rejects the null that sales are exogenous at any significance level (χ^2 < 0.0001, p-value=1). The user cost is also likely to be endogenous notably because of the incremental R&D tax credit. Indeed, as R&D increases, the possibility of using tax credits diminishes because of ceilings, hence the user cost elasticity increases as well. A difference in Sargan test rejects the null that the user cost is exogenous at any significance level (χ^2 < 0.0001, p-value=1). While we report TSLS estimates, we have also estimated specification [6] by GMM using as instruments the second lag of the log of R&D expenditures, the first and second lags of the log of sales and the first and second lags of the user cost. The Hansen J test of overidentifying restrictions takes a value 1.61 (p-value=0.45 for a χ^2 statistic with 2 degrees of freedom).[8] So, our set of instruments seems to perform well, but we face the problem of increasing standard errors and we will try to correct for it later on.

There are significant differences between these results, where we estimate the model by IV with or without individual heterogeneity, and baseline estimates in Table 5. In the latter case we face a problem of misspecification while in the former we have correlated effects. We must note first that firm heterogeneity or managerial ability (correlated with the lag of R&D) is an important driver of innovation. Once we control for it, the effect of the lagged dependent variable is reduced significantly in fixed effects models estimated using within-groups. Of course, these estimates are affected by important biases in short panels as proved by Nickell (1981). We want to underline that in our preferred model in statistical terms (last column of table 6), where we account for both the endogeneity of sales and user cost and the presence of unobserved heterogeneity, we should get consistent estimates.[9] Previous investment remains a relevant factor to explain current investment in R&D because of partial adjustment mechanisms and R&D persistence. We should note two problems, however, that may affect our estimates. First, in dynamic random effects models, the lagged dependent variable contains the heterogeneous effect and it is thus correlated with the mixed error, even when estimating the models by IV using as instruments previous lags of the dependent variable. Second, in the TSLS specifications the strictly exogenous variables do not show much variation (except when we consider the user cost as exogenous). In fact, only the mean of the user cost and the initial condition are significant in these specifications and then the modelling of the heterogeneous effects according to equation [5] does not seem to be very satisfactory and we cannot put much confidence on the null hypothesis of no correlation between the remaining error and the explanatory variables.

Again, the legal user cost shows more influence on R&D investment than the effective user cost for both large firms and SMEs. This time the cost elasticities are higher for large firms than for SMEs when they are significant. However, the results are no longer as robust as in Table 5, as they vary with the estimation method used. Financial constraints as well as experience are not significant. The importance of different networks depends on the firm size. Results confirm that SMEs find the use of technological consultants a stimulus to invest more in R&D.

[8] Although we use the subsidies of period t-1, we have also checked for its exogeneity and could not reject the null hypothesis of exogeneity at standard significance levels.

[9] We only present in Table 6 the results obtained by instrumenting the lag of the dependent variable and the log of sales. Other sets of results instrumenting the user cost are very similar to those reported and are available upon request. We turn to estimates obtained by instrumental variables below when presenting GMM and System-GMM estimates.

Table 6. IV estimation for R&D performing firms (ADL model)

	Fixed effects[1, 2]		Random effects[1, 3]		TSLS' [4]	
LARGE FIRMS[5]						
Nº observations	2149	2149	2149	2149	1747	1747
Ln R&D$_{t-1}$	0.27 (10.6)	0.27 (10.6)	0.61 (27.8)	0.61 (27.9)	0.78 (1.81)	0.84 (1.98)
Ln R&D$_{t-2}$	-0.03 (1.04)	-0.03 (1.05)	0.16 (7.35)	0.16 (7.15)	0.07 (0.20)	0.01 (0.03)
Ln effective user cost	-0.03 (1.12)		-0.07 (2.63)		-0.04 (1.27)	
Ln effective user cost$_{t-1}$	-0.00 (0.08)		0.00 (0.14)		-0.01 (0.17)	
Ln effective user cost$_{t-2}$	0.00 (0.14)		-0.01 (0.47)		-0.01 (0.43)	
Ln legal user cost		-0.07 (3.19)		-0.12 (5.18)-		-0.12 (3.14)
Ln legal user cost$_{t-1}$		0.01 (0.52)		0.04 (1.37)		0.04 (0.12)
Ln legal user cost$_{t-2}$		-0.02 (0.83)		-0.02 (0.64)		-0.03 (0.84)
Ln sales	0.26 (2.46)	0.25 (2.30)	0.40 (4.31)	0.39 (4.22)	1.21 (0.74)	0.97 (0.57)
Ln sales$_{t-1}$	-0.05 (0.38)	-0.03 (0.26)	-0.19 (1.42)	-0.18 (1.36)	-0.98 (0.59)	-0.77 (0.45)
Ln sales$_{t-2}$	0.06 (0.51)	0.06 (0.58)	-0.04 (0.38)	-0.03 (0.35)	-0.09 (0.50)	-0.06 (0.40)
Ln age	-0.09 (1.52)	-0.08 (1.32)	0.02 (0.59)	0.01 (0.47)	-0.04 (0.41)	-0.03 (0.32)
Financial constraints	-0.13 (1.73)	-0.14 (1.81)	-0.09 (1.41)	-0.09 (1.39)	-0.06 (0.64)	-0.06 (0.63)
Participation in	0.11	0.11	0.06	0.06	0.01	0.01

technological firms	(1.62)	(1.68)	(1.23)	(1.28)	(0.11)	(0.19)
Joint Ventures	0.07 (1.11)	0.07 (1.02)	0.03 (0.66)	0.03 (0.64)	0.01 (0.22)	0.02 (0.29)
Use of technological consultant	0.02 (0.38)	0.02 (0.38)	0.02 (0.62)	0.02 (0.51)	0.00 (0.04)	0.00 (0.03)
R&D subsidies$_{t-1}$	0.02 (0.40)	0.02 (0.44)	0.06 (1.43)	0.06 (1.39)	0.03 (0.44)	0.03 (0.42)
Initial conditions					0.02 (1.16)	0.02 (0.98)
Long-run elasticity of user cost[6]	-0.03 (0.60)	-0.10 (2.00)	-0.34 (2.13)	-0.43 (2.87)	-0.43 (1.13)	-0.73 (2.15)
Long-run elasticity of sales[6]	0.35 (2.92)	0.37 (3.08)	0.77 (6.42)	0.76 (6.50)	0.97 (1.90)	0.94 (1.08)

	Fixed effects[1, 2]		**Random effects**[1, 3]		**TSLS**[, 4]	
SMALL MEDIUM FIRMS[5]						
Nº observations	1208	1208	1208	1208	898	898
Ln R&D$_{t-1}$	0.34 (9.10)	0.34 (9.18)	0.58 (18.1)	0.58 (18.1)	-0.02 (0.01)	0.02 (0.05)
Ln R&D$_{t-2}$	-0.04 (0.99)	-0.04 (1.01)	0.10 (3.05)	0.10 (2.96)	0.46 (1.33)	0.46 (1.33)
Ln effective user cost	-0.01 (0.31)		-0.08 (2.26)		-0.04 (0.70)	
Ln effective user cost$_{t-1}$	0.02 (0.56)		0.02 (0.54)		-0.06 (0.68)	
Ln effective user cost$_{t-2}$	-0.00 (0.11)		-0.01 (0.35)		-0.00 (0.05)	
Ln legal user cost		-0.03 (1.13)		-0.11 (3.21)		-0.07 (1.34)
Ln legal user cost$_{t-1}$		0.02 (0.63)		0.03 (0.76)		-0.06 (0.70)
Ln legal user cost$_{t-2}$		-0.01 (0.38)		-0.01 (0.32)		0.01 (0.10)

Ln sales	0.38 (3.23)	0.36 (3.11)	0.13 (1.27)	0.13 (1.28)	0.05 (0.01)	0.09 (0.02)
Ln $sales_{t-1}$	0.18 (1.43)	0.19 (1.46)	0.04 (0.32)	0.04 (0.31)	0.45 (0.21)	0.41 (0.17)
Ln $sales_{t-2}$	-0.06 (0.53)	-0.05 (0.47)	0.04 (0.52)	0.04 (0.53)	-0.19 (0.16)	-0.21 (0.17)
Ln age	-0.00 (0.05)	0.01 (0.16)	-0.03 (0.55)	-0.03 (0.53)	-0.11 (0.80)	-0.11 (0.81)
Financial constraints	0.09 (0.89)	0.08 (0.79)	0.16 (1.91)	0.16 (1.86)	0.13 (0.75)	0.13 (0.69)
Participation in technological firms	-0.04 (0.28)	-0.05 (0.39)	0.05 (0.48)	0.05 (0.49)	-0.02 (0.06)	-0.02 (0.03)
Joint Ventures	0.06 (0.47)	0.05 (0.39)	0.07 (0.65)	0.07 (0.62)	0.10 (0.49)	-0.09 (0.41)
Use of technological consultants	0.14 (2.04)	0.13 (1.99)	0.14 (2.57)	0.13 (2.44)	0.21 (2.18)	0.20 (1.91)
R&D $subsidies_{t-1}$	-0.08 (0.90)	-0.08 (0.94)	0.03 (0.55)	0.02 (0.27)	0.20 (0.53)	0.19 (0.46)
Initial conditions					0.12 (1.97)	0.12 (1.97)
Long-run elasticity of user cost[6]	0.01 (0.14)	-0.04 (0.57)	-0.24 (1.50)	-0.28 (1.87)	-0.18 (0.62)	-0.23 (0.82)
Long-run elasticity of sales[6]	0.71 (4.73)	0.71 (5.07)	0.65 (4.64)	0.64 (4.57)	0.58 (0.20)	0.56 (0.16)

Notes:

1. Annual dummies are included in all specifications. Sales and two lags of sales as well as all other controls included in Table 5 are also included. In addition, random effects and two stage models include industry and regional dummies.
2. Within-groups estimates instrumenting the lag of dependent variable using its second lag.
3. GLS estimates instrumenting the lag of dependent variable using its second lag.
4. Two-stage least squares modelling the effects using strictly exogenous variables and instrumenting the lag of dependent variable with its second lag.
4. Asymptotic t-statistics are in parentheses. The standard errors of the long-run elasticities have been computed using the delta method.

There are several uncontrolled problems, however, in the results reported in Table 6 that can affect the estimates, and we shall try to correct for them with additional experiments. We first deal with correlated effects and the weakness of the instrument set in this sub-section and we leave the impact of endogenous sample selection for the next one. Concerning the improvement of the efficiency of our estimates we follow Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998, 2000) and use GMM in first differences and System – GMM, which combine equations in first differences with equations in levels, using instruments in levels in the equations where we have ruled out the unobserved effects and instruments in first differences in equations where the heterogeneous terms are present. Together with the use of alternative estimation methods, another important step we make is to propose the estimation of equation [3] instead of [6]. An ECM model allows separating the short-run dynamics from the long-run relationship and provides a straightforward interpretation of the results. Our knowledge that in equations estimated in first differences with dependent variables showing persistence we face a weak instruments problem is an important reason for enriching the model with an equation in levels because it allows improving correlation among regressors and instruments. In our model the inertia affects some endogenous variables, such as the user cost, and, as a consequence, its estimate can suffer from this problem and also contaminate the other coefficients.

We report in Table 7 a selection of GMM estimates for the ECM model. The four columns of the table present two types of results, one for the effective user cost and another for the legal one. In columns 1 and 2 we present standard GMM, in column 1 using the effective user cost and in column 2 using the legal one. Columns 3 and 4 report System-GMM estimates. In all four columns we consider output and user cost as endogenous variables according to the test previously conducted and we instrument them in addition to the lagged R&D regressor. As before, we divide the table in two panels with estimates differing by firm size. For both the standard GMM and the System-GMM we use all available instruments for the lagged dependent variable. In the System-GMM case we extend the model to recover the available equation in levels, and we instrument endogenous or predetermined level variables with their first difference counterparts.[10]

We find that the user cost has a very different impact on R&D expenditures for large firms and for SMEs. In particular, according to our preferred System-GMM estimates, effective long-run user cost elasticities are more than three times as big for SMEs (-1.01) as for large firms (-0.34). The fact that user cost elasticities are higher for small firms than for large ones has also been found in other studies (Baghana and Mohnen, 2009, for Quebec, Lokshin and Mohnen, 2012 for the Netherlands, Hægeland and Moen, 2007, for Norway). When considering the legal user cost, its elasticity becomes considerably higher, double for big firms and 15 % higher for small ones. One possible reason to explain this result can be found in the propensity to use and the intensity of using the programme. Some other authors, as Corchuelo and Martínez-Ros (2008), have studied the determinants for using the tax programme. On one hand, only 45% of entitled large firms and 32% of entitled SMEs in our sample use the tax programme. Moreover, we see that a number of large and SMEs firms do not fully exploit all the possibilities of the instrument. The legislation allows firms a more intense use but for some reason they do not fully take advantage of it. As a consequence, our results for the effects of the legal user cost show

[10] The use of instruments in differences for the lag of the dependent variable is very clear because the level of the lagged dependent variable contains the heterogeneous term. Under the assumption that sales and the user cost are not correlated with the random effects these variables in levels can be included in the instrument set.

a greater potential of the tax credit programme than actually observed. The user cost elasticity is higher for SMEs with any of the two measures, but the potential for improving its effect is higher for large firms than for SMEs due to their lower intensity of the tax credit programme. Our price elasticity for large firms and effective user cost is in line with the long-run elasticity of -0.40 obtained by Mulkay and Mairesse (2013), the most comparable study to ours.

The long-run output elasticity varies both within the ECM estimates and between the ADL and ECM estimates. The sensitivity of R&D expenses to output changes is always greater in large than in small firms. The consideration of heterogeneity and endogeneity joint with a proper instrumentation of the output variable reduces the coefficient. Simultaneity induces a positive correlation for SMEs and large firms, as expected. In our preferred System-GMM estimates long-run elasticity figures are around 0.60 for large firms and 0.50 for SMEs comparable to the figure of 0.65 estimated by Mulkay and Mairesse (2013) for France.

Regarding the other determinants of R&D, we observe a complementary effect with subsidies (a result also found by Busom et al., 2014). In fact, we find that having had an R&D subsidy in the past has only an effect on large firms, revealing that a very small portion of firms that use both instruments dedicates efforts to invest in R&D. Participating in technological firms is only relevant for large firms while the use of technological consultants is only influential in SMEs. These differences make sense since large firms are more able to open new ventures and the SMEs are prone to be advised by specialists in R&D matters. Finally, the SMEs firms that have more experience, measured by age, increase the investment in R&D.

Table 7. GMM estimation for R&D performing firms (ECM model)

	GMM[1]		**SYSTEM GMM[1]**	
LARGE FIRMS[2, 3, 5]	**1**	**2**	**3**	**4**
Nº of observations	**1689**	**1698**	**1764**	**1764**
Δ Ln R&D$_{t-1}$	0.06 (2.86)	0.06 (2.94)	0.07 (2.55)	0.06 (2.40)
Δ Ln effective user cost$_t$	0.04 (1.44)		-0.06 (0.83)	
Δ Ln effective user cost$_{t-1}$	-0.05 (1.96)		0.04 (0.84)	
Δ Ln legal user cost$_t$		-0.03 (1.38)		-0.19 (3.22)
Δ Ln legal user cost$_{t-1}$		0.01 (0.45)		0.07 (1.81)
Δ Ln sales$_t$	0.29 (2.29)	0.26 (2.11)	0.78 (4.49)	0.78 (4.61)
Δ Ln sales$_{t-1}$	-0.05 (0.55)	-0.05 (0.60)	0.28 (1.83)	0.29 (1.90)
Δ Ln age	0.36 (3.89)	0.34 (3.54)	-0.03 (0.10)	-0.08 (0.27)
Δ Financial constraints	0.50 (6.76)	0.48 (6.50)	0.11 (0.46)	0.04 (0.17)

Δ Participation in technological firms	0.57 (10.4)	0.58 (10.7)	0.63 (2.70)	0.63 (2.76)
Δ Joint Ventures	0.51 (10.5)	0.52 (10.7)	-0.27 (1.01)	-0.23 (0.90)
Δ Use of technological assistant	0.44 (11.3)	0.44 (11.2)	0.08 (0.44)	0.14 (0.85)
Δ R&D subsidies$_{t-1}$	0.53 (15.1)	0.52 (14.8)	0.33 (2.14)	0.29 (1.83)
ECM	-0.95 (25.7)	-0.96 (25.5)	-0.33 (12.6)	-0.36 (13.8)
Ln effective user cost$_{t-1}$	-0.82 (12.3)		-0.45 (3.13)	
Ln legal user cost$_{t-1}$		-0.98 (16.3)		-0.61 (5.11)
Ln sales $_{t-1}$	-0.60 (3.74)	-0.64 (4.00)	-0.13 (6.11)	-0.15 (6.84)
Long-run user cost elasticity[6]	0.14 (2.33)	-0.02 (0.40)	-0.34 (0.97)	-0.70 (2.80)
Long-run sales elasticity[6]	0.37 (2.85)	0.33 (2.75)	0.62 (12.4)	0.59 (11.8)
Sargan test (overidentification)[4]	66.56 (60) 0.261	69.45 (60) 0.189	139.5 (128) 0.231	141.1 (128) 0.202
Stock-Wright test (weak instruments)[4]	42.12 (60) 0.039	44.44 (60) 0.066	141.5 (128) 0.804	140.1 (128) 0.782
AR (1)	-6.27 0.000	-5.72 0.000	-7.15 0.000	-6.98 0.000
AR (2)	-0.50 0.612	-0.56 0.577	0.47 0.641	0.37 0.712

	GMM[1]		**SYSTEM GMM[1]**	
SMALL – MEDIUM FIRMS[2, 3, 5]	**1**	**2**	**3**	**4**
Nº of observations	**881**	**888**	**900**	**900**
Δ Ln R&D$_{t-1}$	0.07 (3.69)	0.06 (3.06)	0.00 (0.09)	0.01 (0.13)
Δ Ln effective user cost$_t$	-0.07 (2.60)		-0.11 (1.24)	
Δ Ln effective user cost$_{t-1}$	-0.04 (1.35)		0.10 (1.53)	
Δ Ln legal user cost$_t$		-0.07 (2.30)		-0.12 (1.32)
Δ Ln legal user cost$_{t-1}$		-0.01 (0.21)		0.12 (1.82)
Δ Ln sales$_t$	0.21 (2.60)	0.24 (2.87)	0.11 (0.53)	0.20 (0.70)
Δ Ln sales$_{t-1}$	0.11 (1.34)	0.11 (1.48)	0.11 (0.62)	0.11 (0.62)
Δ Ln age	0.41 (6.07)	0.41 (6.29)	1.15 (2.95)	1.12 (2.73)
Δ Financial constraints	0.53	0.52	0.23	0.34

	(11.6)	(11.4)	(0.99)	(1.27)
Δ Participation in technological firms	0.44 (5.72)	0.44 (5.97)	0.30 (1.01)	0.47 (1.39)
Δ Joint Ventures	0.52 (6.58)	0.49 (6.28)	0.31 (1.09)	0.30 (0.97)
Δ Use of technological assistant	0.59 (12.3)	0.57 (13.2)	0.37 (2.40)	0.34 (2.17)
Δ R&D subsidies$_{t-1}$	0.49 (14.0)	0.49 (14.1)	0.11 (0.72)	0.13 (0.78)
ECM	-0.89 (22.9)	-0.87 (23.1)	-0.23 (7.07)	-0.24 (6.64)
Ln effective user cost$_{t-1}$	-0.94 (13.7)		-0.46 (2.68)	
Ln legal user cost$_{t-1}$		-0.92 (14.4)		-0.52 (2.90)
Ln sales $_{t-1}$	-0.82 (4.81)	-0.77 (4.59)	-0.11 (2.97)	-0.13 (3.19)
Long-run user cost elasticity	-0.06 (0.86)	-0.05 (0.83)	-1.01 (1.80)	-1.17 (2.29)
Long-run sales elasticity	0.08 (1.33)	0.11 (1.83)	0.50 (3.85)	0.47 (3.92)
Sargan test (overidentification)	58.89 (60) 0.516	60.94 (60) 0.442	122.05 (128) 0.631	136 41 (128) 0.289
Stock-Wright test (weak instruments)	56.47 (60) 0.395	57.82 (60) 0,444	114.5 (128) 0.202	114.6 (128) 0.204
AR (1)	-3.46 0.000	-3.34 0.000	-4.81 0.00	-4.72 0.000
AR (2)	-0.01 0.996	-0.25 0.799	0.19 0.852	0.18 0.859

Notes.

1. Annual dummies are included in all specifications.
2. In columns (1) and (3) we use the effective user cost while in columns (2) and (4) we use the legal user cost.
3. In columns (1) and (2) we instrument the lagged dependent variable using all available lags beginning at t-2 while for sales and the user the instruments we only use two lags; number of instruments: 84. In columns (3) and (4) we instrument the lagged dependent variable using all available lags from t-2 to the beginning of the sample while log sales and the user cost are instrumented using all available instruments from t-1 to the initial period. Since we add the equation in levels to the estimation, we use for it all available instruments in first differences. We also include non-time varying variables as regional and industry dummies as well as the initial condition as additional instruments; number of instruments: 151.
4. In parenthesis below the value of the tests we report degrees of freedom and level of significance.
5. Asymptotic t-statistics are in parentheses. The standard errors of the long-run elasticities have been computed using the delta method.

5.3. Robustness checks

We have dealt with correlated effects and the weakness of the instrument set in the results presented in Table 7 and we have arrived to a preferred specification estimated by System-GMM. In order to provide robustness and validate these results, we have to check carefully the maintained assumptions. Concerning the statistical properties of the specifications, residuals in the ECM show first-order serial correlation but they do not show second-order one in any specification. This is the expected pattern given the structure of the model in equation [3] since we have estimated the model in first differences. Then, it is also expected that the Sargan tests validate the adequacy of the instrument set in each specification as it happens. All diagnostics together imply that estimates are adequate except for the problem of weak instruments. We calculate the Stock-Wright test in order to detect whether we are in this situation (see Stock and Wright, 2000). These last diagnostics do detect the usual problem of weak instruments in the GMM specification for the large firms, but they fail to reject the null for SMEs. These tests validate the System-GMM results and they confirm that enriching the model with the equation in levels helps to identify the effects of some variables.

In order to be sure about our preferred specification, we follow Shea (1997) to test the relevance of our set of instruments for each instrumented variable using the Shea partial R-squared. These statistics are high for the lagged dependent variable (between a minimum of 0.13 and a maximum of 0.16 with all the corresponding F-tests statistically different from zero at any significance level). However, they are low for sales and very low for any measure of the user cost (the maximum value of the partial R-squared for the user cost is always below 0.01). As previously mentioned, first differenced variables are difficult to instrument when they show a high level of persistence. As expected, we have a problem of weak instruments in standard GMM specifications and it seems we can solve it when adding the equation in levels and enriching the instrument set. All diagnostics together provide robustness to our System-GMM estimates.

In order to definitively validate our preferred results we focus on the two potential selection problems. If firms select into performing R&D non-randomly but their decisions depend on variables inside our specification, the causal effect of the user cost (and the impact of other variables) could be misleading. In these circumstances, we have not consistently estimated the ATT. In this context, Semykina and Wooldridge (2010) propose some parametric and semiparametric TSLS and GMM methods. We follow this approach and we first estimate T probits one for each year;[11] then we compute the selection term (inverse Mills ratio) and we include it in the model, and estimate it by TSLS and also by GMM. In order to relax some assumption as the constancy of the selection term and heteroskedasticity of the errors we construct interactions among the selection term and time dummies and we include these variables in the specification. When we include just one selection term, a t-test indicates that it is slightly significant (t=1.82, p-value=0.07) while the set of selection terms are not jointly significant using a Wald test (F(6, 149)=0.99, p-value=0.43). In any case, although we do not present these results here to avoid repetition, since the set of selection terms are jointly non-significant, they are very similar to the ones presented in Table 7 with larger standard errors, in particular the long-run elasticities remain close to those presented in Table 7.

A second potential endogenous selection problem occurs when, simultaneously to the decision on the volume of R&D expenses, firms select themselves into using the tax programme. In order to test it we have made another exercise. We have estimated the T_i discrete decision models for each firm in order to adjust the determinants to use the tax credit programme (see Corchuelo and Martínez-Ros, 2008). We are not interested in adjusting a structural model but in using the coefficients in order to compute the selection term for each observation. So, each specification contains all exogenous variables as well as non-linear terms of these variables and interactions among them. Once we compute the selection term, we include it in each of the ADL (equations [2] or [6]) or ECM (equation [3]) models. We have to care about the dynamic nature of the model. Since these specifications are estimated on the subsample of firms using the tax programme, we need at least three consecutive positive observations in order to be able to use them in the final subsample (see Jiménez et al., 2014). Although large firms using the tax programme represent around 45% of the sample used to estimate the models presented in Tables 5 to 7 and SMEs are around 32%, the final sample size is less than half these figures. As a result, we should view these results with caution.

The results, which are not presented but are available upon request, can be summarised as follows. First, the selection term is not significantly different from zero in any specification that uses the effective user cost. This could mean that the marginal impact of the effective user cost at the intensive margin conditional on participation in the tax programme is very small. Second, when the selection term becomes significant in specifications with the legal user cost, the long-run elasticity follows the same

[11] We can begin with a balanced panel but the structure of our information set is unbalanced not only due to selection or attrition but also due to sampling reasons. We make use of two different samples. In the first exercise we select out those firms that do not spend on R&D in any of the periods observed, even in the pre-sample information periods 1997-2000. In a second exercise we include those firms with zero expenses in some period, i.e. *potential innovators*.

pattern as the one estimated on the whole sample of firms spending on R&D with a higher magnitude than the one presented in Table 7. It seems that the marginal effect of the legal user cost could have more potential at the intensive margin conditional on participation in the tax programme than actually observed.

6. Conclusions

Our paper explores in depth the use of the Spanish R&D Tax Credit programme for a representative sample of manufacturing firms. In particular, the analysis has focused on the effectiveness of R&D tax incentives in affecting the evolution of the volume of internal R&D. We have used a structural approach deriving a dynamic demand for R&D equation depending on the user cost of R&D inclusive of R&D tax credits, and we propose to include additional variables in order to analyse the capacity of a public policy to incentivise private action through different channels, such as the use of several technological networks. We have departed from previous studies in several directions. First, we have used firms which, in addition to spending on R&D, use the tax incentive instrument, and we have computed and compared the results with two measures of the user cost, namely the effective user cost with actual tax deductions and the legal user cost with tax deductions based on eligibility and legislation. Finally, we have estimated ADL and ECM models. The latter allow us to separate the short-run dynamics from the long-run relationship and they provide a straightforward interpretation of the results.

In order to test for the effectiveness of tax programmes we have used data provided by the SEPI Foundation on behalf of the Spanish Ministry of Industry, Tourism and Trade. This is a survey containing information on manufacturing firms with more than 10 employees. It provides some information about the knowledge and use of tax incentives for R&D from 2001 onwards and allows us to distinguish between firms that are merely aware of these incentives and firms that actually use them in addition to revealing the amount of those funds. Although the information on the variables related to the tax incentives programme are available in the survey from 2001 onwards, we have built an unbalanced panel from 1998 to 2008 in order to be able to use initial conditions and instruments for solving potential endogeneity problems.

Our analysis contains two important results. First, the impact of the legal user cost on R&D expenses is higher than the impact of the effective user cost as measured by the long-run elasticities. This finding has a policy implication since many firms entitled to receiving R&D tax credits do not use or do not even know the tax incentive programme. The effect at the extensive margin is larger for SMEs because they use the tax programme less than large firms do (see Corchuelo and Martínez-Ros, 2008). It is the responsibility of public authorities to diffuse this information and to convince firms to use all the potential of the R&D tax credits. Doing so could help firms to increase R&D at a time when the economy needs to be able to generate employment and avoid additional welfare reductions.

Second, the long-run elasticity of R&D to its user cost is higher in SMEs than in large firms. Moreover, it is twice as high when the legal instead of the effective user cost is used for large firms and 15% higher for SMEs. Hence the R&D tax incentive programme is particularly well suited for SMEs and although neither large firms nor SMEs use all the potential of such instrument, SMEs are closed to it while large firms take it as a way to reduce the tax liability. At the same time the structure of the Spanish economy is such that more than 90% of firms are SMEs or even micro firms. However, the tax incentive programme delivers annually less than 5% of funds to them (see Labeaga and Martínez-Ros, 2012). R&D tax incentives do not seem to go to the most effective users of it. It is quite likely that a good deal of it flows into the hands of firms that do not necessarily need it to conduct R&D on their own. In these circumstances, there is place to redesign the system. One way would be to differentiate even more tax deductions by the size of the firm. Another way, like other European countries as France, the Netherlands or Denmark have done it, could be to introduce some specific programme for innovative small firms.

References

Audretsch, D. and Feldman M. P. (1996), "R&D Spillovers and the Geography of Innovation and Production" *American Economic Review* 86, 630-640.

Arqué-Castells, P. and P. Mohnen (2012), "Sunk costs, extensive R&D subsidies and permanent inducement effects", UNU-Merit Working Paper #2012-029.

Arellano, M. and S. Bond (1991), "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations", *Review of Economic Studies*, 58, 277-297.

Arellano, M. and O. Bover (1995), "Another look at the instrumental variable estimation of error-components models", *Journal of Econometrics* 68, 29-51.

Arrow, K. (1962), "Economic Welfare and the Allocation of Resources for Inventions" in R. Nelson (ed.), *The Rate and Direction of Inventive Activity*. Princeton University Press.

Baghana, R. and Mohnen, P. (2009), "Effectiveness of R&D tax incentives in small and large enterprises in Quebec", *Small Business Economics* 33, 91-107.

Bérubé, C. and P. Mohnen (2009), "Are firms that received R&D subsidies more innovative?", *Canadian Journal of Economics*, 42, 206-225.

Berger, P. G. (1993), "Explicit and Implicit Tax effects of the R&D Tax credit", *Journal of Accounting Research* 31, 131-171.

Blanes, J.V. and I. Busom (2004), "Who participates in R&D subsidy programmes? The case of Spanish manufacturing firms", *Research Policy* 33, 1459-1476.

Bloom, N., R. Griffith, and J. Van Reenen (2002), "Do R&D tax credits work? Evidence from a panel of countries 1979–1997", *Journal of Public Economics* 85, 1–31

Blundell, R. and S. Bond (1998), "Initial conditions and moment restrictions in dynamic panel data models", *Journal of Econometrics* 87, 115-143.

Blundell, S. and S. Bond (2000), "GMM estimation with persistent panel data: an application to production functions", *Econometric Reviews* 19, 321-340.

Busom, I. (2000), "An empirical evaluation of the effects of R&D subsidies", *Economics of Innovation an New Technology* 9, 111-148.

Busom, I., B. Corchuelo, and E. Martinez Ros (2014), "Tax incentives or subsidies for business R&D?", *Small Business Economics*, forthcoming.

Cappelen, A., A. Raknerud and M. Rybalka (2008) “The effects of R&D tax credits on patenting and innovations”, Discussion Papers 565, Statistics Norway.

Chamberlain, G. (1984) “Panel Data” in Handbook of Econometrics, Volume 2, eds. Z. Griliches and M. Intriligator, Amsterdam: North-Holland, 1247–1318.

Clausen, T. Pohjola, M., K. Sapprasert and B. Verspagen (2012). Innovation strategies as a source of persistent innovation. *Industrial and Corporate Change* 21, 553-585.

Cohen, W. A. Goto, A. Nagata, R. R. Nelson and J.P. Walsh (2002), “R&D Spillovers, patents ans the incentives to innovate in Japan and the United States”, *Research Policy* 31, 1349-1367.

Corchuelo, M.B. (2006): “Incentivos fiscales en I+D y decisiones de innovación”, *Revista de Economía Aplicada*, 14, 5-34.

Corchuelo, M.B. and E. Martínez-Ros (2008), “Aplicación de los incentivos fiscales a la inversión en I+D en las empresas españolas”, *Hacienda Pública Española*, 187, 9-39.

Corchuelo, B. and E. Martínez Ros (2010), “Who benefits from R&D policy?", *Cuadernos Económicos de Dirección de Empresas* 45, 145-170.

Czarnitzki, D. and A.A. Toole (2007), “Business R&D and the interplay of R&D subsidies and product market uncertainty”, *Review of Industrial Organization*, 31, 169-181.

Czarnitzki, D., P. Hanel and J.M. Rosa (2011): “Evaluating the impact of R&D tax credit on innovation: A microeconometric study on Canadian firms”, *Research Policy*, 40, 217-229.

Dominguez, and López-Laborda, J. (1999): “Efectos de la reforma del IRPF sobre las decisions de financiación e inversion societaria y sobre la elección de la forma de empresas”. Papeles de trabajo, 6. Madrid IEF.

Duguet, E. (2008), “Are R&D subsidies a substitute or a complement to privately funded R&D?”, *Revue d’economie politique* 114, 245-274.

Duguet, E. (2012), “The effect of the incremental R&D tax credit on the private funding of R&D: An econometric evaluation on French firm level data”, mimeo.

European Commission (2014), “A study on R&D tax incentives”, study conducted by a consortium under the leadership of CPB Netherlands.

Gelabert, L., A. Fosfuri y J.A. Tribó (2009), “Does the effect of public support depend on the degree of appropriability?”, *The Journal of Industrial Economics* 57, 736-767.

Griliches, Z. (1992). “The search for R&D spillovers” *Scandinavian Journal of Economics*, 94, 529-547.

González, X, J. Jaumandreu and X. Pazó (2005), “Barriers to innovation and subsidy effectiveness”, *Rand Journal of Economics* 36, 930-950.

Hægeland, T. and J. Moen (2007), “Input additionality in the Norwegian R&D tax credit scheme”, report 2007/47, Statistics Norway.

Hall, B.H. and J. Van Reenen (2000), “How effective are fiscal incentives for R&D? A review of the evidence”, *Research Policy* 29, 449-469.

Harris, R. Q. Cher Li and M. Trainor (2009), “Is a higher rate of R&D tax credit a panacea for low levels of R&D in disadvantaged regions?”, *Research Policy* 38, 192-205.

Heijs, J., M. Buesa, L. Herrera and P. Valadez (2006), “Evaluación de los incentivos fiscales a la I+D+i en España basado en el propensity score matching”, DI n. 3, Instituto de Estudios Fiscales.

Jiménez-Martín, S., JM. Labeaga and M.E. Rochina-Barrachina (2014), “Some estimators for dynamic panel data sample selection models”, manuscript.

Labeaga, J.M. and E. Martínez Ros (2012), "Influencia de las políticas públicas de incentivos a la I+D+i sobre la propensión innovadora y el comportamiento de la empresa española". *Papeles de Economía Española*, 132, 108-128.

Lhuillery, S., M. Marino and P. Parrotta (2013), Evaluation de l'impact des aides directes et indirectes à la R&D en France, Rapport pour le Ministère de l'enseignement supérieur et de la recherche, mimeo.

Lokshin, B. and P. Mohnen (2012), "How effective are level-based R&D tax credits? Evidence from the Netherlands", *Applied Economics* 44, 1527-1538.

Mansfield, E. (1986), "The R&D tax credit and other technology policy issues", *American Economic Review*, 76, 190-194.

Martínez-Ros, E. and JM. Labeaga (2009), "Product and Process innovation: persistence and complementarities". *European Management Review* 6, 64-75.

Marra, M.A. (2004), "Incentivos fiscales, inversión en actividades de I+D y estructura de costes. Un análisis por tamaño para una muestra representativa de empresas manufactureras españolas 1991-1999", *Hacienda Pública Española/ Revista de Economía Pública* 170, 9-35.

Marra, M.A. (2008), "Efecto de los incentivos fiscales y subvenciones públicas a la inversión en I+D+i de las empresas manufactureras españolas", *Hacienda Pública Española/Revista de Economía Pública* 184, 35-66.

Mairesse, J. and B. Mulkay (2004), "Une evaluation du crédit d'impôt recherché en France, 1980-1997", *Revue d'économie politique* 114, 747-778.

Mairesse, J. and P. Mohnen (2005), "The Importance of R&D for Innovation: A Reassessment Using French Survey Data" *The Journal of Technology Transfer* 30, 183-197.

Mulkay, B. and J. Mairesse (2013), "The R&D tax credit in France: Assessment and ex-ante evaluation of the 2008 reform", NBER working paper 19073.

Mohnen, P and B. Lokshin (2010), "What does it take for an R&D tax incentive policy to be effective?", in *Reforming Rules and Regulations: Laws, Institutions and Implementation*, Vivek Ghosal (ed.), MIT Press, 33-58.

Mundlak, Y. (1978), "On the pooling of time series and cross section data", *Econometrica*, 46, 69-85.

Nickell, S (1980), "Biases in dynamic models with fixed effects", *Econometrica*, 56, 1371-1395.

OCDE (2012), Main Science and Technology Indicators Database, 2012(1).

Parisi, M. and A. Sembenelli (2003), "Is private R & D spending sensitive to its price? Empirical evidence on panel data for Italy", *Empirica*, 30(4), 357-377.

Romero, D. y Ruiz-Huerta, J. (2001), "Crédito fiscal, costes financieros e inversión empresarial: evidencia para España con un panel de microdatos tributarios", Hacienda Pública Española/ Revista de Economía Pública, 158: 153-189.

Romero, D. and Sanz, J.F. (2007), "Eficacia de los incentivos fiscales a la inversión en I+D en España en la década de los noventa", *Hacienda Pública Española. Revista de Economía Aplicada*, 183, 9-32.

Semykina, A. and J. Wooldridge (2010), "Estimating panel data models in the presence of endogeneity and selection", *Journal of Econometrics*, 157, 375-280.

Semykina, A. and J. Wooldridge (2013), "Estimation of dynamic panel data with sample selection", *Journal of Applied Econometrics*, 28, 47-61.

Shea, J. (1997), "Instrument relevance in multivariate linear models: A simple measure", *Review of Economics and Statistics*, 79, 348-352.

Stock, J.H. and J.H. Wright (2000), "GMM with weak identification", *Econometrica*, 68, 1055-1096.

Warda, J. (2001), “Measuring the value of R&D tax treatment in OECD countries”, *STI Review* 27, 185-211.

Warda, J. (2002), “A 2001-2002 update of R&D tax treatment in OECD countries”, report for OECD Directorate for Science, Technology and Industry.

Appendix I. Construction of the user cost of capital

We measure the user cost of R&D following (King and Fullerton, 1984):

$$p_{jt} = \sum_{i=1}^{3} \omega_i \left[\frac{(1 - uz_{ijt} - h_{jt})}{(1 - u_t)} (r_{jt} + \delta_{it}) \right] = \sum_{i=1}^{3} \omega_i \left[b\_index_{ijt} (r_{jt} + \delta_{it}) \right]$$

where u is the statutory corporate tax rate, r is the opportunity cost of funds, δ is the R&D depreciation rate, z the present value of tax depreciation allowed, uz the present value of tax savings due to amortisation and h the tax credit. We consider that uz_{ijt} takes different values depending on the tax depreciation rate, in particular it equals 1 for labour and other current costs. The term ω_i represents the weight attached to different components of R&D expenditures (Bloom et al, 2002): current expenditures (90%), R&D capital expenditures (assets except buildings) (6.4%) and equipment and buildings related to R&D (3.6%).

We calculate the user cost taking into account the following assumptions:

The R&D depreciation rate, δ

We consider three different rates according to the different expenditures on R&D: 30% for current expenditures, 12.64% for machinery and equipment expenditures and 3.61% for investments in buildings.[12]

The statutory corporate rate, *u*

We split this rate depending on the firm size as follows: for large firms 35% from 2001-2006, 32.5% in 2007 and 30% in 2008; for SME 30% from 2001-2006, 25% in 2007 and 2008.

The weighted opportunity cost of funds, r_{jt}

We assume that firms get their financial funds in a specific proportion from internal and external sources.[13] Denoting by *b* debt, *(1-b)* the retained earnings, d_d the cost of debt, and d_r the cost of retained earnings, we define the total cost of funds as, $r = bd_d + (1-b)d_r$, which represents the returns to the financial owners.

[12] The economic depreciation rate of R&D varies across studies with figures ranging from 10% al 30% without differentiating among different assets. Since we do not have specific estimates of these rates for the Spanish economy, we borrow the figures taken from recent similar studies by Parisi and Sembenelli (2003) or Bloom et al. (2002).

[13] Parisi and Sembenelli (2003) and Mairesse and Mulkay (2004) focus on financing costs with the aim of differentiating in an individual way the cost of R&D capital. They use three financing sources (debt, shares and undistributed profits), and they also take into account size and location of the firm. In Spain, Marra (2003) also considers interdependence between sources of financing and tax structure, but she assumes that 100% of R&D investment is financed using debt. She does not consider differences according to size or any other firm characteristic.

If we introduce taxes, the effective cost of funds is the following:

$$r_{jt} = bd_{djt} + (1-b)d_{rjt} = b \cdot i_{jt} \cdot (1-u) + (1-b) \cdot i_{jt} \cdot \frac{(1-t_m)}{(1-t_p)}$$

where the term $d_{djt} = i_{jt} \cdot (1-u)$ is the effective cost of debt (deduction in the corporate rate); $d_{rjt} = i_{jt} \cdot \frac{(1-t_m)}{(1-t_p)}$ is the effective cost of retained earnings; i_{jt} is the nominal cost of debt declared by firm j at moment t (it includes also the risk premium); t_m is the marginal rate according to the Income Tax for an intermediate level (we assume 36% following Domínguez and López Laborda, (1999)), and t_p is the rate of capital gains (in Romero and Ruiz-Huerta (2001) it is 10%).

The tax credit, *h*

In our data set it is possible to distinguish between ex ante claimable tax credits according to legislation and ex post actual claimed tax credits. Some firms may decide not to apply for tax credits and some firms may not receive immediately all the tax credits they deserve because of administrative delays. We compute the claimable tax credit taking into account that decision when firms have R&D spending. For firms with R&D deductions, we calculate the effective or actually claimed R&D tax credit as the ratio in each year and for each firm of the sum of all claimed R&D deductions and the R&D expenditure. For firms that do not claim any R&D tax credit we calculate the legal or claimable R&D tax credit as the ratio of the sum of all claimable R&D tax credits according to legislation and the actual R&D expenditure in each year and for each firm.

We call *base* the part of the deduction applicable according to the R&D spending in time t. This *base* includes labour costs, material, external services and amortisation of goods related to R&D activities, excluding investment in buildings (3.6% from total R&D spending) and 65% of subsidies perceived.

The incremental part is the difference between the base and the average R&D expenditure in the two preceding years. We apply different rates of tax credit depending on whether the incremental part is greater than 0 (30% on the average R&D expenditure and 50% on the increment) or less than 0 (30% on the base)[14].

Additionally, we take into account the evolution of the law regarding labour costs and investments related to R&D activities. Hence, following the Law 55/99 we apply the deductions of 10% for the years 2001 and 2002 and following the Law 62/03, a deduction of 20% for 2003 to 2008.

Following Warda (2001), we consider that 90% of R&D costs correspond to current R&D expenditures (60% are personnel expenditure) and for the remaining 10%, 6.4% correspond to equipment and 3.6% to buildings (Bloom et al., 2002). We also take into account that our tax design has some specificity like the carry-forward deductions and several modifications in the legislation in the period considered.

[14] For a more detailed explanation of this calculation see (Corchuelo, 2006).

The UNU-MERIT WORKING Paper Series

2014-01 *The medium-term effect of R&D on firm growth* by Marco Capasso, Tania Treibich and Bart Verspagen

2014-02 *Diverse and uneven pathways towards transition to low carbon development: The case of diffusion of solar PV technology in China*Michiko Iizuka

2014-03 *User innovators and their influence on innovation activities of firms in Finland* by JariKuusisto, MerviNiemi and Fred Gault

2014-04 *Migration, remittances and household welfare in Ethiopia* by Lisa Andersson

2014-05 *Path-breaking directions of nanotechnology-based chemotherapy and molecular cancer therapy* by Mario Coccia and Lili Wang

2014-06 *Poor trends - The pace of poverty reduction after the Millennium Development Agenda*Richard Bluhm, Denis de Crombrugghe, Adam Szirmai

2014-07 *Firms' adoption of international standards: Evidence from the Ethiopian floriculture sector* by MuluGebreeyesu

2014-08 *School choice, segregation, and forced school closure*by Cheng Boon Ong andKristof De Witte

2014-09 *Gender difference in support for democracy in Sub-Saharan Africa: Do social institutions matter?*by MatyKonte

2014-10 *Why are women less democratic than men? Evidence from Sub-Saharan African countries* by Cecilia García-Peñalosa and MatyKonte

2014-11 *Tipping points? Ethnic composition change in Dutch big city neighbourhoods* by Cheng Boon Ong

2014-12 *Technology life cycle and specialization patterns of latecomer countries. The case of the semiconductor industry* by Giorgio Triulzi

2014-13 *Patents as quality signals? The implications for financing constraints on R&D* by Dirk Czarnitzki, Bronwyn H. Hall and Hanna Hottenrott

2014-14 *Assessment of effectiveness of Chinese aid in competence building and financing development in Sudan* by SamiaSatti Osman Mohamed Nour

2014-15 *Education, training and skill development policies in Arab Gulf countries: Macro-micro overview* by SamiaSatti Osman Mohamed Nour

2014-16 *Structure of labour market and unemployment in Sudan* by SamiaSatti Osman Mohamed Nour

2014-17 *Overview of knowledge transfer in MENA countries - The case of Egypt* by SamiaSatti Osman Mohamed Nour

2014-18 *The impact of ICT in public and private universities in Sudan*by SamiaSatti Osman Mohamed Nour

2014-19 *End-user collaboration for process innovation in services: The role of internal resources* by Mona Ashok, Rajneesh Narula and Andrea Martinez-Noya

2014-20 *Public investment and regional politics: The case of Turkey* by Mehmet Guney Celbis, Denis de Crombrugghe and Joan Muysken

2014-21 *Infrastructure and the international export performance of Turkish regions* by Mehmet Guney Celbis, Peter Nijkamp and Jacques Poot

2014-22 *Discovering and explaining work-family strategies of parents in Luxembourg* by Nevena Zhelyazkova

2014-23 *Parental leave take up and return to work of mothers in Luxembourg: An application of the model of nested dichotomies* by Nevena Zhelyazkova

2014-24 *Millennium Development Goals: Tool or token of global social governance?* by Mueid Al Raee, Elvis Amoateng, Elvis Korku Avenyo, Youssef Beshay, Mira Bierbaum, Charlotte Keijser and Rashmi Sinha

2014-25 *One Europe or several? Causes and consequences of the European stagnation* by Jan Fagerberg and Bart Verspagen

2014-26 *The harmony of programs package: Quasi-experimental evidence on deworming and canteen interventions in rural Senegal* by Théophile Azomahou, Fatoumata Diallo and Wladimir Raymond

2014-27 *Country Terms of Trade 1960-2012: Trends, unit roots, over-differencing, endogeneity, time dummies, and heterogeneity* by Thomas Ziesemer

2014-28 *The structure and comparative advantages of China's scientific research - Quantitative and qualitative perspectives* by Lili Wang

2014-29 *Transition to knowledge-based economy in Saudi Arabia* by Samia Satti Osman Mohamed Nour

2014-30 *Challenges and opportunities for transition to knowledge-based economy in Arab Gulf countries* by Samia Satti Osman Mohamed Nour

2014-31 *Migration of international students and mobilizing skills in the MENA Region* by Samia Satti Osman Mohamed Nour

2014-32 *Beyond product innovation; improving innovation policy support for SMEs in traditional industries* by René Wintjes, David Douglas, Jon Fairburn, Hugo Hollanders and Geoffrey Pugh

2014-33 *The impact of innovation support programmes on SME innovation in traditional manufacturing industries: an evaluation for seven EU regions* by Dragana Radicic, Geoffrey Pugh, Hugo Hollanders and René Wintjes

2014-34 *Beliefs dynamics in communication networks* by Théophile T. Azomahou and Daniel C. Opolot

2014-35 *Stability and strategic diffusion in networks* by Théophile T. Azomahou and Daniel C. Opolot

2014-36 *Epsilon-stability and the speed of learning in network games* by Théophile T. Azomahou and Daniel C. Opolot

2014-37 *Afghan unaccompanied minors in the Netherlands: Far away from home and protected?* by Carla Buil and Melissa Siegel

2014-38 *Multinational production and trade in an endogenous growth model with heterogeneous firms* by Hibret B. Maemir and Thomas Ziesemer

2014-39 *The political economy of research and innovation in organic photovoltaics (OPV) in different world regions* by Serdar Türkeli and René Kemp

2014-40 *Towards the societal system of innovation: The case of metropolitan areas in Europe* by Serdar Türkeli and René Wintjes

2014-41 *To return permanently or to return temporarily? Explaining migrants'* intentions by Özge Bilgili and Melissa Siegel

2014-42 *Catching up and lagging behind in a balance-of-payments-constrained dual economy* by Alejandro Lavopa

2014-43 *An introduction to the economics of rare earths* by Eva Bartekova

2014-44 *The unequal effect of India's industrial liberalization on firms' decision to innovate: Do business conditions matter?* By Maria Bas and Caroline Paunov

2014-45 *Insurgents in motion: Counterinsurgency and insurgency relocation in* Iraq by Pui-hang Wong

2014-46 *Successive leadership changes in the regional jet industry* by Daniel Vertesy
2014-47 *Demand, credit and macroeconomic dynamics: A microsimulation model* by Huub Meijers, Önder Nomaler and Bart Verspagen
2014-48 *Accessibility analysis as an urban planning tool: Gas station location* by D.A. Escobar , C. Cadena-Gaitán, F.J. Garcia
2014-49 *China's economic embrace of Africa - An international comparative perspective* by Tobias Broich and Adam Szirmai
2014-50 *Mapping regional social enterprise ecosystems in India: Framework and indicators* by Lina Sonne
2014-51 *Does shelter assistance reduce poverty in Afghanistan?* By Craig Loschmann, Christopher R. Parsons and Melissa Siegel
2014-52 *How important is innovation? A Bayesian factor-augmented productivity model on panel data* by Georges Bresson, Jean-Michel Etienne and Pierre Mohnen
2014-53 *Does too much work hamper innovation? Evidence for diminishing returns of work hours for patent grants* by Mehmet Güney Celbi¸ Serdar Türkeli
2014-54 *Globalization, the rise of biotechnology and catching up in agricultural innovation: The case of Bt technology in India* Michiko Iizuka and Ajay Thutupalli
2014-55 *Where are innovation indicators, and their applications, going?* by Fred Gault
2014-56 *Productivity in services in Latin America and the Caribbean* by Elena Arias-Ortiz, Gustavo Crespi, Alejandro Rasteletti and Fernando Vargas
2014-57 *Optimal public investment, growth, and consumption: Fresh evidence from African countries* by Augustin Kwasi Fosu, Yoseph Yilma Getachew and Thomas H.W. Ziesemer
2014-58 *International R&D alliances by firms: Origins and development* by Rajneesh Narula and Andrea Martínez-Noya
2014-59 *Appropriability mechanisms, innovation and productivity: Evidence from the UK* by Bronwyn H. Hall and Vania Sena
2014-60 *The size of patent categories: USPTO 1976-2006* by François Lafond
2014-61 *Asset recombination in international partnerships as a source of improved innovation capabilities in China* by Simon C. Collinson and Rajneesh Narula
2014-62 *The viability of sustained growth by India's MNEs: India's dual economy and constraints from location assets* by Rajneesh Narula
2014-63 *The effect of unconditional cash transfers on adult labour supply: A unitary discrete choice model for the case of Ecuador* by Andrés Mideros and Cathal O'Donoghue
2014-64 *Giving in South Africa: Determining the influence of altruism, inequality aversion and social capital* by Nyasha Tirivayi
2014-65 *The impact of food transfers for people living with HIV/AIDS: Evidence from Zambia* by Nyasha Tirivayi and Wim Groot
2014-66 *Size and economies of scale in higher education and the implications for mergers* by Nyasha Tirivayi, Henriette Maasen van den Brink and Wim Groot
2014-67 *Widowhood and barriers to seeking health care in Uganda* by Nyasha Tirivayi
2014-68 *An individual-centered approach to multidimensional poverty: The cases of Chile, Colombia, Ecuador and Peru* by Andrea Franco Correa
2014-69 *Innovation and productivity in services: Empirical evidence from Latin America* by Gustavo Crespi, Ezequiel Tacsir and Fernando Vargas
2014-70 *Analysing global value chains using input-output economics: Proceed with care* by Önder Nomaler and Bart Verspagen

2014-71 *The deposit financing gap: Another Dutch disease* by Huub Meijers, Joan Muysken and Olaf Sleijpen

2014-72 *Do remittances and social assistance have different impacts on expenditure patterns of recipient households? The Moldovan case* by Jennifer Waidler, Jessica Hagen-Zanker, Franziska Gassmann and Melissa Siegel

2014-73 *The role of industry and economic context in open innovation: Evidence from Nigeria* by Abiodun Egbetokun, Omolayo Oluwatope, David Adeyeye and Maruf Sanni

2014-74 *Means to improve access to justice and legally empower victims of domestic violence: An empirical legal study on legislation and legal offices in Buenos Aires, Argentina* by Julieta Marotta

2014-75 *Do remittances not promote growth? A bias-adjusted three-step mixture-of-regressions* by Maty Konte

2014-76 *Structural modernization and development traps: An empirical approach* by Alejandro Lavopa and Adam Szirmai

2014-77 *Democratizing intellectual property systems: How corruption hinders equal opportunities for firms* by Caroline Paunov

2014-78 *Can internet infrastructure help reduce regional disparities? Evidence from Turkey* by Mehmet Guney Celbis and Denis de Crombrugghe

2014-79 *Obesity of women in Jordan - Prevalence and associated factors: Making a case for a comprehensive obesity policy* by Sebastian Göllner and Zina Nimeh

2014-80 *International R&D spillovers and business service innovation* by Neil Foster-McGregor, Johannes Pöschl and Robert Stehrer

2014-81 *Tax incentives and firm size: effects on private R&D investment in Spain* by José M. Labeaga, Ester Martínez-Ros and Pierre Mohnen