UNITED NATIONS UNIVERSITY

UNU-MERIT

# The R&D Tax Credit of Chile: A Baseline Study

Principal Researcher: Pierre Mohnen, UNU-MERIT and Maastricht University

Associate Researcher: Jocelyn Olivari, UNU-MERIT

Estudio realizado para el Ministerio de Economía de Chile, División de Innovación.

07th February, 2013

# Table of Contents


*1 Executive Summary ..... 4*

*2 Introduction ..... 6*

*3 Ex ante Assessment of Impact of the changes in the system of tax benefits for R&D in Chile 8*

**3.1 Baseline for the new scheme _____8**

3.1.1 Characterizing R&D performers .....8

3.1.2 Non R&D performers .....14

3.1.3 Comments to the R&D questionnaire: .....16

3.1.4 Recommendations for data collection in view of future evaluations of the effectiveness of R&D tax credits 17

**3.2 Impact of incentives on the cost of capital for R&D _____22**

3.2.1 Background: Theory on optimal capital accumulation .....22

3.2.2 The R&D user cost .....23

3.2.3 The R&D user cost under the Chilean tax incentive .....24

**3.3 Estimation of the elasticity of R&D to the existence of a tax incentive _____34**

3.3.1 Data discussion on panel building using the 5th, 6th and 7th Innovation Surveys and R&D Census .....34

3.3.2 Estimation of R&D elasticity to its user cost using the R&D Census .....37

3.3.3 The effect of R&D tax credits on R&D propensity: a matching approach .....40

3.3.4 Simulation on the impact of a change in the user cost over R&D demand .....46

**3.4 How does the higher spending on R&D impact on productivity and aggregate value? _53**

**3.5 Expected fiscal cost of the new incentive scheme _____64**

*4 Qualitative Interviews ..... 69*

*5 References..... 71*

*6 Annex..... 73*

**6.1 Construction methodology of the directory of potential R&D performers_____73**

**6.2 Qualitative Interviews: Questionnaire for non-users_____75**

**6.3 Qualitative Interviews: Questionnaire for users _____77**

**6.4 Interview transcription _____79**

6.4.1 Interviewee: Juan Elizalde, Director of the R&D and Sales Department (Core Area of the firm) .....79

6.4.2 Interviewee: Fernando Nilo, Director. .....86

6.4.3 Interviewee: René Guttelman, Director of the R&D Department.....91

6.4.4 Interviewee: Sebastián Monckeberg, Innovation, Research and Development Manager.....96

6.4.5 Interviewee: Francisco Lozano, Marketing and Innovation Manager, Innova Arauco.....104

# 1 EXECUTIVE SUMMARY

The rationale for government intervention in R&D markets relies mainly on the evidence that social rates of return are substantially above private ones. The government is then called to design incentives that bring private rates of return closer to social ones. Among the wide range of policy instruments available to foster business private R&D, tax credits have become a popular policy tool and developing economies have started incorporating R&D tax credits into their policy mix.

Chile implemented an R&D tax incentive in 2008 (Law N° 20.241), quite recently as compared to other OECD economies. However, the timing may be right according to the stage of development of its National System of Innovation.

Between the years 2008-2010 a total of 33 out of 40 applications were approved by the agency that administers the fiscal incentive. The diagnosis regarding the low number of applications pointed towards some design flaws in the scheme that could discourage companies from using it. In response, modifications were proposed and a new scheme came into effect in September of 2012. This study attempts to estimate the possible effects the new scheme might have and how much it may cost. Furthermore, it will provide a benchmark against which future visible impacts should be compared.

The latest R&D Census of 2011 showed that 349 firms conducted R&D in 2010, most of which are large firms, which is consistent with international tendencies. Furthermore, most firms are exclusively engaged in intramural R&D; consequently we expect an increase in the use of the tax incentive, as the new scheme extended the benefit to intramural R&D.

The direct effect of a tax incentive is to reduce its price (or its user cost). This constitutes an incentive for firms to carry out R&D activities and attempts to bring closer private and social returns to R&D. The current study showed that the modifications to the tax incentive increased the incentives to carry out R&D activities, mainly for intramural R&D performers, which constitute the core of Chilean R&D performers. This is captured by an average decrease of 35% in the B-Index, which measures the generosity level of the fiscal incentive; the higher generosity, the lower the B-Index. The R&D user cost is a function of the B-Index, the real interest rate, the knowledge depreciation rate and an R&D price deflator. Even though the user cost does not decrease as much as the reduction in the B-Index, due to the macroeconomic parameters, we still consider the reduction in the B-Index as a good signal from the government regarding its commitment towards business R&D.

The lower costs of doing R&D faced by firms, due to a more generous tax credit, should generate a demand increase (assuming no R&D supply restrictions; although qualified human capital could be binding in the case of Chile). Based on outside estimates for short and long run price elasticity of R&D demand, and assuming for the moment no supply restrictions, we obtain a short run increase in the demand for R&D that ranges from 3% to 29% depending on the assumed scenario. In the long run the growth in R&D goes from 19% to 65% depending again on the scenario.

R&D, or knowledge capital, is one of the most important inputs for the innovative process, as well as a vehicle to develop absorptive capabilities that allow the firm to adopt and adapt external knowledge. An increase in R&D projects, due to a reduction in its price, will push forward firm productivity through new

products, or costs reductions from more efficient processes or use of new materials, among other productivity enhancing outcomes from the interactive R&D-innovation-imitation process. Using outside estimates on output elasticity to R&D stock, we approximate the increase in output, both in the short and long term, due to higher R&D levels. We also allow for positive externalities: as knowledge has public good characteristics (non rival and partially excludability) R&D conducted by one firm can spill over and benefit other firms (although some stock of previous knowledge is required to codify knowledge itself). Consequently, we also make an approximation of output increase using social elasticity rates. Our results indicate that an increase in R&D can increase output growth rates between 0.45% and 3.4% in the short run, and between 1.5% and 5.2% in the long run (considering social externalities).

The reduction in the price of R&D will increase its demand, which will ultimately imply a higher exchequer cost for the government. Not only because the scheme itself has turned more generous, but also because some firms may be now motivated to do R&D. This implies a higher loss in tax revenues. Nevertheless, the increase in output can help to partly alleviate the higher costs through a higher corporation tax bill. Our calculations, based on our previous results, show that the net fiscal cost can range from 7% to 17% of the 2010 National System of Innovation Budget.

Finally, the results of the qualitative analysis, based on 5 interviews, showed that even though firms did not mention financial constraints as the main obstacle to carry out R&D activities, the incentive was in general considered as a good incentive to carry out R&D. Firms in general knew about the existence of the tax incentive, although some of them were not aware of its details or if they were eligible to apply. Firms that used the incentive, were in general satisfied with the design of the instrument although the application procedure could be too burdensome sometimes, which may discourage them to apply.

Finally, the general assessment on the modified tax incentive is positive and we expect a positive impact at least on firms that are already engaged in R&D activities (mainly because most of them are doing R&D internally). Our results are encouraging. However, they should be taken with caution as they are based on a set of assumptions, although supported, mainly because of data limitations. We strongly encourage the Ministry to make an effort to collect better data (longitudinal), which is crucial to produce serious and quality studies and evaluations that result informative for the policymaking process.

# 2 INTRODUCTION

Investment in research, development and innovation (R&D+i) in Chile and Latin America (LAC) is considerably low, especially in the private sector. Indeed, industrialized countries spend on average four times more than Latin American countries in R&D and more than half of their efforts is funded and executed by the private business sector.

The rationale for government intervention in R&D markets relies mainly on the evidence that social rates of return are substantially above private ones (see for example a review on R&D returns done by Hall, Mairesse and Mohnen in 2010). This is basically due to the fact that knowledge developed by the inventor spills over and benefits other companies, other industries or even other geographical locations. But given that firms only take into consideration their private rates of return when taking investment decisions, the outcome is an under-investment in R&D from a social point of view. The government is then called to design incentives that bring private rates of return closer to social ones.

Among the wide range of policy instruments available to foster business private R&D, tax credits have become a popular policy tool (see OECD, 2011). A considerable number of developed economies have adopted this kind of incentive, some of them already a while ago, and had them improved when required. Developing economies, increasingly aware of the importance of R&D and innovations as key drivers of productivity growth, have started incorporating R&D tax credits into their policy mix.

R&D tax incentives programs in LAC adopt different forms, in their design as well as in their implementation, differing in some cases in some key features from those implemented in developed countries. In fact, and in order to mitigate the moral hazard problems, in various countries of LAC tax incentives are normally granted against the ex-ante submission of a research project, instead of ex-post considering the whole portfolio of R&D projects by the company. So in principle, R&D tax incentives in LAC look closer to direct subsidies (matching grants) programs. However, even if they resemble direct subsidies, the actual impacts of an R&D tax credit program will depend on the overall fiscal regime that the firm is inserted in and on its own fiscal position. So, the impact of an R&D tax credit program might end-up being very different from a direct subsidy.

Developed countries have a considerable trajectory in evaluating the impact of tax incentive programs for R&D. From a methodological point of view, evaluating these programs represents a challenge. In the first place, firms cannot be excluded from the benefit provided by the law, thus making it very difficult, if not impossible, to construct a control group in an experimental setting. Another important restriction is that access to the beneficiary records is needed and this is not always available for confidentiality reasons.

For these reasons, one of the preferred evaluation approaches has been the use of structural models (Hall, et. al, 2000 and OECD, 2010). These models assume that investment in R&D depends on the user cost of capital, which in turn depends on the parameters that integrate the tax incentives policy (rate of tax credit, tax deduction rate, ceilings, etc.), and other variables such as the real interest rate and the rate of depreciation of knowledge. To evaluate the effect of tax incentives on R&D investment, their impact on the user cost of capital is computed and then the elasticity of R&D demand to its user cost is estimated.

Finally, in order to evaluate the fiscal sustainability of R&D tax incentive policy, the estimation of the effects of additional R&D on productivity is required. Structural methods assume that all the firms that spend on R&D obtain the fiscal benefit and this makes the identification of firms that use it unnecessary, and through innovation surveys enough information can be obtained in order to accomplish the evaluation. This methodology works fine in OECD countries where the benefit is almost automatic, ex post and of a high coverage. However, the result is not obvious for the Latin American countries. Furthermore, the application of this methodology requires longitudinal data to have enough time variation in the user cost of R&D and to build R&D stocks.

Chile implemented a fiscal R&D incentive in 2008 (Law N° 20.241), quite recently as compared to other OECD economies like Canada, France, Japan and the U.S., among others, who have a long history of R&D incentives. Between the years 2008-2010 a total of 40 applications were received by the agency, from which 33 were approved[1]. And despite the fact that there is a normal adjustment process through which a new instrument gets to be known, understood, trusted and used by firms, which may explain a low number of firms using it at the beginning, the diagnosis pointed towards some design flaws in the current scheme that could discourage companies from using it.

In response, modifications to the scheme were proposed to the Congress in January of 2011 and a new version of the tax credit (Law N° 20.570) was approved by March of 2012 and came into effect by 9$^{th}$ of September, 2012. A set of questions naturally emerges. Will these changes stimulate more private R&D spending of those firms that are already engaged in research activities? Will they stimulate non-R&D performers to engage in research activities? How much will this cost to the Government? Does this additional cost offset the extra R&D expenditures of firms?

This study attempts to answer these and other questions and will be useful for the policymaker since it will not only give some estimations on the possible effects the new scheme might have and how much it may cost, but will also provide an additional benchmark against which future visible impacts should be compared.

To answer the previous questions both a quantitative and a qualitative approach were implemented. The results are presented in Sections 3 and 4 respectively. Regarding the quantitative approach, section 3.1 presents a description of R&D performers based on the results of the last R&D Census of 2011. It also contains recommendations about the data that needs to be collected to evaluate the impact of the tax incentive program in the future. Next, in section 3.2, an expression for the R&D user cost is developed, which allows to determine how it changed due to the modifications to the tax incentive scheme introduced in 2012. In section 3.3, the elasticity of R&D to its user cost is approximated based on assumptions consistent with the previous literature. Section 3.4 approximates the effect of higher R&D levels on firm output, and section 3.5 estimates the expected fiscal cost of the new incentive scheme. Section 4 presents the main results obtained from five interviews with firms engaged in R&D activities.

[1] Information obtained from “Informe de Gestión Mensual Agosto 31 de 2012” del Programa Incentivo Tributario a la Inversión Privada en I+D”. Subdirección Innovación Empresarial, Innova Chile de CORFO.

# 3 EX ANTE ASSESSMENT OF IMPACT OF THE CHANGES IN THE SYSTEM OF TAX BENEFITS FOR R&D IN CHILE

## 3.1 Baseline for the new scheme

### *3.1.1 Characterizing R&D performers*

The following description uses the results of the 4th Survey on R&D Expenditures and Personnel in the Business Sector of the year 2011, which collects information for the years 2009 and 2010. This survey was conducted as a census, in which a specific questionnaire was developed to collect information on R&D expenditures and personnel[2]. Prior to year 2011 R&D data were collected through innovation surveys, which are based on a stratified sample representative at the national level. But R&D data, following OECD standards, should be collected through a census because the aim is to calculate total R&D expenditures of the private business sector. Consequently total R&D expenditures in the private sector cannot be calculated through a survey based on a representative sample.

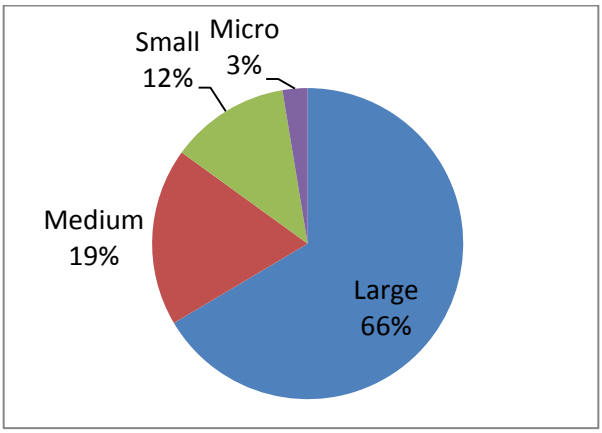
The number of surveyed firms in the census totals 914, out of which 728 are National Private, 102 are Foreign Private, 79 are of mixed property (national/foreign) and 5 are state-owned companies. The R&D tax credit benefit is not available for state-owned companies. Therefore, the focus will be on private, foreign and mixed companies, leaving aside state-owned firms.

In what follows a description of R&D performers is developed relying on the results of the 4th Survey on R&D Expenditures and Personnel in the Business Sector of the year 2011. The main highlights are the following:

- **R&D performers:** Out of the universe of 909 firms[3], 349 (38%) firms reported positive extramural and/or intramural R&D expenditures in 2010[4]. The average overall (intramural and extramural) R&D expenditure in 2010 was MMCLP$566.
- **Size:** Most R&D performers are large (66%) and medium (19%) sized firms (see Figure 1).

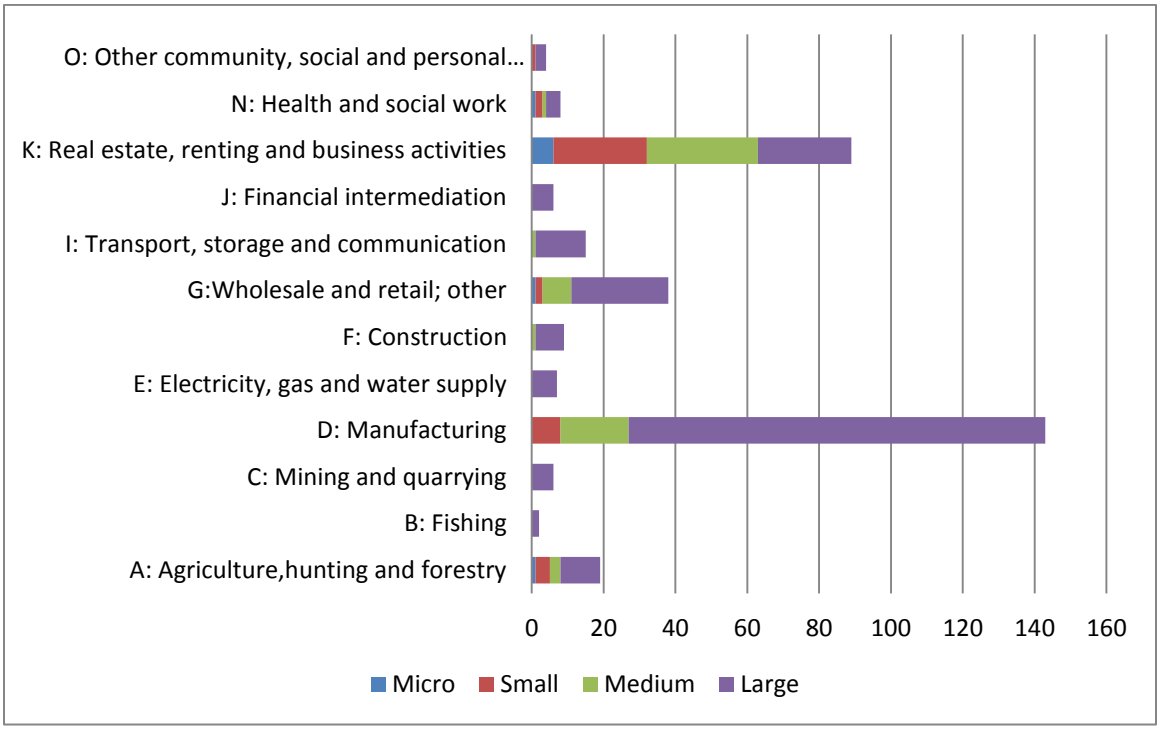
[2] See Annex for a description on the construction methodology of a directory of potential R&D performers.
[3] Leaving aside state-owned companies (914-5=909).
[4] Statistics will be reported only for 2010 given that extramural R&D was only collected for this year.

Figure 1. R&D performers in 2010 by size




- **Sector:** Almost half of the R&D performers belong to the manufacturing sector (41%), while 26% are related to the real estate, renting and business activities, and 11% to the wholesale and retail trade sector (see Figure 2).

Figure 2. Number of R&D performers in 2010 by size and sector




- **Average intramural R&D expenditures:** The average intramural R&D expenditure in 2010 was MMCLP$565, with a median of MMCLP$76 and a standard deviation of MMCLP$4,079. These statistics depict an asymmetric distribution of intramural R&D expenditures.

- **Average extramural R&D expenditures:** The average extramural R&D expenditures in 2010 was MMCLP$165, with a median of MMCLP$30 and a standard deviation of MMCLP$435. The distribution of extramural R&D is also very asymmetric.

- **Average R&D expenditures by size:** As expected, larger firms spend bigger amounts of resources in R&D. Large, Medium, Small and Micro firms spent in 2010 MMCLP$778, MMCLP$169, MMCLP$92 and MMCLP$395 on average respectively (see Table 1 and Figure 3).

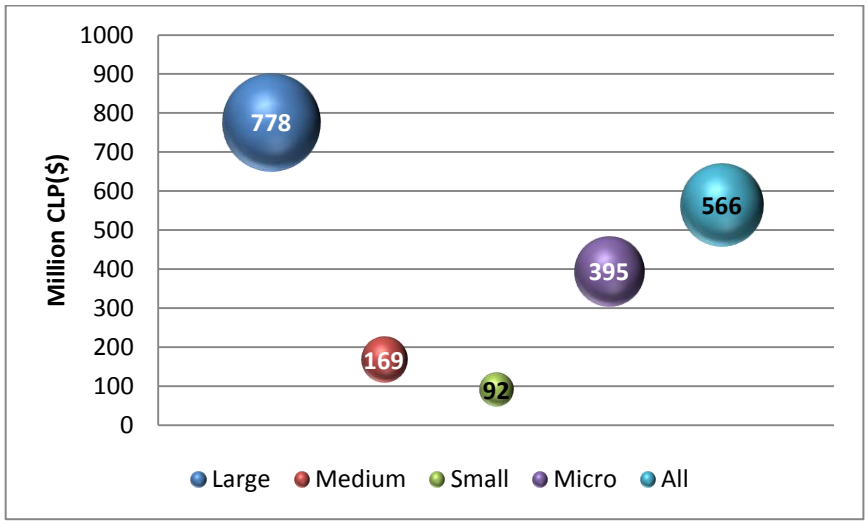
  One result that calls the attention is that the average intramural R&D expenditure of Micro firms is higher than the one of Medium and Small firms. This is mainly due to a couple of firms spending a lot in R&D, which might represent knowledge-intensive start-up firms. These 9 micro firms belong mainly to the K sector (67%) so probably they belong to the K73 sector of R&D. The other three firms belong to sector A, G and N.

  In fact, there is a subset of firms whose ratio of R&D to sales is very big, which could represent companies whose principal aim is doing R&D and therefore their R&D cannot be considered as an input but rather as an output per se. The number of firms with a ratio of R&D to sales higher than 50% is 26. If we consider only privately funded intramural R&D (we cannot distinguish extramural R&D by source of funding) the number of firms falls to 14.

**Table 1. R&D expenditures statistics in 2010 by size (MMCLP$)**

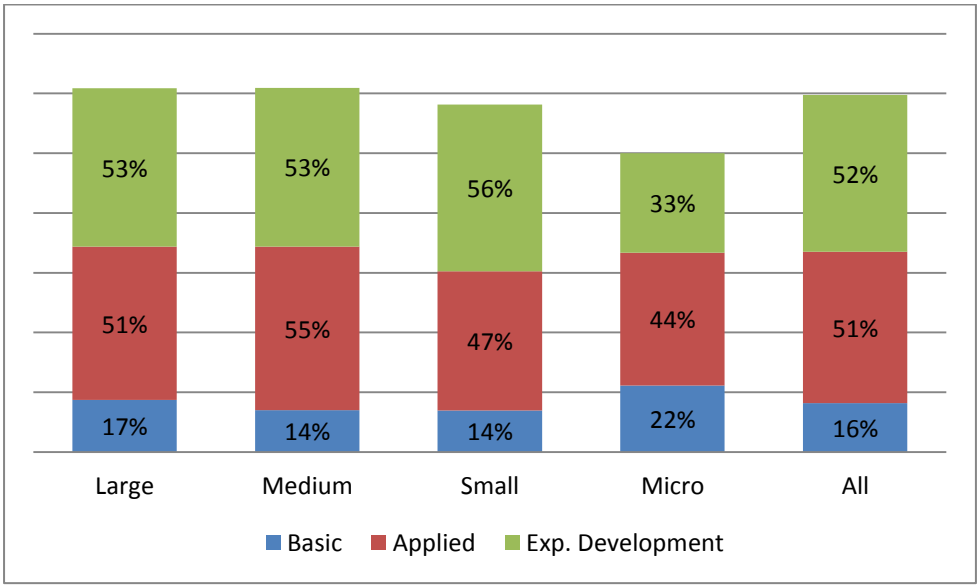
| Size/Statistic | Mean 2010 | Median | Standard Deviation 2010 | N |
|---|---|---|---|---|
| Large | 778 | 98 | 4,777 | 230 |
| Medium | 169 | 51 | 304 | 64 |
| Small | 92 | 65 | 111 | 43 |
| Micro | 395 | 161 | 511 | 9 |
| ***Overall*** | ***566*** | ***85*** | ***3,890*** | ***349*** |

Figure 3. R&D expenditures in 2010 by size (MMCLP$)




- **Type of intramural R&D:**
  - **Intramural versus extramural:** From the 349 R&D performers, 67% did intramural R&D only; 10% did extramural R&D only; and 23% were both intra and extramural R&D performers. For those that do both intramural and extramural R&D, the distribution is on average 26% on extramural R&D and 74% on intramural R&D. A total of 115 firms were engaged in extramural R&D in 2010, hence potentially eligible to apply to the R&D tax credit incentive in 2010.
  - **Current and Capital R&D costs:** On average, firms devote 83% of their intramural R&D expenditures in current costs (66% in labor costs and 17% on other current costs).,while 17% is devoted to capital costs (4% to land and building; 10% to machinery and equipment; and 3% to software).
  - **Current costs by R&D type:** On average, firms are more prone to conduct applied research (51%) and experimental development (52%). Only 16% of firms performed basic R&D. The pattern holds within each category of firm size, although micro firms conduct relatively more basic research (see Figure 4).

**Figure 4. Percentage of firms by type of research and size in 2010**




Note: Percentages by size category do not add up to 1 since the same firm can be engaged in more than one type of R&D.

- **Source of intramural R&D funding:** Main source of intramural R&D funding is own-resources (83%). The participation of government funding reaches on average 14%. The contribution of other firms, higher education organizations, international sources and non-for profit organizations is almost absent. A total of 86 firms (27% of intramural R&D performers) used public funds in 2010 to finance intramural R&D expenditures. The average amount reaches MMCLP$312.

**Table 2. Use of public funds for intramural R&D in 2010**

| Size | Mean of intramural R&D funded with public funds | Number of beneficiaries | Intramural R&D performers | % of beneficiaries out of intramural R&D performers in each size category |
|---|---|---|---|---|
| Micro | 173 | 5 | 6 | 83% |
| Small | 51 | 23 | 41 | 56% |
| Medium | 84 | 22 | 60 | 37% |
| Large | 671 | 34 | 206 | 17% |

- **Extramural R&D:** 33 firms only did extramural R&D (locally and abroad) without performing any intramural R&D. 108 companies subcontracted R&D within Chile, out of which 78 are both intramural and extramural R&D performers. 25 firms subcontracted R&D abroad and did not engage in intramural R&D spending. Firms that did not do intramural R&D (or subcontract R&D locally) but

subcontracted all of their R&D abroad were not eligible to benefit from the tax credit. Still, if a firm that subcontracted R&D abroad also subcontracted R&D locally, it could still benefit from the incentive as long as the proportion subcontracted abroad was less than or equal to 50% of overall R&D costs. According to this restriction, a total of 6 firms were not eligible to benefit from the tax credit incentive. Finally, those that subcontracted all R&D to a local performer within Chilean territory still had the possibility to benefit from the R&D tax benefit.

- **R&D eligibility and tax credit:** Under the original law, only extramural R&D performers were eligible to benefit from the tax credit, while after the September 2012 modifications, intramural R&D performers were also included. In the next table we show the number of R&D performers that were eligible to benefit from the "old" tax incentive in 2010. We have used the same sample of firms to simulate how many of them could benefit from the tax incentive after the modifications of September, 2012 took place.

  It is important to mention that these numbers should be considered only as a reference since **we are considering total amounts of extramural and intramural R&D, which probably include more than one R&D project**. In fact, the tax incentive works with specific R&D projects presented by the firms, so the minimum floor and the threshold on the proportion of R&D subcontracted abroad should be more binding, leaving more firms out of the benefit. The figures of the following Table simulate what would happen if all R&D expenditures were applied as one big R&D project.

  As previously mentioned, the results of the 2011 R&D Census do not provide extramural R&D expenditures by source of funding so we are forced to consider the whole amount despite the fact that a proportion of it might be financed by public funds. Sources of funding are only reported for intramural R&D so we use expenditures financed with private resources of the firm. Even though this is not exactly comparable with the whole amount of extramural R&D we are considering, we think it is more realistic to report on privately funded intramural R&D.

**Table 3. Eligibility conditions in 2010**

| Criteria | Original Law | New Law | Comment |
|---|---|---|---|
| Potential beneficiaries | **115** firms did extramural R&D in 2010 | **349** firms did both extramural and intramural R&D in 2010 | The universe of potential users of the tax credit has triplicated. |
| Minimum of UTM 100 | **105** firms did more than 100 UTM[5] of extramural R&D in 2010 | **326** firms did more that 100UTM of total R&D (intramural and extramural) in 2010 | |
| Max of 50% subcontracted abroad | 94 firms | 323 firms | |

[5] The average value of the UTM for 2010 was CLP$ 37,112.

| Criteria | Original Law | New Law | Comment |
|---|---|---|---|
| (conditional on the floor of UTM 100) | | | |
| Reaching cap | 8 eligible firms reached the cap of 5,000 UTM | 15 eligible firms reach the cap of 15,000 UTM | The triplication of the cap and the inclusion of intramural R&D increased the number of firms affected by the cap by around 50%. Still, there are not many of them. |

Note: Considers firms with privately funded intramural R&D. But considers firms engaged in extramural R&D despite of the source of funding, as this information is not available.

### *3.1.2 Non R&D performers*

- Out of the potential R&D performers included in the R&D Census, 560 were not engaged in R&D activities in 2010.
- Non R&D performers are mainly large (75%) and medium (17%) firms and belong to sectors D, G and K (see Figure 5).
- The main reason for which firms do not carry out R&D activities (see Figure 6) is because there is no need or the firm is not interested. Financially related variables are also very important: lack of financial resources (20%), lack of knowledge regarding available public instruments aimed at supporting R&D (19%) and lack/insufficient tax incentives (14%). The lack of qualified personnel and uncertainty regarding long-term results are important as the lack/insufficiency of R&D tax incentives (14%).
- In Figure 7 the distribution of reasons for not doing R&D are presented by size, to check if the obstacles faced by firms are different according to size. As expected, *lack of financial resources* is considered more important as size decreases. *Lack/insufficient tax incentives* and *bad experience with public instruments* seems also to be more important as size decreases.
- Out of these non-R&D performers there might be potential R&D performers in a future. In fact 5% of them did R&D in 2011. Although those that mentioned there was no need or were not interested in doing R&D (35%) are less likely to become R&D performers.

**Figure 5. Distribution of non R&D performers by sector (%)**

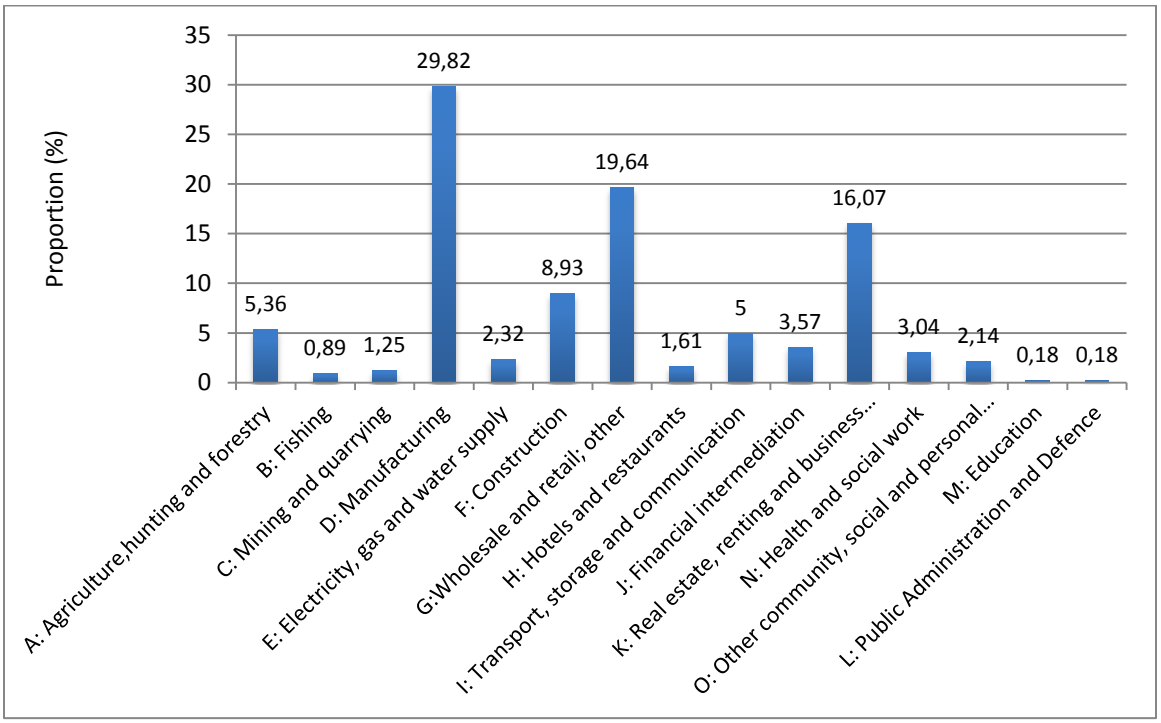



**Figure 6. Reason not to do R&D in 2009/2010**

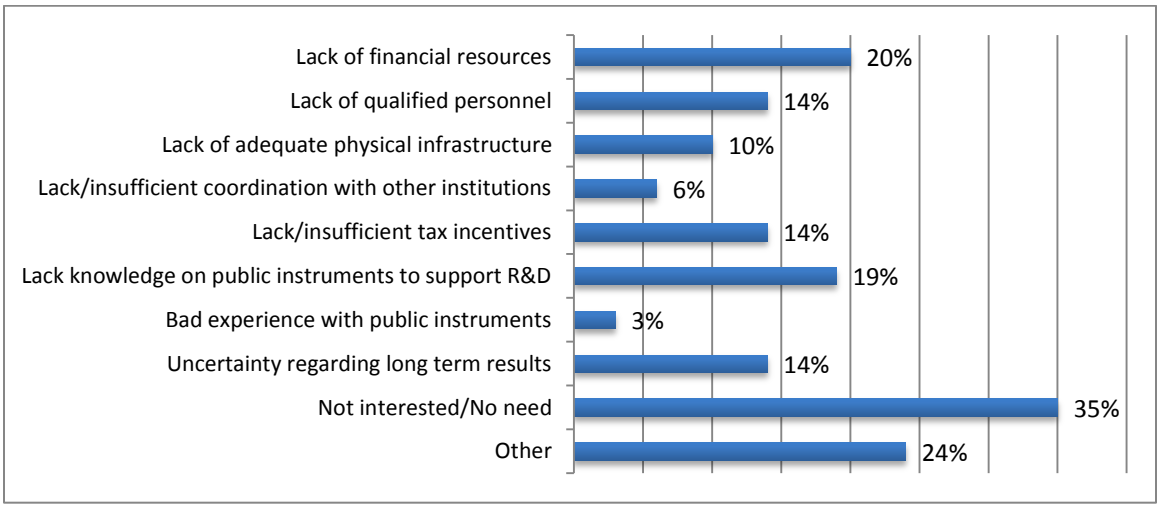
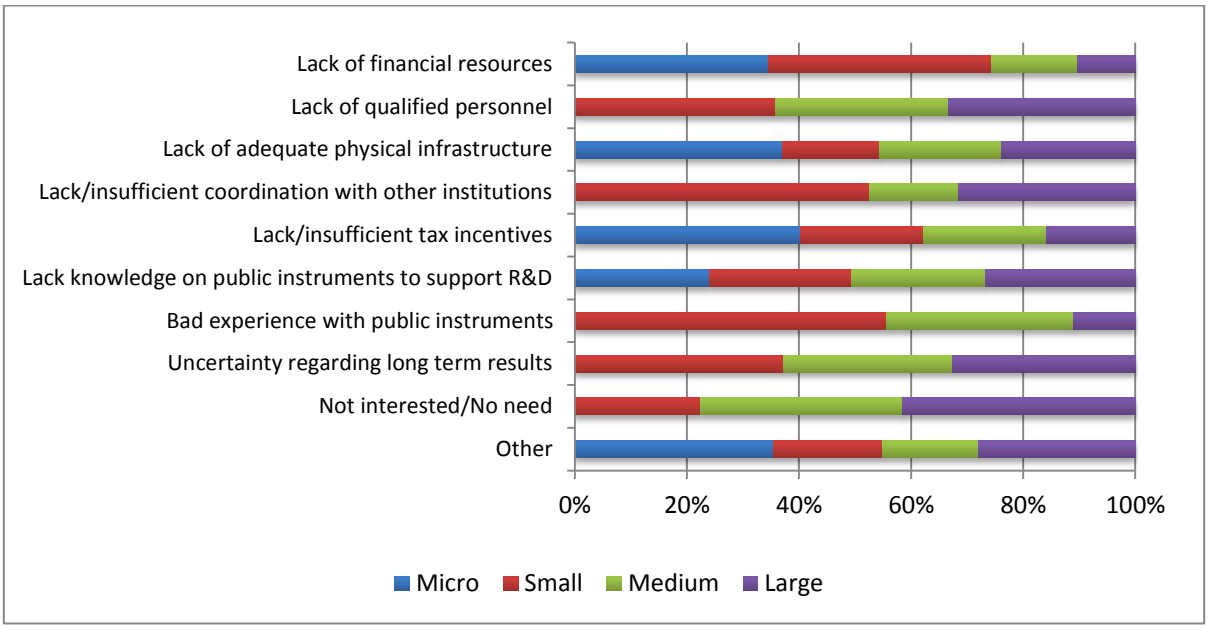


**Figure 7. Reason not to do R&D in 2009/2010 by size**




### *3.1.3 Comments to the R&D questionnaire:*

1. Section III.0: R&D Expenditures inside the firm

    a. Firms should be asked if they did or not R&D separately for each year. This helps to identify firms that are engaged in R&D on a continuous or temporal basis. Knowing the average proportion of temporal and continuous R&D performers is informative to estimate the fiscal cost of the tax incentive.

    b. Firms are asked first if they did intramural R&D or not in 2009/2010. Next they are asked: "*If your answer is NO, Did the firm subcontract R&D in the years 2009 and/or 2010*?" The question about extramural R&D is asked only to those firms that answered "NO" to intramural R&D; so firms that did intramural R&D were not allowed to answer if they did extramural R&D or not. This is wrong because both activities are complementary. In fact, this mistake is verified when firms are asked to report the level of R&D expenditures as intramural R&D performers report extramural R&D expenditures even though they were not supposed to. In fact, according to the expenditure level question in section III we observe that from the 115 extramural R&D performers, 82 also do intramural R&D.

2. Use of tax incentive:
    a. Firms should be asked in the census if they know and whether they have used the R&D tax incentive.
3. Question on extramural R&D
    a. The survey only asked for the level on extramural R&D only for 2010. Given that a question regarding use of the tax incentive was not included in this survey, an approximation for eligible firms to benefit from the tax credit is the expenditure on extramural R&D. This is only available for 2010. This information should be included for both years as the figure of R&D Contracts (the extramural version of the tax incentive) is going to continue and it is useful to have this information to approximate the fiscal cost.
4. It is important to remark that the number of firms engaged in intramural R&D according to the results of the 2011 R&D Census is lower than the number obtained from the 2011 Innovation Survey. If we consider just the Yes/No answers from the Census a total of 324 firms mentioned to have been engaged in intramural R&D in 2009 and/or 2010, while the Yes/No answers from the Innovation Survey show a total of 556 firms that were engaged in intramural R&D during the same period.

### *3.1.4 Recommendations for data collection in view of future evaluations of the effectiveness of R&D tax credits*

It would be interesting to monitor the increase in R&D spending by private Chilean firms as a result of the R&D tax credit. For that matter, it would be useful to collect data on all R&D-performing firms (the R&D census) and on a sufficient large number of non R&D performing firms so as to have a sufficiently large number of firms in the control group that could be compared with similar R&D performing firms for the construction of counterfactuals. It would also be useful to work with panel data so as to be able to control for unobserved firm heterogeneity. Hence the best would be to start up building a sample of firms that would be followed year after year with some additions of new-born firms, and to make sure that these data can be linked as much as possible to data collected from other surveys, such as the R&D and the innovation surveys. Therefore it is, among others, important that the units are defined in the same way, e.g. firms or establishments, and that these units have a common identifier in the different surveys.

To assess the effectiveness of the R&D tax credits, it is necessary to monitor which eligible firms apply for the R&D tax credits, how much they spend on R&D, how much innovative output they produce and finally how performing they are. So, in addition to R&D expenditure, it would be interesting to have data on their innovation output (sales of new products would probably do a better job than patents because patents are not used to the same extent in all industries) and on their productivity, export or employment performance. This requires data on labor, production, export, and capital stock (or at least investment in buildings and equipment from which stocks could be constructed). In order to account for externalities, either some data should be collected on the connections between firms (such as trade in intermediate inputs, research collaborations, flows of personnel) or on the proximity between firms (in the type of patents they apply for, the type of research they do, the type of output they produce or the

type of labor qualifications they hire). Alternatively, externalities could be appreciated by comparing the results at the firm and the sectoral level.

A close collaboration between CORFO, various ministries (Finance and Industry in particular), the statistical agency and the tax office with exchanges of data between these entities would allow a much richer analysis of the effectiveness of this policy measure.

***Recommendations on the collection of R&D and Innovation Data***

It is appropriate to calculate national levels of R&D financed by the private sector through a census. In fact, using a representative sample from an innovation survey to calculate total R&D levels yields biased estimators, as its computation using expansion factors would overestimate the true levels. Likewise, adding up R&D levels without expansion factors would sub estimate the total figures, as it does not consider all firms engaged on R&D. However, even though we agree on measuring total R&D levels in the private sector through a census, we recommend going back to collect R&D data through the innovation survey, but on an improved way. Next we explain why and how.

The Oslo Manual mentions the following pros and cons of combining R&D and Innovation Surveys:

- Because **R&D and innovation are related phenomena**, some countries may consider the **combination of R&D and innovation surveys**. There are a number of arguments for and against:
    - With a combined survey, the overall response burden of the reporting units will be reduced (a single questionnaire, instead of two separate surveys asking some of the same questions).
    - If the length of the questionnaire for combined surveys is much longer than for a separate survey, response rates may decline.
    - A **combined survey offers scope for analyzing the relations between R&D and innovation** activities at the unit level. There is less scope for this with separate surveys, especially when these are carried out by different institutions.
    - There is a risk that units not familiar with the concepts of R&D and innovation may confuse them in a combined survey.
    - Combined surveys offer an efficient method of increasing the frequency of innovation surveys.
    - Country experiences (for example, Denmark, Finland, the Netherlands, Norway and Spain) indicate that it is **possible to obtain reliable results for R&D expenditures in combined surveys**.
    - The frames for the two surveys are generally different. For example, the frame population for innovation surveys may cover industrial classifications (and small units) that are not included in R&D surveys. Combining them may involve sending questions about R&D to a large number of non-R&D performers that are included in the frame population for the innovation survey. This would increase the cost of the joint survey.
- While the Manual does not recommend the use of combined surveys, country experience indicates that they provide a feasible option for increasing the frequency of data collection. Some guidelines for conducting combined surveys are:

- In order to reduce the risk of conceptual confusion between R&D and innovation, the questionnaire should have two distinct sections. Separate sections should also be used when combining innovation with other types of surveys.
- To avoid declines in response rates, individual sections for R&D and innovation should be smaller than in separate surveys, so that the overall length of the combined survey is comparable to that of a separate survey.
- Comparisons of results from combined surveys with those from separate innovation surveys should be done with care, and surveying methods should be reported.
- Samples to carry out such surveys should be extracted from a common business register in order to avoid inconsistencies in the frame populations.

Even though there are evident pros and cons of combining R&D and Innovation Surveys we strongly believe that it is possible to implement in Chile a mixed method that produces quality data and at the same time is able to produce quality studies and evaluations. The recent experience, in 2011, on the collection of R&D and innovation data separately showed that the number of firms from the Innovation Survey for which it was possible to retrieve R&D data was very low. And since R&D and innovation are related phenomena, it is important to collect figures jointly. Especially if the policymaker is interested on measuring the effects over productivity of any tax or subsidy policy aimed at fostering R&D or innovation.

The present study was not able to implement the appropriate methodology (structural models) to evaluate the effects of R&D tax incentives partly because of data limitations. As a consequence, we had to rely on outside estimates and calculate approximations of the effects. Furthermore, the counterpart of this study was concerned with the application of outside estimations (elasticities) arguing that the context of developed countries differs from the context of developing economies like Chile. We could not agree more. But the only way to understand the Chilean context is to produce the data that allows us to answer the questions we have.

The measurement of the effects of policy actions requires the collection of panel data; that is, to follow a set of firms in time. Regarding panel data, Mairesse and Mohnen (2007) make the following recommendations.

- Create longitudinal datasets. If a panel of firms could be constructed, that was followed over a number of years, it would be possible to correct for firm-specific effects, individual unobserved heterogeneity, and to get better estimates that could help devise more effective policy interventions. A major difficulty of course is that firms change shape over time by mergers, acquisitions and rationalizations. To what extent is firm A, which still bears the same name 10 years later, still comparable in its activities and strategies with firm A today? It would help the econometrician if the same firms could be followed over time, rather than wave-by-wave using different samples of firms.
- Need for more studies on panel data. Most studies are based on cross-sectional data from a single innovation survey. It would be interesting to exploit panel data to study the dynamics of innovation, i.e. the time lags in the determinants and the effects, and to control for individual unobserved heterogeneity. Little is known about the dynamics of innovation, precisely because cross sectional data does not allow to study this topic.

- Pay more attention to endogeneity  Most variables in the innovation surveys are codetermined and jointly influenced by other variables. Few studies take the joint causality and dependence on third effects explicitly into account, partly because of the lack of long time series and partly because of the lack of other variables than those collected in the innovation surveys. The danger is to base policy measures on alleged causalities that are nothing more than mere correlations.

Given the current stage on the Chilean innovation policymaking, in which resources have significantly increased in the last years, it is important to accurately evaluate the different policy actions that have been implemented with the aim of generating quality information that provides feedback to the policymaker. The only way to accurately evaluate the impact of policy actions is through a panel that allows identifying causalities properly.

Regarding the building of Panel Surveys, the Oslo Manual recommends the following (See Chapter 8, pp.122):

- The standard approach for innovation surveys is repeated cross-sections, where a new random sample is drawn from a given population for each innovation survey. An alternative or supplementary approach is to impose an explicit panel data structure, whereby a given sample of units is surveyed more frequently and in every subsequent survey using the same set of questions.
- Panel data provide the opportunity to follow the development over time of the innovation process at the microeconomic level. In particular, it allows for the analysis of effects of various innovation indicators over time on economic variables such as sales, productivity, exports and employees.
- Panel data surveys can be conducted in parallel to larger cross- sectional innovation surveys. However, a number of guidelines should be followed:
    - Units should be integrated with full-scale cross-sectional surveys in years in which both are conducted, in order to reduce burdens on units and to ensure an acceptable level of consistency between the results from the two surveys.
    - Panels should be constructed in such a way that they do not affect the main cross-sectional survey.
    - If possible, information from other surveys on employment, sales, value added and investment should be linked to the panel survey as well as the larger cross-sectional innovation survey for empirical analyses.

We strongly believe that Chile is ready to implement a mixed method following the example of Spain who is widely recognized for its quality panel data[6]. Spain is the proof that it is possible to build indicators comparable at the international level and at the same time is able to produce quality studies on policy evaluation. Furthermore there is a tremendous positive externality if panel data is produced: as panel data is scant, the interest of both local and foreign researchers on using this database will increase significantly (as panel data sets are highly regarded by scholars). Consequently, the number of studies on Chile will increase; not only to the benefit of the policymaker who will have more information

[6] See for example http://icono.fecyt.es/PITEC/Paginas/por_que.aspx

at hand to feed back its STI policymaking, but also to the benefit of Chile in general as it will increase the discussion about Chile at the international level.

## 3.2 Impact of incentives on the cost of capital for R&D

The main objective of a tax credit is to encourage R&D investment in companies through a reduction in its cost. R&D is considered an activity through which another type of intangible capital is generated, knowledge capital (especially through the *research* component of R&D). As such, the investment decision in knowledge capital shares some features of the standard theory of optimal (physical) capital accumulation (Jorgenson, 1967).

### *3.2.1 Background: Theory on optimal capital accumulation*

The theory of optimal capital accumulation of Jorgenson (1967) starts with a firm that maximizes the utility of a consumption stream subject to a production function relating the flow of output to the flows of labor and physical capital services. A firm can be thought of supplying capital services to itself through the acquisition of investment goods. The rate of change in the flow of capital services is proportional to the rate of acquisition of investment goods less than the rate of replacement of previously acquired investment goods.

In the standard model of one variable input, labor ($L(t)$), and investment goods ($I(t)$) the firm wants to maximize its revenues $R(t)$:

$$R(t) = p(t) \cdot Q(t) - w(t) \cdot L(t) - q(t) \cdot I(t)$$

Subject to a production function:

$$F(Q, L, K) = 0$$

and the change in the flow of capital services $K$:

$$\dot{K(t)} = I(t) - \delta \cdot K(t)$$

where $p(t), w(t), q(t)$ are the market prices of output, labor and investment goods respectively and $\delta$ is the rate of replacement of the capital stock.

The capital cost that the firm faces is related to the rental price of the capital services supplied by the firm to itself through the acquisition of investment goods at a market price of $q(t)$. There is then a relationship between the price of a new capital good and the discounted value of all the future services delivered from this capital good, which is given by:

$$q(t) = \int_t^{\infty} e^{-r(s-t)}\, c(s)\, e^{-\delta(s-t)}\, ds$$

where $q$ is the price of capital goods, $r$ is the discount rate, $s$ is the time at which capital services are supplied, $t$ is the time of acquisition of the capital good, $c$ is the cost of capital services and $\delta$ is the rate of replacement.

The standard maximization problem of the firm yields an optimal capital accumulation relationship in which the marginal productivity of capital equals its user cost expressed in output units (see Jorgenson, 1967, for the derivation of the optimal conditions):

$$\frac{\partial Q}{\partial K} = \frac{q \cdot (r + \delta) - \dot{q}}{p} = \frac{c}{p}$$

If price expectations of investment goods are static ($\dot{q} = 0$) or if there is no second-hand market for investment goods, then:

$$c = q(r + \delta)$$

The previous expression establishes a relationship between the user cost of capital $c$ (or the implicit rental value of capital services), the discount rate $r$, the replacement rate $\delta$ and the price of the capital good $q$. This is the cost that the firm takes into consideration when making investment decisions. Any tax policy on capital investment will then affect the user cost of capital (see for example Hall and Jorgenson, 1967).

For example, Hall and Jorgenson (1967) calculate how the user cost of capital services changes due to a change in tax policy over capital investments. They assume that tax authorities prescribe a depreciation formula D(s) which gives the proportion of the original cost of an asset of age *s* that may be deducted from income for tax purposes. Further, they assume that a tax credit at a rate *k* is allowed on investment expenditure and that the depreciation base is reduced by the amount of tax credit. If the corporate tax rate is constant over time at a rate *u*, the equality between the price of investment goods and the discounted value of capital services is:

$$q(t) = \int_t^\infty e^{-r(s-t)}\left[(1-u)c(s)\, e^{-\delta(s-t)} + u(1-k)q(t)D(s)\right]ds + kq(t)$$

If the present value of the depreciation deduction on one dollar investment (after tax credit) is denoted by z,

$$z = \int_0^\infty e^{-rs} D(s)ds$$

The implicit rental value of capital services (or user cost) under static expectations then becomes:

$$c = q(r + \delta)\frac{(1-k)(1-uz)}{1-u}$$

### *3.2.2 The R&D user cost*

The previous framework has also been used to estimate the user cost of knowledge capital (R&D) (see for example Mairesse and Mulkay (2011) and Lokshin and Mohnen (2010, 2012)). Similarly, the R&D user cost is given by the following expression:

$$u_{it}^R = P_t^R(r_t + \delta_t)B_{it}$$

where $i$ represents a firm and $t$ denotes time, measured in years. Also:

$P_t^R$ : is the R&D deflator[7], which aims at correcting for an increase in the prices of R&D inputs.

$r_t$ : is the real interest rate in t.

$\delta_t$ : is the depreciation rate of the stock of knowledge[8].

$B_{it}$ : B-Index, measures the ratio of net cost of a dollar spent on R&D after all quantifiable tax incentives have been accounted for $(1 - A)$, to the net income (after tax corporate is applied) of one dollar revenue $(1 - \tau)$. The B-index can then be expressed as follows:

$$B_{it} = \frac{(1 - A)}{(1 - \tau)}$$

where A includes all the discounts a firm can apply through the tax system because of investing in R&D. That is, A captures the value of tax deduction plus tax credit on one currency unit of R&D. If, for example, a firm is allowed to deduct 100% of R&D expenses as a necessary cost, then the tax deduction will be full and equal to $\tau$. If it is allowed to deduct only 50% of R&D expenses, then the tax deduction will be equal to $(0.5 \cdot \tau)$. If furthermore a tax credit $\tau^c$ is allowed, then $A = 0.5 \cdot \tau + \tau^c$.

Intuitively, the B-Index compares the tax relief for a one-dollar expenditure in R&D (or in other words, what is the effective cost for the firm of a one dollar R&D), which is captured in the numerator $(1 - A)$, with 1 dollar of income after tax, captured by $(1 - \tau)$. In other words, it compares the effective cost of this 1 dollar of R&D expense, with the after tax income that this R&D investment generated. Intuitively, if the after tax income is much less than the effective cost of the R&D, then it will not be very attractive for a firm to engage in R&D. But if what the firm earns is higher than what it costs in R&D to generate that earning, then it is attractive to keep on investing on R&D. This is why the B-Index is considered as a measure of the generosity of tax relief on R&D expenditures, and can be compared between countries. The lower the B-Index, more generous the R&D tax incentive scheme is.

The B-Index will depend on the local parameters of the tax incentive scheme. Next we develop the R&D user cost under the Chilean R&D tax incentive.

### *3.2.3 The R&D user cost under the Chilean tax incentive*

Next we derive a general expression for the B-index based on the parameters of the tax incentive available in Chile. Consider the following:

[7] If R&D deflator is not available, GDP deflator could be used although it does not exactly reflects the price variation in the inputs for R&D activities (i.e. labor, machinery and equipment for example) as it captures the price variation in the goods and services produced within an economy in a reference period (output rather than input). R&D input costs are mainly composed of current costs (around 70-85%), which include mainly the wages of labor. This means that a combination of a wage deflator and the GDP deflator would be more suitable that the GDP deflator alone.

[8] Lokshin and Mohnen (2009) and Mairesse and Mulkay (2011) assume 15%. Benavente et al. (2006) assume 0%, while Harris et al. (2009) assume different depreciation rates according to the asset: intramural current spending (30%); plant and machinery spending (12.64%); spending in buildings (3.61%); and extramural spending (30%).

$$D_{it}^{1} = \begin{cases} 1 \; if \; R \; \& \; D \; performer \; is \; eligible \; and \; willing \; to \; use \; the \; R \; \& \; D \; tax \; credit \; incentive \\ 0 \; if \; non \; eligible \; or \; not \; willing \; to \; use \; the \; incentive \end{cases}$$

Eligibility will be understood as:

- Firms of any size.
- Firms that are first category tax liable.
- Firms whose R&D Contracts or Projects were certified by CORFO.
- R&D expenses are higher than a lower threshold of USD 8,000 (or 100 UTM).
- T≥2008

Defining the prevailing tax credit scheme:

$$D_{it}^{2} = \begin{cases} 1 \; if \; the \; prevailing \; R \; \& \; D \; tax \; incentive \; scheme \; is \; Law \; N° \; 20{,}241 \\ 0 \; else \end{cases}$$

$$D_{it}^{3} = \begin{cases} 1 \; if \; the \; prevailing \; R \; \& \; D \; tax \; incentive \; scheme \; is \; the \; modified \; Law \; N° \; 20{,}570 \\ 0 \; else \end{cases}$$

Type of R&D share in overall R&D

Total R&D ($R\&D_{it}$) is defined as the sum of intramural ($\mathrm{R\&}D^{\mathrm{I}}$) and extramural ($\mathrm{R\&}D^{\mathrm{E}}$) R&D for a given period *t*.

$$R\&D_{it} = \mathrm{R\&}D_{it}^{I} + \mathrm{R\&}D_{it}^{E}$$

where:

$\phi_{it}^{I}$ : Share of intramural R&D on Total R&D.

$\phi_{it}^{E}$ : Share of extramural R&D on Total R&D.

Furthermore, the type of R&D costs will be defined as follows:

***Current costs:***

$\omega_{it}^{L}$ : Proportion of Total R&D devoted to *labor*.

$\omega_{it}^{OC}$ : Proportion of Total R&D devoted to *other current costs*.

It is important to mention that the modified tax credit scheme covers patenting costs. The proportion of Total R&D devoted to patenting costs will not be considered as a separate cost given that it is very small

(very few firms are engaged in patenting) and also because there are no separate figures for patenting expenditures in the R&D census database. Given that this item on R&D costs is small, it should not change the estimations on the R&D user cost.

***Capital costs:***

$\omega_{it}^{LB}$ : Proportion of Total R&D devoted to *land and building*.

$\omega_{it}^{ME}$ : Proportion of Total R&D devoted to *machinery and equipment*.

$\omega_{it}^{S}$ : Proportion of Total R&D devoted to *software*.

The eligibility of R&D costs in each tax incentive scheme is presented in the next table:

**Table 4. R&D costs by type of scheme**

| Type of R&D Cost | Law N° 20,241 | Law N° 20,570 |
|---|---|---|
| ***Current Costs*** | | |
| Labor | ✓ | ✓ |
| Patenting | × | ✓ |
| Other current costs | ✓ | ✓ |
| ***Capital Costs*** | | |
| Land and building (annual depreciation installment) | × | ✓ |
| Machinery and equipment (annual depreciation installment) | × | ✓ |
| Software | ✓ | ✓ |

R&D capital costs were included in the modified tax incentive and it covers the annual depreciation of assets. According to the tax office[9] (SII) the useful life of buildings goes from 20 to 80 years, while for machinery and equipment it goes from 5 to 15 years. We will assume a depreciation rate of 5% for land and buildings and of 10% for machinery and equipment. In this case, the amount covered by the tax incentive in the case of machinery and equipment would be $\omega_{it}^{ME} \cdot 10\%$. Finally, software is not considered a depreciable asset. Depreciation rates will be denoted as $\delta^{LB}$ for lands and buildings and $\delta^{ME}$ for instruments and machinery.

[9] See in http://www.sii.cl/pagina/valores/bienes/tabla_vida_enero.htm

Other parameters:

$Z_{it}$ : Deductibility rate of R&D expenses. Given there is no variability over time, type of firm or type of cost it can be assumed that $Z_{it} = Z$. In this case $Z_{it} = 65\%$.

$\tau_{it}$ : Corporate income tax rate. It is the same for every form so strictly speaking $\tau_{it}=\tau_t$. But it does vary over time:

**Table 5. Corporate Tax rates 2001-2013**

| Year | Corporate tax rate |
|---|---|
| 2001 | 15% |
| 2002 | 16% |
| 2003 | 16.5% |
| 2004-2010 | 17% |
| 2011 | 20% |
| 2012 | 18.5% |
| 2013 | 17% |

Source: SII Website

$\tau_{it}^{c}$: R&D tax credit rate, applied to first category income liabilities. It does not vary by type of firm or in time so $\tau_{it}^{c} = \tau^{c} = 35\%$.

The B-Index considering the previous parameters can be expressed as follows. It is important to remark that it is the marginal cost, not the average cost, the one that affects firms' decisions on how much to invest. The B-Index should then include the cost reductions a firm can achieve on an extra dollar of R&D investment.

$$B_{it} = \frac{1}{(1-\tau_{it})} \cdot \{1 - D_{it}^{1} \cdot [D_{it}^{2} \cdot \tau_{it} \cdot Z_{it} \cdot \phi_{it}^{E} \cdot (\omega_{it}^{L} + \omega_{it}^{OC}) + D_{it}^{3} \cdot \tau_{it} \cdot Z_{it} \cdot \langle \phi_{it}^{I} \cdot (\omega_{it}^{L} + \omega_{it}^{OC} + \delta^{LB} \cdot \omega_{it}^{LB} + \delta^{ME} \cdot \omega_{it}^{ME} + \omega_{it}^{S}) + \phi_{it}^{E} \cdot (\omega_{it}^{L} + \omega_{it}^{OC} + \delta^{LB} \cdot \omega_{it}^{LB} + \delta^{ME} \cdot \omega_{it}^{ME} + \omega_{it}^{S}) \rangle] - D_{it}^{1} \cdot D_{it}^{2} \cdot \tau_{it}^{c} \cdot \phi_{it}^{E} \cdot (\omega_{it}^{L} + \omega_{it}^{OC}) - D_{it}^{1} \cdot D_{it}^{3} \cdot \tau_{it}^{c} \cdot \langle \phi_{it}^{I} \cdot (\omega_{it}^{L} + \omega_{it}^{P} + \omega_{it}^{OC} + \delta^{LB} \cdot \omega_{it}^{LB} + \delta^{ME} \cdot \omega_{it}^{ME} + \omega_{it}^{S}) + \phi_{it}^{E} \cdot (\omega_{it}^{L} + \omega_{it}^{OC} + \delta^{LB} \cdot \omega_{it}^{LB} + \delta^{ME} \cdot \omega_{it}^{ME} + \omega_{it}^{S}) \rangle\}$$

Assuming a firm was eligible to benefit from the tax credit in 2010 ($D_{it=2010}^{1} = 1$), the B-Index for the tax incentive under the original Law Nº 20,241 ($D_{it=2010}^{2} = 1$) is given then by the following expression:

$$B_{it} = \frac{1}{(1-0.17)} \cdot \{1 - 0.17 \cdot 0.65 \cdot \phi_{it}^{E} \cdot (\omega_{it}^{L} + \omega_{it}^{OC}) - 0.35 \cdot \phi_{it}^{E} \cdot (\omega_{it}^{L} + \omega_{it}^{OC})\}$$

From the previous section we know that for those firms engaged in both extramural and intramural R&D (23% of R&D performers in 2010), the proportion devoted to the former is on average 0.26 ($\overline{\phi^{E}} = 0.26$). This means that the tax credit applies only to 26% of overall R&D expenditures of an average firm. In other words, for every unit of currency just a proportion of 0.26 is eligible to benefit from the tax incentive.

Furthermore, the average distribution of R&D expenditures by type of cost[10] (see previous section) is $\omega_{it}^{L} = 0.66$, $\omega_{it}^{OC} = 0.17$, meaning that 83% of extramural R&D expenditures were eligible to benefit from the R&D tax incentive in 2010 (since capital costs were not covered in the original version of the incentive).

Given these assumptions we can calculate the B-index for an average firm that is engaged in both intramural and extramural R&D activities in 2010:

$$B_{it} = \frac{1}{(1-0.17)} \cdot \{1 - 0.17 \cdot 0.65 \cdot 0.26 \cdot 0.83 - 0.35 \cdot 0.26 \cdot 0.83\} = 1.085$$

$$B_{it} = 1.085$$

This result indicates that for an average firm that devotes 26% of its R&D expenditures to extramural R&D and 83% to current costs, the tax incentive does not constitute a real incentive as the cost of doing one unit of currency of R&D is higher that a one unit of currency of revenue after tax.

A firm that is engaged only in intramural R&D (67% of R&D performers in 2010) was not eligible to benefit from the R&D tax incentive in 2010. This means that the B-Index for this subgroup of firms is given by:

$$B_{it} = \frac{1}{(1-0.17)} = 1.20$$

If a firm only subcontracts R&D (10% of R&D performers in 2010) the B-index turns:

$$B_{it} = \frac{1}{(1-0.17)} \cdot \{1 - 0.17 \cdot 0.65 \cdot 1 \cdot 0.83 - 0.35 \cdot 1 \cdot 0.83\} = 0.744$$

$$B_{it} = 0.744$$

This results shows that the tax incentive is attractive for those firms that are more intensive on extramural R&D. On the one hand, the incentive could have turned collaboration more appealing as the cost of a dollar spent on extramural R&D was lower than the cost of doing intramural R&D. Nevertheless, this could go against the development of internal research capabilities within firms.

The recent modifications to the tax incentive scheme in 2012 (under Law Nº20.570) included intramural R&D, meaning that the potential beneficiaries increased three times approximately, as showed in the previous section. It also allowed for capital R&D costs. As shown in the previous section, an average firm devotes 17% to capital costs, distributed like this: 4% in land and building; 10% in machinery and equipment; and 3% in software. The incentive considers the annual depreciation of the first two items. The B-index is now given by the following expression[11]:

[10] These proportions were obtained from the R&D Census for the distribution of intramural R&D by type of cost. The R&D Census does not collect this information for extramural R&D, so we use the distributions available for intramural R&D.

[11] The corporate income tax rate increased from 17% in 2010 to 18.5% in 2012.

$$B_{it} = \frac{1}{(1-0.185)} \cdot \{1 - 0.185 \cdot 0.65 \cdot [\phi_{it}^{I} \cdot (\omega_{it}^{L} + \omega_{it}^{OC} + \delta^{LB} \cdot \omega_{it}^{LB} + \delta^{ME} \cdot \omega_{it}^{ME} + \omega_{it}^{S}) + \phi_{it}^{E} \cdot (\omega_{it}^{L} + \omega_{it}^{OC} + \delta^{LB} \cdot \omega_{it}^{LB} + \delta^{ME} \cdot \omega_{it}^{ME} + \omega_{it}^{S})] - 0.35 \cdot [\phi_{it}^{I} \cdot (\omega_{it}^{L} + \omega_{it}^{OC} + \delta^{LB} \cdot \omega_{it}^{LB} + \delta^{ME} \cdot \omega_{it}^{ME} + \omega_{it}^{S}) + \phi_{it}^{E} \cdot (\omega_{it}^{L} + \omega_{it}^{OC} + \delta^{LB} \cdot \omega_{it}^{LB} + \delta^{ME} \cdot \omega_{it}^{ME} + \omega_{it}^{S})]\}$$

$$B_{it} = \frac{1}{(1-0.185)} \cdot \{1 - 0.185 \cdot 0.65 \cdot [(\phi_{it}^{I} + \phi_{it}^{E}) \cdot (\omega_{it}^{L} + \omega_{it}^{OC} + \delta^{LB} \cdot \omega_{it}^{LB} + \delta^{ME} \cdot \omega_{it}^{ME} + \omega_{it}^{S})] - 0.35 \cdot [(\phi_{it}^{I} + \phi_{it}^{E}) \cdot (\omega_{it}^{L} + \omega_{it}^{OC} + \delta^{LB} \cdot \omega_{it}^{LB} + \delta^{ME} \cdot \omega_{it}^{ME} + \omega_{it}^{S})]\}$$

$$B_{it} = \frac{1}{(1-0.185)} \cdot \{1 - 0.185 \cdot 0.65 \cdot (\omega_{it}^{L} + \omega_{it}^{OC} + \delta^{LB} \cdot \omega_{it}^{LB} + \delta^{ME} \cdot \omega_{it}^{ME} + \omega_{it}^{S}) - 0.35 \cdot (\omega_{it}^{L} + \omega_{it}^{OC} + \delta^{LB} \cdot \omega_{it}^{LB} + \delta^{ME} \cdot \omega_{it}^{ME} + \omega_{it}^{S})\}$$

$$B_{it} = \frac{1}{(1-0.185)} \cdot \{1 - 0.185 \cdot 0.65 \cdot (0.66 + 0.17 + 0.05 \cdot 0.04 + 0.1 \cdot 0.1 + 0.03) - 0.35 \cdot (0.66 + 0.17 + 0.05 \cdot 0.04 + 0.1 \cdot 0.1 + 0.03)\} = 0.723$$

$$B_{it} = 0.723$$

This result shows that the incentive to do R&D has increased, as the cost of a unit of currency spent on R&D is lower than a unit of revenue after tax. This implies that with the modifications, the firms should be more encouraged to engage in R&D activities. In fact, as the following table shows, the modifications will benefit mainly those that were engaged in intramural R&D, which constitutes two thirds of the population of R&D performers in 2010. Furthermore, the overall decrease in the B-Index of 35%[12] constitutes an important incentive for this subset of firms.

**Table 6. B-Index change after modifications**

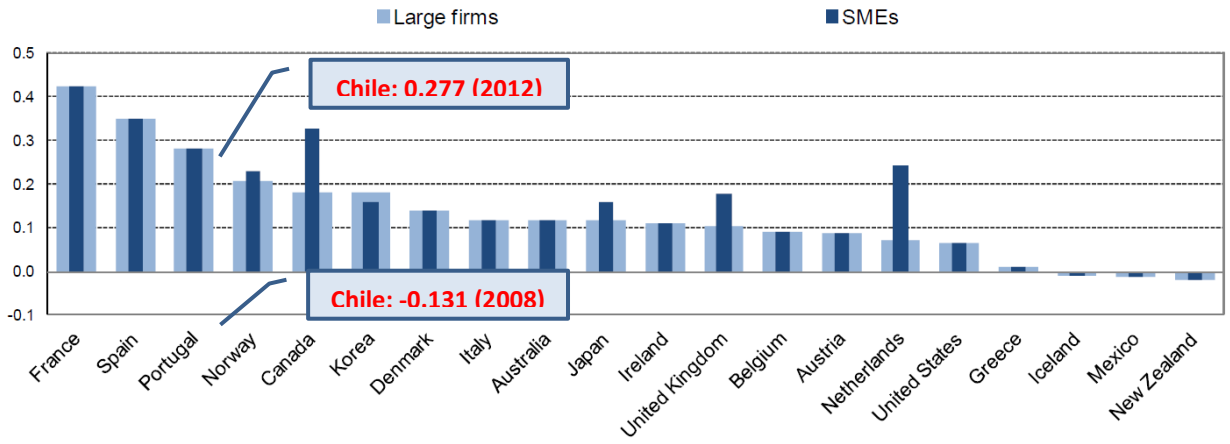
| Category | Proportion over R&D performers in 2010 | B-Index under Law Nº 20,241 | B-Index under Law Nº 20,570 | Change in B-Index (%) |
|---|---|---|---|---|
| Only intramural R&D performer | 67% | 1.204 | 0.723 | -40% |
| Both intramural and extramural R&D performer | 23% | 1.085 | 0.723 | -33% |
| Only extramural R&D performer | 10% | 0.744 | 0.723 | -2% |
| *Average* | -- | *1.131* | *0.723* | *-35%* |

*Note: For the category of both intra and extramural R&D performer, the proportions used correspond to the average proportions for intramural and extramural R&D expenditures obtained for year 2010.*

[12] This 35% comes from the product of: $67\% \cdot (-40\%) + 23\% \cdot (-33\%) + 10\% \cdot (-2\%)$.

The tax subsidy rate can be calculated as 1-B-Index (OECD, 2011). How Chile compares to other OECD countries regarding the level of generosity of the tax incentive? Considering the average B-Index for 2008 of 1.131, the tax subsidy rate is negative and equal to -0.131, meaning that the tax incentive did not constitute an incentive for the overall population of R&D performers. While after the 2012 modifications, the tax subsidy rate went up to 0.277. As can be seen in Figure 8, after modifications took place in 2012, Chile's tax subsidy rate went up at levels comparable to Portugal in 2008.

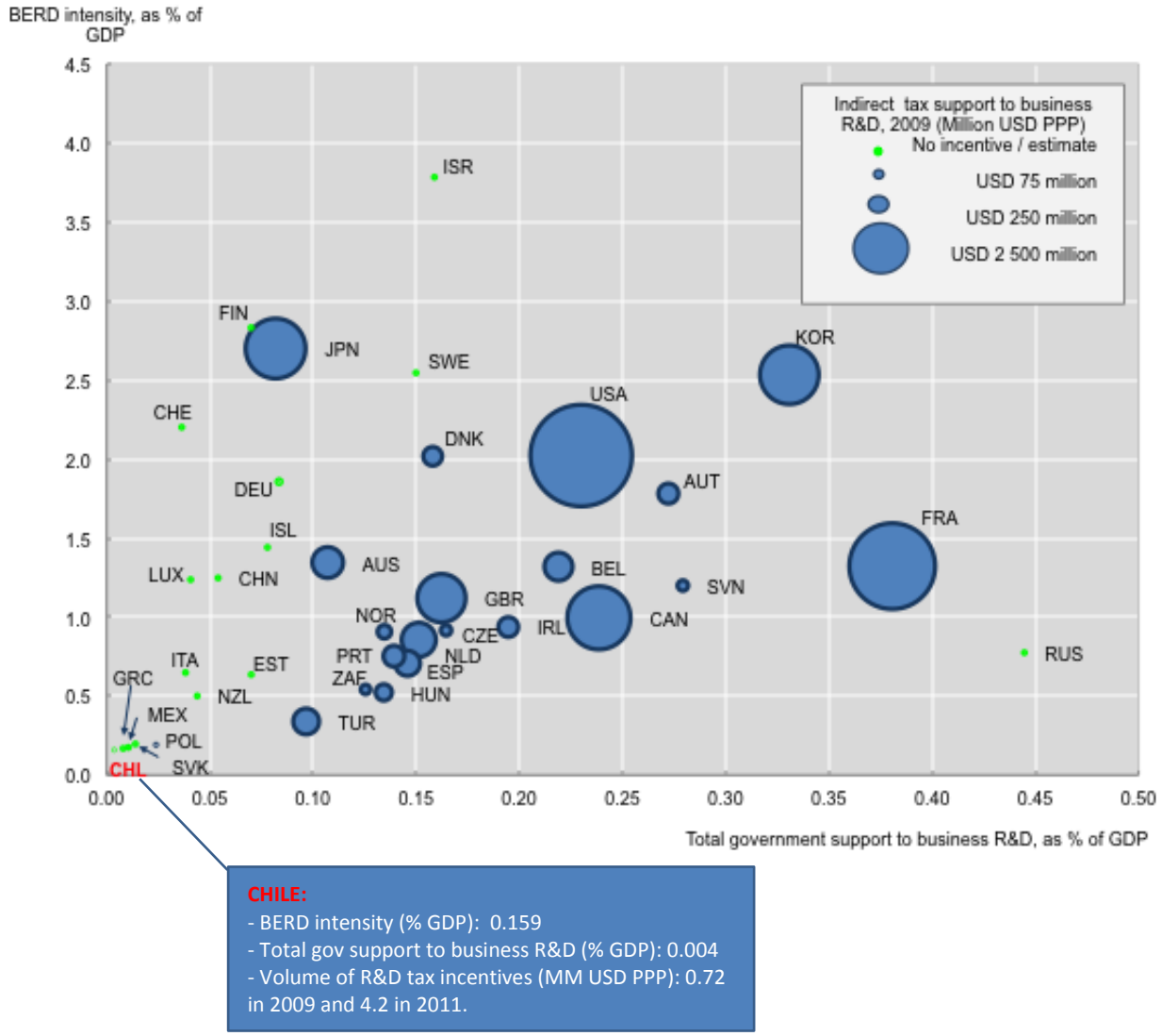
**Figure 8. Tax subsidy rate for 1 unit of currency of R&D (2008)**




Source: OECD (2011) and own calculations for Chile (no distinction by firm size).

Figure 10 below compares Chile to other OECD countries in terms of the level of government support to business R&D. Chile appears at the bottom left of the graph depicting its low levels of tax support to business R&D. Nevertheless we expect these levels go up after the 2012 modifications to the tax incentive.

## Figure 9. Business R&D intensity and government support to business R&D (2009)




Source: OECD Science, Technology and Industry Scoreboard 2011 (Tax incentives for business R&D[13]). Data on Chilean volume of R&D tax credit is obtained from the financial report of the Program. This volume is obtained by computing the 35% of the total amount of certified R&D Contracts in 2009 and 2011, plus the deduction allowed (65%) on R&D expenses (considering the amount of certified R&D Contracts). This totals MMCLP$268[14] for 2009 and MMCLP$1,559 for 2011, which is equivalent to MMUSD PPP 0.72 and 4.2 respectively[15].

[13] http://www.oecd-ilibrary.org/docserver/download/9211041ec048.pdf?expires=1358942035&id=id&accname=guest&checksum=E8C6CA82F72B1100FE254FAD7C06B452

[14] See Table 2 in Second Report.

[15] USD PPP conversion for 2009 was obtained from http://world-economic-outlook.findthedata.org/l/1135/Chile

Using the values of the B-Index in Table 6 we can also derive an expression for the user cost of R&D given by $u_{it}^R = P_t^R(r_t + \delta_t)B_{it}$. The depreciation of the R&D stock is assumed to be the same for both years 2010 and 2012 and equal to $\delta_t = 15\%$[16]. The real interest rate in 2010 was -2.5% and we consider the expected real interest rate in 2012 to reach 2%. The R&D price deflator was approximated by the cost of labor index (ICMO) as most R&D expenditures go to labor costs. The ICMO is published by the National Statistics Office[17] and it is reported by occupation category. Following the Frascati Manual (2002) the proportion of wages devoted to researchers, technicians and other supporting personnel is 59.7%, 22.4% and 17.9% respectively. We approximated these categories as follows: researchers=professionals, scientists and intellectuals; technicians=technicians and professionals of intermediate level; other supporting personnel=workers on administrative support and machinery operators. Using the weights from the Frascati Manual and the evolution of the index we calculated the price index for the years 2010 and 2012[18].

$$P_t^R = 1 + (0.597 \cdot \Delta\, price\ researchers + 0.224 \cdot \Delta\, price\ technicians + 0.179 \cdot \Delta\, price\ sup.personnel)$$

$$P_{2008}^R = 1 + (0.597 \cdot 0.04 + 0.224 \cdot 0.04 + 0.179 \cdot 0.05) = 1.04$$

$$P_{2010}^R = 1 + (0.597 \cdot 0.17 + 0.224 \cdot 0.18 + 0.179 \cdot 0.21) = 1.18$$

The resulting deflator is 1.04 for year 2010 and 1.18 for year 2012, showing that the price level has gone up, making the inputs to carry out R&D relatively more expensive.

---

[16] The measurement of R&D depreciation has for long been the central unresolved problem in the measurement of the rate of return to R&D (Griliches, 1996). As Hall (2007) explains *"determining the appropriate depreciation rate is difficult if not impossible, for at least two reasons. First, from the firm's perspective, the appropriate depreciation rate is endogenous to its behavior and that of its competitors, in addition to depending to some extent on the progress of public research and science. Therefore there is no reason to assume that it is constant over time or over firm, although it will usually (but not always) change slowly in the time dimension. Second, identifying the depreciation rate independently from the return to R&D requires determination of the lag structure of R&D in generating returns. But years of experience with the specification of production functions, market value equations, or even patent production functions (Hall, Griliches, and Hausman 1989) has shown convincingly that this is extremely difficult, because of the lack of appropriate natural experiments. That is, in practice R&D does not vary much over time within firm, so that trying to identify more than one coefficient of R&D is problematic and leads to very unstable results"* (Hall, 2007 pp. 4). Still, most researchers use the 15% that Griliches had settled on his early work in 1981. And despite Hall (2007) argues that private depreciation is likely to be more variable and higher than the 15% normally assumed, and that it surely varies across sectors, there is no consensus yet regarding R&D depreciation rates. On another work using US patent data, Pakes and Schankerman (1984) obtain a point estimate of 25% for depreciation (or strictly speaking, the average decay rate in appropriable revenues). Nevertheless patents are likely to go obsolete faster than knowledge itself, meaning that a 15% depreciation of R&D stock seems more reasonable. Furthermore, as our aim is just to consider only an average depreciation rate, we stick to the standard 15% used in the literature.

[17] http://www.ine.cl/canales/chile_estadistico/mercado_del_trabajo/remuneraciones/series_estadisticas/nuevo_series_estadisticas.php

[18] The year 2012 includes only the index until October 2012, last available year in the website of INE.

Using the above-mentioned parameters, the user cost for three categories of R&D performers is presented in Table 7. Since the tax incentive is horizontal by size, the user cost of R&D is the same for all firms, although it will vary according to the proportion of extramural R&D in the original version of the tax incentive.

The results show that the user cost has gone down 7% for intramural R&D performers, but it has gone up for the other two categories. If we consider the proportions of each category of R&D performers we observe that the user cost has gone up on 1% approximately. This is mainly due to the increase in the real interest rate and the price index[19]. Nevertheless the drop in the B-Index shows that the level of generosity on the tax incentive has increased for all categories. The weighted average shows an overall drop of 35% in the index.

**Table 7. Change in R&D User Cost**

| Category | Proportion over R&D performers in 2010 | $P^R_{2010}$ | $r_{2010}$ | $\delta_{2010}$ | B-Index Law Nº 20,241 | User cost 2010 | $P^R_{2012}$ | $r_{2012}$ | $\delta_{2012}$ | B-Index Law Nº 20,570 | User cost 2012 | Change in B-Index | Change in user cost (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Only intramural R&D performer | 67% | 1.04 | -2.5% | 15% | 1.204 | 0.157 | 1.18 | 2% | 15% | 0.723 | 0.145 | -40% | -7% |
| Both intramural and extramural R&D performer | 23% | 1.04 | -2.5% | 15% | 1.085 | 0.141 | 1.18 | 2% | 15% | 0.723 | 0.145 | -33% | 3% |
| Only extramural R&D performer | 10% | 1.04 | -2.5% | 15% | 0.744 | 0.096 | 1.18 | 2% | 15% | 0.723 | 0.145 | -2% | 51% |

[19] The year 2010 was a special year in which Chile suffered an earthquake, which had an important impact for the economy. This and the world financial crisis explains the negative interest rate.

## 3.3 Estimation of the elasticity of R&D to the existence of a tax incentive

The initial plan to estimate the elasticity of firm R&D capital accumulation to its user cost using a factor demand approach as estimated in Lokshin and Mohnen (2012) had to be dropped due to data limitation problems.

First, panel data is required to estimate this equation as it requires lagged values of R&D to estimate the R&D stock. But with the data at hand it is not possible to build a suitable panel data set. This will be explained in the next subsection.

Second, variation in time and within cross sections is required in the user cost of R&D. As described in the previous section, variation in the price of R&D is explained by changes in the design of the tax incentive and by changes in the macroeconomic parameters like real interest rates and R&D deflators. However the tax credit scheme is relatively new in Chile so we are left with no variation due to changes in its design as modifications were just applied in September 2012. The study developed by Lokshin and Mohnen (2012) covered a time span of 9 years and it included changes in the design of the incentive, allowing for variation in the price of R&D.

As an alternative, matching techniques using the innovation survey were applied to estimate the impact of the tax incentive on the propensity to engage in R&D. Available studies will be used to approximate the R&D elasticity to its user cost for the Chilean case.

### *3.3.1 Data discussion on panel building using the 5th, 6th and 7th Innovation Surveys and R&D Census*

Next we describe the difficulties encountered when building the panel database.

***R&D expenditures***

As previously mentioned, the Ministry of Economics, responsible for the collection of innovation and R&D data, decided in 2011 to collect both topics separately through an R&D census and an innovation survey. The innovation survey of 2011 did not collect data at the level of R&D expenditures, a key input of the knowledge-based innovation process. The 2011 innovation survey only asks whether firms did R&D or not in 2009 and/or 2010, but this is not enough to characterize the innovation process that starts with the decision of a firm to engage in R&D activities and continues with the decision on how much to invest. With the new knowledge created through R&D activities new products and process may be created (innovations) that will end up affecting the firm productivity (see Crèpon et al., 1998). We strongly advise to collect the level of R&D expenditures in subsequent surveys.

A strategy to try to overcome this problem was trying to retrieve R&D data from the 2011 R&D Census and add it to the 2011 Innovation Survey. Nevertheless, the number of hits was not very satisfactory. Only 278 hits were found between the innovation survey and the R&D Census, out of which 113 were R&D performers.

According to the 7th Innovation survey, 556 firms[20] said they had been engaged in intramural R&D in 2009 and/or 2010. But the R&D census showed that only 349 out of the 909 potential R&D performers censed actually performed intramural and/or extramural R&D in 2009 and/or 2010. There is clearly a mismatch between the information obtained from the Innovation Survey and the R&D Census regarding firm engagement in R&D activities. Still, the low match is not surprising because, first, the person that answered both surveys was probably not the same and a different answer to the same question is possible. And second, because the sample is not the same despite the fact that one would expect to find most the R&D performers from the Innovation Survey sample in the R&D Census.

Consequently, through the retrieval strategy we were able to recover information for only 113 out of the 556 (20%) that reported having done R&D in 2009/2010.

***Information mismatch***

Both the 7th Innovation Survey and the R&D Census collected information on firm characteristics (sector, region, founding year and other characteristics that generally do not change in time[21]), turnover, exports and labor for the same years 2009 and 2010. A consistency check was done on the 278 hits by comparing the information reported for the same variable in both data sources. Next a list with the variables that were compared:

- Region: In general the region is missing in the R&D Census (with code 99). But for non-missing values, a mismatch was found in 9 cases.
- Sector: In 33 cases the sector reported was different.
- Group: In 35 cases, the answer on whether the firm belongs to a group of firms was different.
- Type of property: In 22 cases the reported type of property was different (mainly mismatch between Mixed and Private National).
- Founding year: In 77 cases the foundation year was reported differently.
- Number of establishments: in 88 cases the number of establishments did not coincide.
- Legal Status: In 24 cases legal status differed.
- Size: In 20 out of 25 cases there is missing information in the Innovation Survey. In the other 5 cases there was a mismatch in the information.
- Turnover 2009: In 126 cases reported turnover differed. In 33% of the cases the difference is greater than 21 thousand Euros (13 million pesos). Even though differences are expected due to rounding procedures, in some cases differences are quite big.

[20] This is just to have a picture on the number of firms. But strictly speaking the figure should be a percentage of firms engaged in R&D using expansion factors, such that a number representative at the national level is obtained.
[21] Although sector or region could change in time.

- Turnover 2010: In 124 cases reported turnover differed. In 32% of the cases the difference is greater than 21 thousand Euros (13 million pesos).
- Exports 2009: In 53 cases reported exports differed. In 21% of cases the difference is greater than 24 thousand Euros (15 million pesos).
- Exports 2009: In 52 cases reported exports differed. In 17% of cases the difference is greater than 24 thousand Euros (15 million pesos).
- Labor 2009: In 127 cases reported labor was different.
- Labor 2010: 1In 32 cases reported labor was different.

***Repeated identification codes in Innovation Surveys***

The 7th survey is done at the firm level. The 6th survey as well although some observations were still surveyed at the establishment level. The 5th survey was mostly done at the establishment level. This difference in the unit of analysis requires the definition of a strategy because the analysis should be done using comparable units. In practical terms, the database will have the same identification code (ID) whenever different establishments of the same firm were surveyed. There are two options to deal with this:

- *Drop the observations for which repeated IDs are observed.* The problem with this strategy is that it may bias the sample if those observations with repeated IDs have specific characteristics. For example, it could be the case that most of them are large firms. Dropping them will introduce then a sample selection problem that will bias the estimators.
- *Define collapsing criteria.* This might seem like a better strategy because it avoids loosing data and introducing a sample selection problem. But the criteria to combine repeated IDs might also introduce some bias. For example, data on turnover could be added up to reach a total turnover at the firm level. But it is not clear that data on turnover reported by establishments is always reported at the establishment level. In some cases, if the headquarter is surveyed for example, turnover at the firm level might be reported. This might induce double counting and overestimation of turnover. Furthermore, it may be the case that not all establishments of a firm were surveyed, in which case totals would be underestimated. Difficulties continue with qualitative variables. For example, only some of the establishments may have introduced innovations. This could be solved by assuming that the firm innovated if at least one establishment introduced an innovation. But what about the perceived obstacles to innovate? What if for the same obstacle one establishment answers high importance (code 4 in a Likert scale of 4) and another one answers medium importance (code 3). One way would be to take the average of both answers, which would yield 3.5, a fractional number. This fraction needs to be rounded to be comparable to the integer values of the other firms. No matter if the average is rounded to 3 or 4, a bias in the reported intensity will be introduced in both cases.

So the trade-off is clear. On the one hand dropping the observations might introduce sample selection bias. But collapsing repeated IDs might introduce an important bias to the values of the variables. Which is more serious? First it is important to dimension the problem:

- There are 529 firms that can be observed in the three waves of the Innovation Surveys.
- There are 1,958 firms than can be observed in the 6th and 7th innovation survey.
- There are 848 that can be observed in the 5th and 6th innovation survey.
- In the 5th Survey there are 135 cases with repeated IDs. In the 6th Survey there are 71 cases with IDs repeated. In the 7th Survey there are no IDs repeated as the survey is done at the firm level.
- 54 out of 135 repeated IDs in the 5th Survey belong to the three-wave-panel (or six-year-panel). This represents 10% of the six-year-panel sample.
- 41 out of 71 IDs repeated in the 6th Survey belong to this three-wave-panel (or six-year-panel). This represents 10% of the six-year-panel sample.
- Dropping repeated IDs of both surveys would imply losing 95 firms that belong to the 529 three-wave-panel, meaning 18% of the sample.

***Summing Up***

All the above-mentioned problems prevented us from building a suitable panel database to estimate the elasticity of firm R&D capital accumulation to its user cost using a factor demand approach as estimated in Lokshin and Mohnen (2012). The most serious problem is the size of the sample available to run the estimations. As already mentioned, the hits between the three Innovation Surveys were around five hundred firms. From this three-wave-panel we were only able to retrieve R&D data for around 60 firms, out of which only 5 firms used the R&D tax incentive (out of the 52 firms that reported having used the tax incentive in 2009/2010). The size of this sample is considered too small to estimate the elasticity of the R&D stock to its user cost following the methodology applied in Lokshin and Mohnen (2012).

Despite the fact that the data at hand prevents us from applying a factor demand approach as applied in Lokshin and Mohnen (2012), we still estimated an R&D demand equation using the cross sectional data from the R&D Census of 2011. The next section presents the results of this exercise.

### *3.3.2 Estimation of R&D elasticity to its user cost using the R&D Census*

As the R&D Census does not collect information on R&D tax credit recipients we imposed the condition that every firm that fulfilled the eligibility criteria used the tax credit in 2010. The eligibility criteria is defined as follows:

1. The firm was engaged in extramural R&D activities in 2010.
2. The level of extramural R&D expenditures is higher than the minimum threshold of 100 UTM.
3. The proportion of subcontracted R&D abroad is equal or less than 50% of overall extramural R&D expenditures.

According to these eligibility criteria, there were 94 firms out of 349 R&D performers that were potentially able to benefit and use the R&D tax incentive in 2010. For these firms we calculated the price

of R&D using the expression on the user cost developed in the previous section. Unfortunately we do not have information on the evolution of the cost of labor by sector and type of labor so we had to use only the cost of labor index by sector to approximate the R&D deflator $P_t^R$[22]. We assumed an R&D depreciation rate $\delta_t$ of 15% and a real interest rate $r_t$ of -2.5%.

$$u_{it}^R = P_t^R(r_t + \delta_t)B_{it}$$

Where:

$$B_{it} = \frac{1}{(1-0.17)} \cdot \{1 - 0.17 \cdot 0.65 \cdot \phi_{it}^E \cdot (\omega_{it}^L + \omega_{it}^{OC}) - 0.35 \cdot \phi_{it}^E \cdot (\omega_{it}^L + \omega_{it}^{OC})\}$$

Given that extramural R&D expenditures divided by source of funding and type of R&D costs is not available in the database we are not able to include only $\omega_{it}^L$ and $\omega_{it}^{OC}$ financed by the firm. So we had to include all extramural R&D expenditures for 2010.

The average B-Index for these 94 firms is 0.92 with a standard deviation of 0.21. This number means that on average, the tax credit constitutes an incentive for extramural R&D performers, as the cost of doing one unit of currency of R&D is lower than an after tax unit of currency of revenue. While the average user cost of R&D for these 94 firms is 0.11 with a standard deviation of 0.025.

The variation on the user cost for these 94 eligible firms comes from the difference in $\phi_{it}^E$ and $\mathrm{R\&}D_{it}^E$ between firms. However, for non-tax credit users the user cost is the same for firms within the same sector as the only source of variation is the R&D deflator, which is approximated by a price index on the cost of labor by sector. The B-Index for this group is the same and equal to 1.20 ($B_{it} = 1/(1-0.17) = 1.20$). As we are not able to calculate R&D stock, we are left with R&D flows.

We estimated the following models based on the R&D demand equations specified in Bloom et al. (2002). The results are presented in Table 8.

1. Model 1: Total R&D without lagged R&D

$$\ln(R\&D_{it}) = \alpha + \beta_1 \cdot \ln(u_{it}^R) + \beta_2 \cdot \ln(Y_{it}) + \varepsilon_{it}$$

   where $\ln(u_i^R)$ stands for the user cost described in the previous section measured in logs; $\ln(Y_i)$ is the level of output (turnover) in logs measured in prices of 2008; and $\ln(R\&D_i)$ captures the level of extramural and intramural R&D expenditures in logs for 2010 measured in prices of 2008 (it does not distinguish by source of funding).

2. Model 2: Extramural R&D without lagged R&D

$$\ln(\mathrm{R\&}D_{it}^E) = \alpha + \beta_1 \cdot \ln(u_{it}^R) + \beta_2 \cdot \ln(Y_{it}) + \varepsilon_{it}$$

   where $\ln(\mathrm{R\&}D_{it}^E)$ captures the level of extramural R&D expenditures in logs for 2010 measured in prices of 2008 (it does not distinguish by source of funding).

[22] The index is not reported for sector A (Agriculture, Hunting and Forestry) and sector B (Fishing) so we used the average of the index for the rest of the sectors.

3. Model 3: Intramural R&D with lagged R&D

$$\ln\left(\mathrm{R\&D}_{it}^{I}\right) = \alpha + \beta_0 \cdot \ln\left(\mathrm{R\&D}_{it-1}^{I}\right) + \beta_1 \cdot \ln\left(u_{it}^{R}\right) + \beta_2 \cdot \ln(Y_{it}) + \varepsilon_{it}$$

where $\ln(\mathrm{R\&D}_{it}^{I})$ captures the level of intramural R&D expenditures in logs for 2010 measured in prices of 2008 (it does not distinguish by source of funding).

4. Model 4: Privately financed intramural R&D with lagged R&D.

$$\ln\left(\mathrm{R\&D}_{it}^{I-Pv}\right) = \alpha + \beta_0 \cdot \ln\left(\mathrm{R\&D}_{it-1}^{I-Pv}\right) + \beta_1 \cdot \ln\left(u_{it}^{R}\right) + \beta_2 \cdot \ln(Y_{it}) + \varepsilon_{it}$$

where $\ln(\mathrm{R\&D}_{it}^{I-Pv})$ captures the level of extramural R&D expenditures in logs for 2010 measured in prices of 2008 and $\ln\left(\mathrm{R\&D}_{it-1}^{I-Pv}\right)$ is its lagged value in 2009 measured in prices of 2008.

5. Model 5-8: All previous models using a sample selection correction model.

Given that non-R&D performers may react differently to changes in the user cost of R&D vis-à-vis firms engaged on R&D activities, sample selection potentially may bias the estimation of the elasticity of interest. Thus, we apply a sample selection model in which we estimate a first stage probit with a R&D dummy (coded 1 if R&D>0; and 0 if R&D=0) regressed on size dummies, age of the firm, manufacturing sector dummy, a group membership dummy and a location dummy (belongs to the capital or not).

The results of the 8 models estimated are presented in Table 8. Our results do not allow us to draw any conclusions. The sign of the elasticity of the user cost varies with the specification and the measurement of the R&D flow. In fact, once lagged R&D is included, the sign turns positive. Model 2 uses only extramural R&D expenditures and the user cost has the expected sign and it is significant. The corresponding sample correction model 6 does not change this result. Still, the results are not robust to specification changes so we are not able to draw any conclusions from our estimations.

Estimation problems are due to the potentially endogenous nature of R&D, user cost and output. The use of lagged values could be a way to instrument these variables but the lack of access to panel data does not allow us to estimate a dynamic model and improve our estimations through this strategy. Furthermore, we are using figures on R&D flows instead of R&D stock.

This leaves us with the need to use R&D elasticity figures available in the literature.

**Table 8. R&D elasticity to its user cost**

| Variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 | Model 8 |
|---|---|---|---|---|---|---|---|---|
| Log of lagged R&D | -- | -- | 0.8500<br>(0.000) | 0.8206<br>(0.000) | -- | | 0.8469<br>(0.000) | 0.8271<br>(0.000) |
| Log of user cost | -0.2536<br>(0.664) | -3.1431<br>(0.000) | 0.8907<br>(0.004) | 0.7042<br>(0.030) | -0.0705<br>(0.920) | -3.1827<br>(0.000) | 0.9168<br>(0.003) | 0.5871<br>(0.073) |
| Log of output | 0.2162<br>(0.000) | 0.0856<br>(0.211) | 0.0261<br>(0.174) | 0.0592<br>(0.012) | 0.2481<br>(0.000) | 0.1458<br>(0.026) | 0.0321<br>(0.109) | 0.0538<br>(0.037) |
| Constant | 7.4316<br>(0.000) | 2.3839<br>(0.163) | 3.0943<br>(0.000) | 2.5053<br>(0.000) | 6.7753<br>(0.000) | 2.7579<br>(0.131) | 3.2991<br>(0.000) | 2.5720<br>(0.000) |
| N | 342 | 112 | 283 | 265 | 336 | 110 | 280 | 262 |
| $R^2$ | 0.095 | 0.19 | 0.61 | 0.83 | -- | -- | -- | -- |
| Wald test of indep. eqns. $(\rho = 0)$ Prob > chi2 | -- | -- | -- | -- | 0.7547 | 0.1217 | 0.0180 | 0.0663 |

Note: P-values are reported in brackets. Estimation of models 1-4 is done by OLS. Models 5-8 apply a Tobit Model.

### *3.3.3 The effect of R&D tax credits on R&D propensity: a matching approach*

Even though we are not able to check how a reduction in the price of R&D affects its demand level, we are able to study the effect of the tax credit on the propensity for a firm to get engaged in R&D. To do this we will use the 7th Innovation Survey.

According to the 7th Innovation Survey 52 firms reported that they *had access to the R&D tax credit* but only 34 of them did R&D (intra and/o extramural) in 2009-2010. This apparent mismatch calls for attention as one should expect that firms that got the tax credit should at least be doing extramural R&D. This could be explained by how the question is formulated as it asks if the firm had access to the tax incentive (which could be confused with application to the tax incentive for example) instead of asking if the firm directly received it.

Furthermore, according to the statistics of Innova Chile, out of 38 applications a total number of 31 firms were certified with R&D contracts between 2009 and 2010, hence eligible to benefit from the tax credit. This could be another possible explanation to the mismatch: these 31 certified firms may be the ones that reported R&D expenditures, while those that got certified later on in 2011[23] might have reported having applied to/received the tax benefit earlier than 2011. Another possible explanation is that despite the fact they got their R&D contracts certified, the R&D project had not started yet.

#### 3.3.3.1 Methodology

The aim of this section is to assess the **effect of R&D tax credits on the probability of doing R&D** by firms in 2009-2010. The average treatment effect on the treated (ATT) is estimated using propensity score matching. This methodology basically consists in comparing the average outcome variable of interest, in this case the propensity to engage in R&D activities, between those firms that used the tax

[23] Forty nine firms according to the statistics of the Program.

incentive – or the "treated" from now onwards following the impact evaluation language – and those that did not use it, or the "controls". When applying this methodology it is important to avoid possible selection bias arising from the endogenous nature of the treatment variable since R&D tax credit recipients might differ systematically from non-recipients in several characteristics. In fact, even though the R&D tax incentive is available for all eligible firms, not all of them are eligible or decide to use it. So the difference between both groups needs to be "cleaned up" because otherwise we might attribute to the tax incentive any difference in the outcome variable of interest that is due to differences in firm characteristics.

The way to go through this problem is to be sure that both groups are akin on relevant characteristics. This condition is achievable through the estimation of the propensity score, which is a function of covariates and a random error term that yields a scalar that represents the probability of a firm to participate in the treatment, or in this specific case, the probability to use the tax incentive. By the Conditional Independence Assumption (CIA) firms with similar propensity scores should be akin on their characteristics, which assures that the comparison between treated and control firms is done between firms of similar observable characteristics. This is expressed as $y_0, y_1 \perp D|\boldsymbol{x} \Rightarrow \text{as } y_0, y_1 \perp D|p(\boldsymbol{x})$, where $y_0$ and $y_1$ are the outcome of the controls and treated respectively, D is the treatment condition, $\boldsymbol{x}$ is a vector of covariates and $p(\boldsymbol{x})$ represents the propensity score as a function of the covariates.

Once the propensity score has been calculated[24] the process of finding matches with similar characteristics starts. But before this, we need to be sure that the assumption of common support between both groups is fulfilled. This assumption states that $0 < p[D = 1|\boldsymbol{x}] < 1$ and it ensures that for each value of $\boldsymbol{x}$ we will be able to find both treated and non treated cases. In other words, for each treated individual there is another matched untreated individual with a similar $\boldsymbol{x}$. This is achieved by dropping treatment observations whose propensity score is higher than the maximum or less than the minimum propensity score of the controls.

In addition to the common support in propensity score, we might need to discard observations on the basis of further controls to be sure of the comparability of both groups. For example, controls with turnover too high or too low as compared to the treated group will be discarded from the potential set of controls. The same will be done with firm age and labor.

Once the common support is verified and we are sure that there are potential similar controls for the treated, the process of finding a match starts. There are different options and the pick depends on the data at hand and the taste of the researcher in terms of variance and bias of the estimator (See Imbens and Rubin 2012; Cameron and Trivedi, 2005). One option is to pick a single match with the closest propensity score (nearest neighbor) or the closest one within a certain radius to avoid picking one that is too far away[25] (radius matching). In both cases a single match is picked. Another option is to build a match by weighting the closest neighbors, where the weight is defined according to the distance on the propensity score. What matters the most is to pick the matching algorithm than ensures that the balancing condition is met, meaning that the characteristics between the treated and controls are as similar as possible (Cameron and Trivedi, 2005, pp. 893) such that both groups are comparable and the only difference is mainly due to the treatment status. This can be verified through an equality of means test.

[24] Through a limited dependent variable model like a probit or logit.
[25] In that case the treated firms are dropped as no valid match has been found.

Once this is verified, the difference in the average outcome of both groups is calculated, which represents the ATT, which is the effect we are looking for. If this difference is significant at standard levels, then it shows that the treatment has had an impact on the treated.

#### 3.3.3.2 Variables

##### *Treatment indicator*

The treatment indicator is a dummy variable called *use_taxincentive* that has unit value if a firm had access to the R&D tax credit in 2009-2010. The sample consists on $N^1$=52 recipients and $N^0$=3,575 firms in the potential control group.

##### *Control variables*

The following variables were considered as possible determinants of tax credit access.

- *Size*: captured through dummy variables for large, medium and small size. The two latter ones were included such that coefficients denote the difference with respect to larger firms.
- *Financial constraints*: captured through a dummy variable that takes unit value if a firm reported that "lack of own funding" was of high or medium importance within the obstacles to innovate faced by the firm[26].
- *R&D department*: captured through a dummy variable that takes unit value if a firm has a formal R&D unit, department or laboratory inside the firm where R&D is carried out[27].
- *Technological innovator*: captured through a dummy that takes value 1 if the firm introduced new products or processes in 2009-2010.
- *Firm age*: Measured as 2010 minus the year the firm was founded.
- *Location*: captured through a dummy variable that takes value 1 if a firm is based in the capital Santiago.
- *Use of other public instruments*: captured through a dummy variable that takes unit value if a firm used other public instruments that support innovative activities[28].
- *Manufacturing sector*: captured through a dummy variable that takes value 1 if a firm belongs to the manufacturing sector.

It is important to highlight that other firm characteristics could have been controlled for but the cross sectional nature of the data prevent us from including some variables due to endogeneity problems arising from simultaneity. For example, the initial design of the instrument covered only R&D paid by firms but carried out by certified research centers (extramural R&D), so a logical covariate to include

[26] This corresponds to question 10.1.1 from the 7th Innovation Survey form.
[27] This corresponds to question 8.1 from the 7th Innovation Survey form.
[28] This corresponds to question 8.3 from the 7th Innovation Survey form.

would be firm collaboration activities with universities or other research organizations. But in the same year the use of tax credit determines collaboration by construction since it only covers extramural R&D, implying a simultaneous determination between the dependent an independent variables, which would yield biased estimators. The same occurs with engagement in extramural R&D activities. Ideally these variables should be measured before the use of the instrument took place.

- **Outcome variable**

A dummy variable $D$ that takes value 1 if a firm did R&D (both intramural and intramural) in years 2009-2010 is the dependent variable of the model. Unfortunately it is not possible to study the effect over a continuous outcome like the level of R&D since this information is not available in the 7th Innovation Survey database. This could have been feasible, as explained earlier in section 3.3.1, if enough information on R&D expenditures had been retrieved from the results of the R&D Census, but this was not the case. From the 52 firms that had access to the tax incentive in 2009-2010, we were able to retrieve R&D data for only 5 of them, too little to carry out any meaningful estimation. So we stick to the binary variable of R&D propensity as the main outcome. The objective is to check much how higher the propensity of a firm to engage in R&D is due to the use of the R&D tax incentive, as compared to a similar firm that did not use the incentive.

#### 3.3.3.3 Results

The propensity score was estimated using a Logit model and the following results were obtained.

**Table 9. Results of propensity score**

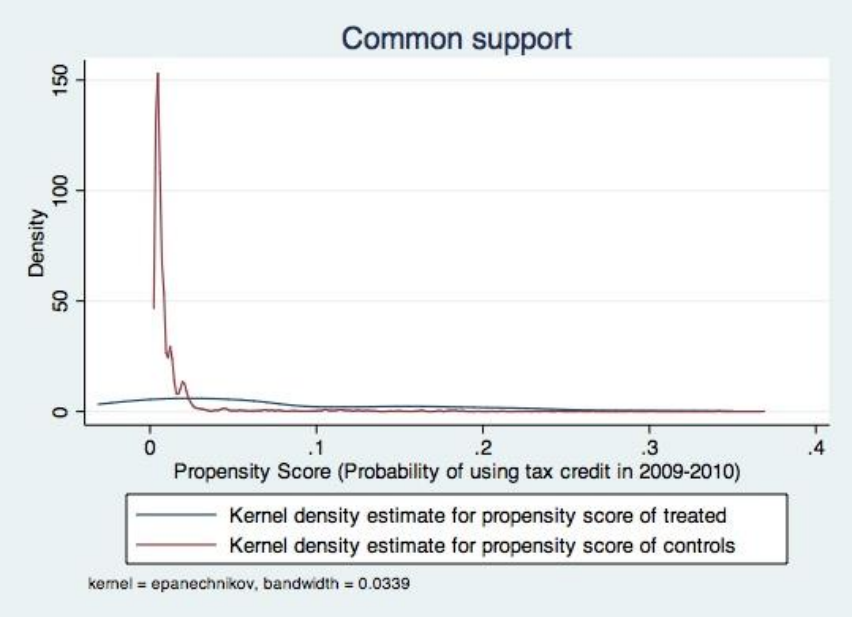
| **Dependent Variable: $p[use\_taxincentive = 1 \mid x]$** | **Coefficient (P-value)** |
|---|---|
| Small[a] (dummy=1) | -0.509<br>(0.239) |
| Medium[a] (dummy=1) | -0.603<br>(0.157) |
| Financial constraints (dummy=1) | 0.0615<br>(0.837) |
| R&D Department (dummy=1) | -0.060<br>(0.880) |
| Technological innovator (dummy=1) | 0.988<br>(0.003) |
| Firm age | 0.010<br>(0.042) |
| Location in the capital (dummy=1 if firm is located in Santiago) | -0.421<br>(0.193) |
| Use of other public instruments (dummy=1) | 2.358<br>(0.000) |
| Manufacturing sector (dummy=1) | -0.135<br>(0.690) |
| Constant | -5.020 |

| Dependent Variable: $p[use\_taxincentive = 1|x]$ | Coefficient (P-value) |
|---|---|
| | (0.000) |
| Number of observations | 3,586 |
| Pseudo R Squared | 0.18 |
| $p > \chi^2$ | 0.00 |

Notes: [a] Size category of comparison is large.

Once the propensity score has been calculated, we need to verify the common support. As can be verified in Figure 10, we are able to find treated and controls with similar propensity scores. Or in other words, that a pair of treated and control firms have similar probabilities of having access to the tax credit, conditional on the observables we described earlier. Once the common support is verified, we are able to do the matching procedure.

**Figure 10. Common support check**




The matching procedure was estimated using an Epanechnikov Kernel with a bandwidth of 0.01. This methodology calculates a weighted average of the potential controls that are close to the treated units in terms of propensity score. 51 out of 52 firms were within the common support, so we were able to build controls for 51 of the treated firms.

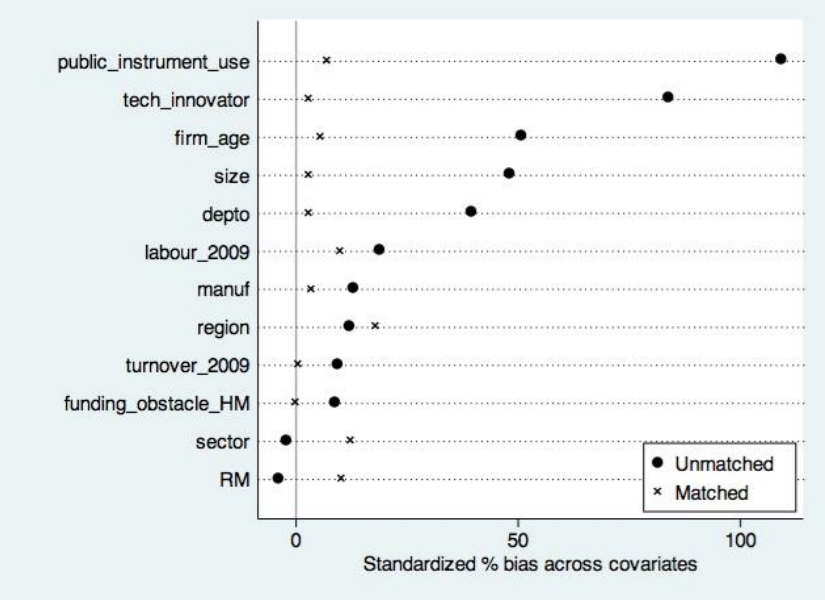
A way to verify the robustness of the matching estimator is to verify that once the matching is done, the differences between both the matched treatment and control groups are not statistically significant. This is done through an equality of means test on key variables. Next we show the results of this test.

**Table 10. Equality of means test between matched and control units**

| Variable | Matched | Mean Treated | Mean Control | Mean Test p>\|t |
|---|---|---|---|---|
| Labor 2009 (continuous) | Unmatched | 738.77 | 404.6 | 0.250 |
| | Matched | 748.94 | 575.91 | 0.568 |
| Turnover 2009 (continuous) | Unmatched | 7.1e+07 | 4.2e+07 | 0.597 |
| | Matched | 7.2e+07 | 7.1e+07 | 0.987 |
| Funding obstacle (dummy) | Unmatched | 0.53846 | 0.49406 | 0.525 |
| | Matched | 0.54902 | 0.55 | 0.992 |
| R&D Department (dummy) | Unmatched | 0.21154 | 0.0747 | 0.000 |
| | Matched | 0.19608 | 0.18662 | 0.904 |
| Technological innovation (dummy) | Unmatched | 0.65385 | 0.26599 | 0.000 |
| | Matched | 0.64706 | 0.63449 | 0.896 |
| Age of the firm (continuous) | Unmatched | 30.827 | 19.374 | 0.000 |
| | Matched | 29.373 | 28.141 | 0.817 |
| Capital RM (dummy) | Unmatched | 0.34615 | 0.36474 | 0.782 |
| | Matched | 0.35294 | 0.30395 | 0.603 |
| Use of other public instruments (dummy) | Unmatched | 0.48077 | 0.05348 | 0.000 |
| | Matched | 0.47059 | 0.44369 | 0.788 |
| Manufacturing sector (dummy) | Unmatched | 0.30769 | 0.24901 | 0.332 |
| | Matched | 0.29412 | 0.27803 | 0.859 |
| Size (categorical) | Unmatched | 2.5385 | 2.1454 | 0.001 |
| | Matched | 2.5294 | 2.5053 | 0.874 |
| Region (categorical) | Unmatched | 9.9231 | 9.4244 | 0.381 |
| | Matched | 9.9608 | 9.217 | 0.359 |
| Sector (categorical) | Unmatched | 6.7885 | 6.8568 | 0.881 |
| | Matched | 6.8431 | 6.4426 | 0.535 |

From the previous table we can see that none of the differences is statistically significant, meaning that we were able to find comparable matches. This is also verified in the following graph, which shows how the bias between the unmatched and matched samples is reduced after the matching is done.

**Figure 11. Bias reduction after matching**




Now that we are sure that the treated and control matches are comparable, we are able to calculate the average treatment effect on the treated. We obtain a difference in the outcome variable of 0.21 with a t-statistic of 3.01, meaning it is significant at 5%. This result means that treated firms had 21% higher probability of engaging in R&D activities in 2010 due to their access to the tax incentive.

### *3.3.4 Simulation on the impact of a change in the user cost over R&D demand*

Given that our estimations on the R&D elasticity to its user cost are not robust for reasons explained earlier in section 3.3.2, we will use short- and long-run elasticities obtained from other studies to approximate how much the demand for R&D stock should rise due to a change in its price. We have chosen three representative studies: the Bloom, Griffith and van Reenen (2002) study on country data, the Harris, Li and Trainor (2009) study on Northern Ireland firm data and the Lokshin and Mohnen study (2011) on Dutch firm data.[29]The product between the elasticity and the reduction in the user cost gives the change in the demand for R&D stock. However we are interested in measuring the effect of the change in the tax incentive and isolate it from the change in prices and the real interest rate. For this reason we will use the change in the B-index from Table 7 instead of the change in the user cost. Consequently, the change in the demand for R&D stock will be the product of the elasticity of the R&D to its user cost and the reduction on the B-Index.

[29] Bloom, N., Griffith, R. and Van Reenen, J., Do R&D Credits Work? Evidence From A Panel Of Countries 1979-97, *J. of Public Economics*, 85, 1-31, 2002; Harris, R., Q.C. Li and M. Trainor, "Is a higher rate of R&D tax credit a panacea for low levels of R&D in disadvantaged regions", *Research Policy*, 38, 192-305, 2009; Lokshin, B. and P. Mohnen, "How effective are level-based R&D tax credits? Evidence from the Netherlands", *Applied Economics*, 1-12, 2011.

We have divided firms according to their R&D performing profile: only intramural; both intra and extramural; and only extramural R&D performers. The first group is the one that benefits the most from the change in the tax incentive, as shown in section 3.2.3.

Table 11 shows the range of the changes in the demand for R&D stock. For an average intramural R&D performer, the short-run (SR) increase in the demand for R&D stock goes up from 4% to 12% depending on the study. This means that we could expect an **average increase in the R&D stock of 8.1% in the short run**. The increase in the long run (LR) demand for R&D stock for intramural R&D performers goes up from 28% to 54.4%. On average, we should expect an **increase in the demand for R&D stock of 40.8% in the long run**.

**Table 11. Change in the demand for R&D stock due to change in the R&D user cost by R&D profiles**

| Study | Time span | R&D elasticity to user cost (a) | Change in B-Index for intramural R&D performers (b) | Change in R&D Stock of intramural R&D performers (a*b) | Change in B-Index for intra and extramural R&D performers (c) | Change in R&D Stock of intra and extramural R&D performers (a*c) | Change in B-Index for extramural R&D performers (d) | Change in R&D Stock of extramural R&D performers (a*d) |
|---|---|---|---|---|---|---|---|---|
| Harris, Li and Trainor (2009) evidence for Ireland | SR | -0.21 | -40% | 8.4% | -33% | 7.0% | -2% | 0.4% |
| | LR | -1.36 | -40% | 54.4% | -33% | 44.9% | -2% | 2.7% |
| Mohnen and Lokshin (2012) evidence for The Netherlands | SR | -0.30 | -40% | 12.0% | -33% | 9.9% | -2% | 0.6% |
| | LR | -0.70 | -40% | 28.0% | -33% | 23.1% | -2% | 1.4% |
| Bloom, Griffith and Van Reenen (2002) for 5 OECD countries | SR | -0.10 | -40% | 4.0% | -33% | 3.3% | -2% | 0.2% |
| | LR | -1.00 | -40% | 40.0% | -33% | 33.0% | -2% | 2.0% |

Using the average changes in the demand for R&D stock and the profiles of R&D performers, we can estimate the overall change in R&D stock both in the short and long run. In the long run, the average change in the demand for R&D stock is 40.8%, 33.7% and 2% for intramural, both intra and extramural,

and extramural R&D performers respectively[30]. Using their proportion in the firm population we should expect an average demand change of 35.3% as shown in the following calculation:

$$\dot{R\&D}^{LR} = 67\% \cdot 40.8\% + 23\% \cdot 33.7\% + 10\% \cdot 2\% = 35.3\%$$

while in the short run, we should expect an average change[31] in the demand for R&D stock of 7%.

$$\dot{R\&D}^{SR} = 67\% \cdot 8.1\% + 23\% \cdot 6.7\% + 10\% \cdot 0.4\% = 7\%$$

As Harris et al. (2009) points out, these results are based on the underlying assumption that there are no supply-side constraints on the ability of the economy to respond to changes in demand for R&D. Or in other words, that the supply of qualified R&D workers would be sufficient to meet demand.

The previous results represent the changes for those firms that are already engaged in R&D activities. However, firms not undertaking R&D might find it worthwhile to carry out R&D given the reduction in its price. For example, Harris et al. (2009) assume that a fall in the price of R&D induces an additional 10% of plants in Northern Ireland to start spending on R&D. While for Chile, those firms that faced financial constraints in 2010 are possibly more likely to get involved in R&D. In section 3.1.2 we showed that 20% and 14% of non-R&D performers mentioned the lack of financial resources and insufficient tax credits respectively as the main reasons for not carrying out R&D. These firms represent 28% (156 firms[32]) of non-R&D performers in 2010 and we consider them as potential candidates to react to the changes in the tax incentive. Furthermore, from our matching exercise in section 3.3.3 we obtained that the tax incentive (in its original version) increased the likelihood of firms carrying out R&D activities by around 20 percentage points in 2010.

Based on this information, we could then expect that 20% non-R&D performers may change their status from non-R&D to R&D performers (which we call novice R&D performers[33]). This 20% sounds reasonable for a country like Chile as compared to the 10% assumed by Harris et al. (2009) for Northern Ireland. Given that the R&D tax credit scheme in Northern Ireland is available since year 2000, one would expect that most effects of the incentive have already been perceived by firms. Consequently, potential new R&D performers due to the incentive are probably less than in Chile, where the effects of the relatively new (and recently modified) tax incentive still need to be perceived by firms. Furthermore, one expects that a country like Ireland is closer to the technological frontier as compared to Chile, so one would expect that more firms are already engaged on R&D in relative terms. In this sense there is more space of improvement in a country like Chile.

The next step is trying to quantify the change in the level of R&D expenditures. From the 2011 R&D Census we know the average level of R&D expenditures by R&D performing profile. We will apply the change rates in the demand of R&D stock to the average R&D expenditures of those firms eligible to

[30] Average changes in long run demand for R&D stock are given by: 40.8%=(54.4%+28.0%+40.0%)/3 for intramural R&D performers; 33.7%=(44.9%+23.1%+33.0%)/3 for both intra and extramural R&D performers; 2%=(2.7%+1.4%+2.0%)/3 for extramural R&D performers.

[31] Average changes in short run demand for R&D stock are given by 8.1%=(8.4%+12.0%+4.0%)/3 for intramural R&D performers; 6.7%=(7.0%+9.9%+3.3%)/3 for both intra and extramural R&D performers; 0.4%=(0.4%+0.6%+0.2%)/3 for extramural R&D performers.

[32] There are firms that picked both reasons; this explains that the 28% is not the sum of the 20% and 14%.

[33] It must be noted that non-R&D performers in 2010 might have been engaged on R&D activities prior 2010 in which case they are not necessarily novice R&D performers.

benefit from the tax incentive to have an idea of how much the level of R&D expenditures would change[34]. We assume that all eligible firms under the "new" tax incentive will make use of it. The total resulting R&D level will be the sum of the level of expenditures of eligible firms, and the level of expenditures of non-eligible firms.

Another assumption we are making is that the level of R&D expenditures we observe represents one big project of R&D. Despite the fact that the tax incentive works with firms applying for a specific R&D Project or Contract, we do not have information on R&D projects but on overall levels of R&D[35]. We think our estimations, and the assumptions we are making, **provide an upper-bound change in the demand for R&D stock**. Furthermore, we will assume a 20% increase in R&D performers due to novice R&D performers[36].

The results of this exercise are presented in Table 12. We have distinguished the three R&D performing profiles and used the average demand increase rates for each category (based on Table 11). The last two columns represent the increase in R&D expenditures for R&D performers, and for R&D performers including novice ones respectively. Total R&D increase can be obtained by adding up the three performing profiles for each time span. In the short run the level of R&D expenditures should increase to MMCLP$247,487.3; while in the long run it should reach MMCLP$309,617.8 (considers firms that are already doing R&D and novice R&D performers).

To illustrate, for intramural R&D performers only, who represent 67% of the total R&D performers, 213 firms would have been eligible to receive R&D tax credits according to the new Law while 21 were not eligible. Using the average of the three estimates of the price elasticity of R&D and the 40% decrease in the B-index for those firms (reported in Table 11), the long-run R&D would have gone up by 40.8%.[37] Applying this number to the average R&D of the eligible firms gets us an increase in R&D for those firms of MMCLP$873.59 x 213=MMCLP$186,075.4 To that total amount of R&D we have to add the R&D of the non-eligible firms that ceteris paribus should not change with the introduction of the R&D tax credit. Hence these firms continue making MMCLP$1,063.76 x 21 =MMCLP$22,338.9. The total amount of R&D is thus equal to MMCLP$208,414.3. Now, in addition we have supposed that following the introduction of the tax credits, the probability of doing R&D increase by 20%, which implies that 20% more firms than before will start doing R&D. To know which firms would start doing R&D we would need to relate that probability to some firm characteristics. As a rough approximation, we shall assume that those firms that start doing R&D will do as much R&D as the existing firms with the same characteristics, in other words, the increase in R&D due to newcomers is similar to a 20% increase in existing R&D. This assumption will probably overestimate the additional R&D due to the extensive margin, especially in the short run when new R&D performers need to learn how to do R&D and certainly experience adjustment costs in doing so. Hence the additional amount is probably less than proportional to the increase in the probability of doing R&D. Our estimates are therefore again likely to represent an upper bound. If we

[34] It is important to highlight that we are using figures of R&D expenditures of 2010 (latest available) to approximate a change in the tax incentive that occured in 2012.

[35] The size of an R&D Project or Contract should be lower than the overall R&D expenditures of a firm, so a subset of the firms we are considering to be eligible might not be, for example because they do not reach the minimum levels.

[36] Following the simplification made by Harris et al. (2009) we will assume that firms that are eligible to benefit from the tax incentive increase by 20% rather than trying to choose which firms begin to spend on R&D.

[37] Normally we should use R&D stocks, but in the absence of sufficiently long time series data on R&D expenditure, we must work with R&D flows. However, in the long run we can consider that flows are proportional to stocks.

apply this additional 20% to the new R&D total of eligible R&D firms we get MMCLP$186,075.4 x 1.2=MMCLP$223,290.4. Adding this to the MMCLP$22,338.9 we get the new total R&D reported in the last column, namely MMCLP$245,629.4. The numbers for the other two types of R&D performers can be computed similarly.

The previous figures include overall R&D expenditures without distinguishing the source of funding. However it is more intuitive to apply the change in the demand rate to privately funded R&D expenditures, as it is the main target of the policy instrument: to foster private R&D expenditures. We will do the same exercise applied to R&D financed with firm resources. As we do not have figures on privately financed extramural R&D, we will assume that the proportion of intramural R&D that is privately financed (83%; see section 3.1.1) is the same for extramural R&D expenditures. This way we will have an idea of how much privately financed total R&D expenditures will change due to the change in the tax incentive. Table 13 reports these results. In the short run the level of privately financed R&D expenditures should increase to MMCLP$211,332.9; while in the long run it should reach MMCLP$270,333 (considers firms that are already doing R&D and novice R&D performers).

## Table 12. Change in demand for R&D stock (all sources of funding)

| Category of R&D Performer | Proportion of each category over all R&D performers in 2010 | Total Nº of firms in each category | Nº of eligible firms under the new tax incentive (a) | Nº of non eligible firms (b) | Average R&D in each category for eligible firms (MMCLP$) (c) | Average R&D in each category for non eligible firms (MMCLP$) (d) | Time span of elasticity | Average change in demand for R&D stock (e) | Total average R&D after demand increase for eligible firms (MMCLP$) (f=c*(1+e)) | Total R&D after demand change (MMCLP$) (g=a*f+b*d) | Total R&D after demand change including novice R&D performers (20% new) (MMCLP$) (g=(a*(1.2*f)+b*d) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Only intramural R&D performer | 67% | 234 | 213 | 21 | 620.45 | 1,063.76 | SR | 0.081 | 671.00 | 165,261.06 | 193,845.48 |
| | | | | | | | LR | 0.408 | 873.59 | 208,414.34 | 245,629.41 |
| Both intramural and extramural R&D performer | 23% | 82 | 82 | 0 | 384.25 | -- | SR | 0.067 | 410.08 | 33,626.34 | 40,351.60 |
| | | | | | | | LR | 0.337 | 513.59 | 42,114.45 | 50,537.34 |
| Only extramural R&D performer | 10% | 33 | 28 | 5 | 293.10 | 680.43 | SR | 0.004 | 294.29 | 11,642.25 | 13,290.27 |
| | | | | | | | LR | 0.020 | 299.07 | 11,776.23 | 13,451.05 |

**Table 13. Change in demand for R&D stock (privately financed R&D[38])**

| Category of R&D Performer | Proportion of each category over all R&D performers in 2010 | Nº of eligible firms under the new tax incentive (a) | Nº of non eligible firms (b) | Average R&D in each category for eligible firms (MMCLP$) (c) | Average R&D in each category for non eligible firms (MMCLP$) (d) | Time span of elasticity | Average change in demand for R&D stock (e) | Total average R&D after demand increase for eligible firms (MMCLP$) (f=c*(1+e)) | Total R&D after demand change (MMCLP$) (g=a*f+b*d) | Total R&D after demand change including novice R&D performers (20% new) (MMCLP$) (g=(a*(1.2*f)+b*d) |
|---|---|---|---|---|---|---|---|---|---|---|
| Only intramural R&D performer | 67% | 213 | 8 | 607.18 | 2.14[39] | SR | 0.081 | 656.64 | 139,881.49 | 167,854.36 |
| | | | | | | LR | 0.408 | 854.90 | 182,111.53 | 218,530.41 |
| Both intramural and extramural R&D performer | 23% | 82 | 0 | 308.99 | -- | SR | 0.067 | 329.75 | 27,039.68 | 32,447.62 |
| | | | | | | LR | 0.337 | 412.99 | 33,865.16 | 40,638.19 |
| Only extramural R&D performer | 10% | 28 | 5 | 243.27 | 564.76 | SR | 0.004 | 244.26 | 9,663.06 | 11,030.92 |
| | | | | | | LR | 0.020 | 248.23 | 9,774.27 | 11,164.37 |

[38] We have assumed that the proportion of privately financed intramural R&D is the same as for extramural R&D.

[39] The difference of privately financed R&D and the overall R&D levels for this category is that for this set of firms most financing comes from public sources. In fact only 8 out of 21 firms reported private financing of their R&D expenditures and the amount is quite small.

## 3.4 How does the higher spending on R&D impact on productivity and aggregate value?

The next question is how the increase in R&D due to a change in the tax incentive affects firms' productivity[40]. Unfortunately the data at hand does not include information on physical capital, which is required to assess the role of R&D in productivity growth, controlling for other production factors. Other studies for Chile have estimated this relationship following the framework developed by Crèpon, Duguet and Mairesse (CDM) (1998), like Benavente (2006)[41]. Nevertheless, the author finds that firms' productivity is not affected by innovative results, nor by research expenditures in the short run. It would probably be worthwhile to reestimate the CDM relationship with more recent data. Instead of assuming a zero elasticity of productivity to R&D we shall instead rely on outside estimates of the rates of return or the R&D elasticities of output reported in the literature. Hall, Mairesse and Mohnen (2010) have made a thorough literature review on returns to R&D[42], and relying on their review we will assume a private elasticity of output[43] to R&D of 8%.

A further interesting effect of the increase in R&D due to the change in the tax incentive is the spillover effect and the consequent externality it generates to other firms that may benefit from this increase in R&D. Unfortunately the data does not allow us to estimate R&D spillovers, as links between firms would be required. Consequently we are left with the assumption of a social elasticity of output to R&D 50% higher than the corresponding private elasticity. Furthermore, based on the theory of absorptive capacity of Cohen and Levinthal (1990)[44], we will assume that only R&D performers are able to benefit from others' R&D. This means that firms need to be involved in R&D and having already existing stock of knowledge to be able to adopt and adapt the knowledge developed by others (copying is not for free).[45]

Based on the assumed private elasticity of output to R&D of 8%, we will calculate the rate of output increase due to a change in the demand for R&D stock. We will use privately financed R&D expenditures from Table 13. In order to have a range of rates of output increase we will consider different levels of increase in the demand for R&D (reported in Table 14) and then compute its growth rate (reported in Table 15). We will consider short- and long-run changes in demand for R&D; plus we are going to verify

[40] Productivity can be defined as the ratio of a measure of output to a measure of input.

[41] Benavente, J. M., "The role of research and innovation in promoting productivity in Chile", *Economics of Innovation and New Technologies*, 15, 2006, 301-315.

[42] Hall, Bronwyn, Jacques Mairesse and Pierre Mohnen, "Measuring the returns to R&D », in the *Handbook of the Economics of Innovation*, B. H. Hall and N. Rosenberg (editors), Elsevier, Amsterdam, 2010, 1034-1082.

[43] Output can be measured by gross output, value-added, or sales. Value-added is the output obtained from the combined use of labor and capital, and can be defined as gross output less purchased inputs such as materials. Thus gross output is the value of the combined use of these two primary inputs plus the intermediate inputs. Frequently sales, which is gross output less increases in inventories of finished goods, is used as a proxy for output (Hall et al., 2010).

[44] Cohen, Wesley, M. and Daniel A. Levinthal, "Absorptive Capacity: A New Perspective on Learning and Innovation", *Administrative Science Quarterly*, 35,1990, 128-152.

[45] Besides knowledge spillovers, for which the assumption of absorptive capacity is quite reasonable, there are also so-called rent spillovers of R&D. For example, the introduction of a new generation of computers will boost the sales of new software optimally adapted to the new computers. In this example, there is not necessarily a transmission of knowledge, just a new business opportunity. Including these elements would require additional data on firms' relationships and assumptions about the particular way R&D rent externalities get transmitted.

how the rates change with and without considering the 20% extra R&D due to novice R&D performers. Furthermore we are going to consider that only 50% of eligible R&D performers are making use of the tax incentive. The figures that assume 100% of eligible R&D performers using the tax incentive are probably less realistic as not all firms are willing to use the tax incentive even though they are eligible to. However, we think this figure gives an upper bound so it is informative itself. The assumption on the 50% is based on the following reasoning. On the one hand, we notice that under the old Law between 6% and 9% of the R&D performers actually applied for R&D tax credits. The exact percentage depends on whether we take the innovation survey or the R&D census and the number of R&D tax credit applicants. On the other hand, we know that the most important modification to the instrument was the inclusion of intramural R&D. As we saw earlier, intramural R&D performers constitute more than two thirds of the overall population of R&D performers, so we expect an important change in the use of the tax incentive as they are now eligible to benefit from the incentive. With this information in mind, assuming that half of the population of R&D performers make use of the instrument seems quite reasonable.

After the different growth rates on demand for R&D are calculated, we will apply the private elasticity of output to R&D to obtain the rate of output increase due to a change in R&D (reported in Table 16). Rates of output increase considering a social elasticity 50% higher can be obtained by multiplying the rates in Table 16 by 1.5. This is reported in the last row of Table 16.

To estimate the overall increase in output we calculate a weighted average of the increase rate in output on each R&D performing profile. We use the participation of each category in total 2010 sales of R&D performers as weights. As an example, consider a long run demand change including novice R&D performers (see column 6 in Table 16); the average output growth rates are given by the following expressions:

$$Output\ growth\ (private) = 79\% \cdot 5.5\% + 15\% \cdot 4.8\% + 6\% \cdot 1.3\% = 5.2\%$$

$$Output\ growth\ (social) = 79\% \cdot 8.3\% + 15\% \cdot 7.2\% + 6\% \cdot 1.9\% = 7.7\%$$

The range of growth rates in output, considering private and social output elasticity to R&D, are reported in the last two rows of Table 16 and go from 0.3% to 2% in the short-run; while for the long run it goes from 1.5% to 5.2%. The results of this example indicate that modifications to the R&D tax incentive should incentivize a higher demand for R&D stock that, assuming no restriction on the supply side for R&D, would provoke an average long-run increase in output of 5.2% (without considering potential externalities).

It is important to remark that our results are rough estimations based on the data at hand and should constitute an upper bound of the impact of the changes in the tax incentive.

A next step is to quantify the increase in output as it will be useful later on to calculate the net fiscal cost of the tax incentive. We use 2010 sales as proxy for output, which totals 17,380 billion pesos considering only the 349 R&D performers[46]. The studies by Cunéo and Mairesse (1984) and Mairesse and Hall (1994) on French data show that the estimates of R&D elasticities derived from a value-added specification do not differ by much from those obtained using sales without including materials. And the reason to consider only R&D performers' sales is related to the previously mentioned theory of absorptive

[46] Own calculations based on the results of the 2011 R&D Census for the private sector.

capacity. We assume that only R&D performers are able to benefit from others' R&D, as firms need to be involved in R&D and to have a stock of knowledge to be able to adopt and adapt the knowledge developed by others.

The level of sales growth, considering the average increase rate using both private and social elasticities, are presented in Table 17. We will use these numbers in the next section when we calculate the expected net fiscal cost of the incentive.

Once the change rates in R&D and output are calculated, we are able to approximate the change in R&D intensity with respect to GDP. According to the report on the R&D Census (2011) from the Ministry of Economics, the intensity of R&D over GDP reached 0.5% in 2010[47]. The business sector represents 41.3% of this intensity, meaning that private sector R&D intensity over GDP reached 0.21% of GDP in 2010. In order to approximate how this intensity could change due to the effects of the tax incentive modifications over both business R&D and output levels, we compute the net growth level on the business R&D intensity using the following expression:

$$Business\ R\&D\ Intensity\ (\%\ GDP) = \frac{(1 +\ rate\ of\ change\ in\ business\ demand\ for\ R\&D)}{(1 + rate\ of\ change\ in\ output)} \cdot 0.21\%$$

$$Overall\ R\&D\ Intensity\ (\%\ GDP) = \frac{(1 +\ rate\ of\ change\ in\ business\ demand\ for\ R\&D)}{(1 + rate\ of\ change\ in\ output)} \cdot 0.21\% + 0.29\%$$

We apply the previous formulas for each scenario on business R&D demand change, and its respective output growth change (considering both private and social output elasticities on R&D). The range of R&D intensities are presented in Table 18. If for example we allow for externalities to take place, we consider a more conservative scenario of 50% of R&D performers that make use of the R&D tax incentive, a short run time span and a 20% of novice R&D performers, we obtain that business R&D intensity as a proportion of GDP could increase from 0.21% to 0.24%. Considering the same scenario in the long run, which is more realistic as the process of output adjustment due to an increase in R&D takes time, the business R&D intensity could reach 0.27%. Considering this, overall R&D intensity could reach 0.53% of GDP in the short run and 0.56% in the long run, ceteris paribus. The latter implies that keeping other things equal, the effects of the tax credit changes over the business sector would provoke this impact over R&D intensity. However, to have a final picture one should consider the rate of increase in the R&D intensity of the other sectors, but that is out of the scope of this study.

[47] At the time of the study, the data of national expenditure on R & D corresponded to 0.5% of GDP, using 2013 base year GDP. Then, with the publication of GDP base year 2008, the number of national expenditure on R & D was 0.42% of GDP.

## Table 14. Range of demand change by R&D performer profile

| Category of R&D Performer | Proportion of each category over total turnover in 2010 | Total Nº of firms in each category | Level of R&D before change in demand (MMCLP$) (a) | Level change in demand for R&D stock in short run considering 20% of novice R&D performers (MMCLP$) (b) | Level change in demand for R&D stock in long run considering 20% of novice R&D performers (MMCLP$) (c) | Level change in demand for R&D stock in short run without considering 20% of novice R&D performers (MMCLP$) (d) | Level change in demand for R&D stock in long run without considering 20% of novice R&D performers (MMCLP$) (e) | 50% of level change in demand for R&D stock in short run considering 20% of novice R&D performers (MMCLP$) (f) | 50% of level change in demand for R&D stock in long run considering 20% of novice R&D performers (MMCLP$) (g) | 50% of level change in demand for R&D stock in short run without considering 20% of novice R&D performers (MMCLP$) (h) | 50% of level change in demand for R&D stock in long run without considering 20% of novice R&D performers (MMCLP$) (i) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Only intramural R&D performer | 79% | 221 | 129,345.53 | 38,508.8 | 89,184.9 | 10,536.0 | 52,766.0 | 19,254.4 | 44,592.4 | 5,268.0 | 26,383.0 |
| Both intramural and extramural R&D performer | 15% | 82 | 25,336.79 | 7,110.8 | 15,301.4 | 1,702.9 | 8,528.4 | 3,555.4 | 7,650.7 | 851.4 | 4,264.2 |
| Only extramural R&D performer | 6% | 33 | 9,635.32 | 1,395.6 | 1,529.1 | 27.7 | 139.0 | 697.8 | 764.5 | 13.9 | 69.5 |

## Table 15. Range of rates of demand change by R&D performer profile

| Category of R&D Performer | Proportion of each category over total turnover in 2010 | Total Nº of firms in each category | Rate of change in demand for R&D stock in short run considering 20% of novice R&D performers (j=b/a*100) | Rate of change in demand for R&D stock in long run considering 20% of novice R&D performers (k=c/a*100) | Rate of change in demand for R&D stock in short run without considering 20% of novice R&D performers (l=d/a*100) | Rate of change in demand for R&D stock in long run without considering 20% of novice R&D performers (m=e/a*100) | Rate of change for a 50% change in demand for R&D stock in short run considering 20% of novice R&D performers (n=f/a*100) | Rate of change for a 50% change in demand for R&D stock in long run considering 20% of novice R&D performers (o=g/a*100) | Rate of change for a 50% change in demand for R&D stock in short run without considering 20% of novice R&D performers (p=h/a*100) | Rate of change for a 50% change in demand for R&D stock in long run without considering 20% of novice R&D performers (q=i/a*100) |
|---|---|---|---|---|---|---|---|---|---|---|
| Only intramural R&D performer | 79% | 221 | 29.8% | 69.0% | 8.1% | 40.8% | 14.9% | 34.5% | 4.1% | 20.4% |
| Both intramural and extramural R&D performer | 15% | 82 | 28.1% | 60.4% | 6.7% | 33.7% | 14.0% | 30.2% | 3.4% | 16.8% |
| Only extramural R&D performer | 6% | 33 | 14.5% | 15.9% | 0.3% | 1.4% | 7.2% | 7.9% | 0.1% | 0.7% |
| Weighted average | | | 28.61% | 64.52% | 7.47% | 37.39% | 14.31% | 32.26% | 3.73% | 18.69% |

Note: Letters (a) to (i) are derived in Table 14.

## Table 16. Range of growth rates of output considering different changes in R&D demand stocks

| Category of R&D Performer | Proportion of each category over total turnover in 2010 | Total Nº of firms in each category | Private elasticity of output to R&D (r) | Growth rate of output based on: | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Change in demand for R&D stock in short run considering 20% of novice R&D performers (r*j) | Change in demand for R&D stock in long run considering 20% of novice R&D performers (r*k) | Change in demand for R&D stock in short run without considering 20% of novice R&D performers (r*l) | Change in demand for R&D stock in long run without considering 20% of novice R&D performers (r*m) | 50% of level change in demand for R&D stock in short run considering 20% of novice R&D performers (r*n) | 50% of level change in demand for R&D stock in long run considering 20% of novice R&D performers (r*o) | 50% of level change in demand for R&D stock in short run without considering 20% of novice R&D performers (r*p) | 50% of level change in demand for R&D stock in long run without considering 20% of novice R&D performers (r*q) |
| Only intramural R&D performer | 79% | 221 | 8% | 2.38% | 5.52% | 0.65% | 3.26% | 1.19% | 2.76% | 0.33% | 1.63% |
| Both intramural and extramural R&D performer | 15% | 82 | 8% | 2.25% | 4.83% | 0.54% | 2.69% | 1.12% | 2.42% | 0.27% | 1.35% |
| Only extramural R&D performer | 6% | 33 | 8% | 1.16% | 1.27% | 0.02% | 0.12% | 0.58% | 0.63% | 0.01% | 0.06% |
| **Growth rate of output considering private elasticity (weighted average)** | | | | **2.29%** | **5.16%** | **0.60%** | **2.99%** | **1.14%** | **2.58%** | **0.30%** | **1.50%** |
| **Growth rate of output considering social elasticity (weighted average)** | | | | **3.43%** | **7.74%** | **0.90%** | **4.49%** | **1.72%** | **3.87%** | **0.45%** | **2.24%** |

Note: Letters (j) to (q) are derived in Table 15.

## Table 17. Sales increase considering different changes in R&D demand stocks

| Private/Social | Sales increase based on demand for R&D stock in short run considering 20% of novice R&D performers (MMCLP$) | Sales increase based on demand for R&D stock in long run considering 20% of novice R&D performers (MMCLP$) | Sales increase based on demand for R&D stock in short run without considering 20% of novice R&D performers (MMCLP$) | Sales increase based on demand for R&D stock in long run without considering 20% of novice R&D performers (MMCLP$) | Sales increase based on a 50% of level change in demand for R&D stock in short run considering 20% of novice R&D performers (MMCLP$) | Sales increase based on a 50% of level change in demand for R&D stock in long run considering 20% of novice R&D performers (MMCLP$) | Sales increase based on a 50% of level change in demand for R&D stock in short run without considering 20% of novice R&D performers (MMCLP$) | Sales increase based on a 50% of level change in demand for R&D stock in long run without considering 20% of novice R&D performers (MMCLP$) |
|---|---|---|---|---|---|---|---|---|
| **Growth rate of output considering private elasticity** | **2.29%** | **5.16%** | **0.60%** | **2.99%** | **1.14%** | **2.58%** | **0.30%** | **1.50%** |
| *Increase in sales* | *397,827.12* | *897,065.72* | *103,795.69* | *519,827.85* | *198,913.56* | *448,532.86* | *51,897.85* | *259,913.93* |
| **Growth rate of output considering social elasticity** | **3.43%** | **7.74%** | **0.90%** | **4.49%** | **1.72%** | **3.87%** | **0.45%** | **2.24%** |
| *Increase in sales* | *596,740.69* | *1,345,598.58* | *155,693.54* | *779,741.78* | *298,370.34* | *672,799.29* | *77,846.77* | *389,870.89* |

Note: Increase in sales is obtained by applying each growth rate to the level of sales of R&D performers in 2010 (17,380 billion pesos).

## Table 18. New R&D Intensity (%GDP) after R&D and output changes

| | New R&D intensity considering: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Private/Social | New levels of R&D in short run and 20% of novice R&D performers (MMCLP$) | New levels of R&D in long run and 20% of novice R&D performers (MMCLP$) | New levels of R&D in short run without 20% of novice R&D performers (MMCLP$) | New levels of R&D in long run without 20% of novice R&D performers (MMCLP$) | 50% of new levels of R&D in short run and 20% of novice R&D performers (MMCLP$) | 50% of new levels of R&D in long run and 20% of novice R&D performers (MMCLP$) | 50% of new levels of R&D in short run without 20% of novice R&D performers (MMCLP$) | 50% of new levels of R&D in long run without 20% of novice R&D performers (MMCLP$) |
| **Average change rate in business R&D demand (a)** | 28.61% | 64.52% | 7.47% | 37.39% | 14.31% | 32.26% | 3.73% | 18.69% |
| **Growth rate of output considering private elasticity (b)** | **2.29%** | **5.16%** | **0.60%** | **2.99%** | **1.14%** | **2.58%** | **0.30%** | **1.50%** |
| ***New business R&D intensity (% GDP)*** *[((1+a)/(1+b))*0.21%]* | ***3.4.1.1*** **0.26%** | **0.33%** | **0.22%** | **0.28%** | **0.24%** | **0.27%** | **0.22%** | **0.25%** |
| ***New overall R&D intensity (% GDP)*** *[((1+a)/(1+b))*0.21%]+0.29%* | **3.4.1.2** **0.55%** | **0.62%** | **0.51%** | **0.57%** | **0.53%** | **0.56%** | **0.51%** | **0.54%** |
| | | | | | | | | |
| **Average change rate in business R&D demand (c)** | 28.61% | 64.52% | 7.47% | 37.39% | 14.31% | 32.26% | 3.73% | 18.69% |
| **Growth rate of output considering social elasticity (d)** | **3.43%** | **7.74%** | **0.90%** | **4.49%** | **1.72%** | **3.87%** | **0.45%** | **2.24%** |
| ***New business R&D intensity (% GDP)*** *[((1+c)/(1+d))*0.21%]* | ***3.4.1.3*** **0.26%** | **0.32%** | **0.22%** | **0.28%** | **0.24%** | **0.27%** | **0.22%** | **0.24%** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ***3.4.1.4 New overall R&D intensity (% GDP)***<br><br>*[((1+c)/(1+d))*0.21%]+0.29%* | **0.55%** | **0.61%** | **0.51%** | **0.57%** | **0.53%** | **0.56%** | **0.51%** | **0.53%** |

| | 3.4.1.5 New R&D intensity considering: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Private/Social | 3.4.1.6 New levels of R&D in short run and 20% of novice R&D performers (MMCLP$) | 3.4.1.7 New levels of R&D in long run and 20% of novice R&D performers (MMCLP$) | 3.4.1.8 New levels of R&D in short run without 20% of novice R&D performers (MMCLP$) | 3.4.1.9 New levels of R&D in long run without 20% of novice R&D performers (MMCLP$) | 3.4.1.10 50% of new levels of R&D in short run and 20% of novice R&D performers (MMCLP$) | 3.4.1.11 50% of new levels of R&D in long run and 20% of novice R&D performers (MMCLP$) | 3.4.1.12 50% of new levels of R&D in short run without 20% of novice R&D performers (MMCLP$) | 3.4.1.13 50% of new levels of R&D in long run without 20% of novice R&D performers (MMCLP$) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **3.4.1.14** | **Average change rate in demand (a)** | 28,6% | 64,5% | 7,5% | 37,4% | 14,3% | 32,3% | 3,7% | 18,7% |
| **3.4.1.15** | **Growth rate of output considering <u>private</u> elasticity (b)** | **2,3%** | **5,2%** | **0,6%** | **3,0%** | **1,1%** | **2,6%** | **0,3%** | **1,5%** |
| **GERD/PIB** | | **0,46%** | **0,46%** | **0,46%** | **0,46%** | **0,46%** | **0,46%** | **0,46%** | **0,46%** |
| **Gasto I+D finan Empresa/PIB** | | **0,17%** | **0,17%** | **0,17%** | **0,17%** | **0,17%** | **0,17%** | **0,17%** | **0,17%** |
| ***3.4.1.16*** | ***New R&D intensity (% GDP)= ((1+a)/(1+b))* 0.46%*** | **0,58%** | **0,72%** | **0,49%** | **0,61%** | **0,52%** | **0,59%** | **0,48%** | **0,54%** |
| ***((1+a)/(1+b))*0.17%*** | | **0,21%** | **0,27%** | **0,18%** | **0,23%** | **0,19%** | **0,22%** | **0,18%** | **0,20%** |
| | | | | | | | | | |
| | | | | | | | | | |
| **3.4.1.17** | **Average change rate in demand** | 28,6% | 64,5% | 7,5% | 37,4% | 14,3% | 32,3% | 3,7% | 18,7% |
| **3.4.1.18** | **Growth rate of output considering <u>social</u> elasticity** | **3,4%** | **7,7%** | **0,9%** | **4,5%** | **1,7%** | **3,9%** | **0,5%** | **2,2%** |
| **GERD/PIB** | | **0,46%** | **0,46%** | **0,46%** | **0,46%** | **0,46%** | **0,46%** | **0,46%** | **0,46%** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Gasto I+D finan Empresa/PIB** | **0,17%** | **0,17%** | **0,17%** | **0,17%** | **0,17%** | **0,17%** | **0,17%** | **0,17%** |
| ***3.4.1.19 New R&D intensity (% GDP)= ((1+a)/(1+b))* 0.46%*** | **0,57%** | **0,70%** | **0,49%** | **0,60%** | **0,52%** | **0,59%** | **0,48%** | **0,53%** |
| ***((1+a)/(1+b))*0.17%*** | **0,21%** | **0,26%** | **0,18%** | **0,22%** | **0,19%** | **0,22%** | **0,18%** | **0,20%** |

## 3.5 Expected fiscal cost of the new incentive scheme

Now we estimate the fiscal cost of the new tax incentive using the parameters estimated in previous sections and the R&D expenditure figures obtained from the R&D Census of 2011. To do this we first compute the amount of privately financed eligible R&D expenditures for the year 2010. Then we apply the range in demand growth rates for R&D stock obtained in previous section (see Table 15) and estimate the new level of R&D for those eligible to benefit from the new tax incentive. This increase in the level of R&D together with the changes in the parameters of the tax incentive will imply an increase in the fiscal cost of the instrument. Different fiscal cost scenarios are obtained given the range in demand growth rates considered in the previous section.

It is important to have in mind that these calculations are based on assumptions so the numbers we obtain should be considered as a reference and most probably an upper bound. These assumptions are:

1. Firm eligibility. We consider two scenarios of firm usage of the tax incentive. First that all 100% of firms that are eligible to benefit from the new tax incentive make use of it. This should constitute an upper bound for the fiscal cost. However, not all firms may be willing to apply to the tax incentive, so we assume a second scenario in which 50% of eligible R&D performers make use of the tax incentive (see explanation in page 53).
2. The R&D expenditures we observe from the results of the 2011 R&D Census constitute one big R&D project. As previously discussed, the tax incentive works through the certification by Innova Chile of an R&D Project or Contract that firms apply for. We do not have information at the project level, but we observe overall R&D expenditures. This implies, again, that our estimations constitute an upper bound. A certain proportion of overall R&D expenditures could alternatively be assumed to represent the R&D Projects or Contracts that are eligible to benefit from the tax incentive.
3. For now we assume that all firms are tax liable hence eligible to receive the tax credit; although this might not be the case. However, as firms are able to carry forward unused tax credits, we assume the government is going to spend this at some point anyway.
4. Since there is no information on extramural R&D by source of funding we assume that the proportion of privately financed intramural R&D (83%) is the same as the proportion of privately financed extramural R&D.
5. Since we do not have cross information on type of R&D cost and source of funding, we will apply the proportion of privately financed intramural R&D to the costs that are eligible to be covered by the tax incentive. We add up current costs, software costs and the annual depreciation rate of land and buildings (assuming a depreciation rate of 4%) and equipment and machinery costs (assuming a depreciation rate of 10%) to build the amount of R&D costs eligible to be covered by the tax credit. This amount represents on average 87.3% of overall intramural R&D costs. Of this proportion we will only consider the 83% that is privately financed with firm resources (meaning 83% x 87.3% of R&D expenditures).
6. We furthermore assume that the distribution of R&D by type of cost for intramural R&D is the same than for extramural R&D. This means that we will consider 87.3% of extramural R&D expenditures

(which should include eligible expenditures covered by the tax incentive) and then consider 83% of this result, to obtain privately financed extramural R&D expenditures.

To compute the gross fiscal cost we calculate first the amount of eligible privately financed R&D expenditures to be covered by the tax incentive. We consider all current costs, software costs and the annual depreciation rate of lands and buildings, and machinery and equipment (for both intramural and extramural R&D expenditures based on the previously explained assumptions). To this level of eligible expenditures we apply the range of growth rates of demand for R&D according to each R&D performer profile (i.e. only intramural R&D performer; both intra and extramural R&D performer; and only extramural R&D performer) that we computed in the previous section (see Table 15).

Using this new level of privately financed R&D (including the increase in R&D due to the reduction in its user cost) we estimate the gross fiscal cost using the following expression:

$$Fiscal\ cost = 35\% \cdot eligible\ expenditures + 65\% \cdot 18.5\% \cdot eligible\ expenditures$$

where 18.5% is the corporate tax rate in 2012. For those firms whose 35% of eligible R&D expenditures surpass the cap of 15,000 UTM we will consider this upper bound, instead of the $35\% \cdot eligible\ expenditures$, and to this we will add the $65\% \cdot 18.5\% \cdot eligible\ expenditures$.

Using the above mentioned expression we obtain the gross fiscal cost under each scenario of R&D growth rate and for each R&D performer profile. We then add up the fiscal cost associated with each R&D performer profile to obtain the total gross fiscal cost. For example, consider a long run demand change including novice R&D performers (column 4 of Table 19); the fiscal cost under this scenario is given by the following expression:

$$Fiscal\ cost = MMCLP\$42{,}313.3 + MMCLP\$19{,}083 + MMCLP\$4{,}018.6 = MMCLP\$65{,}414.8$$

We express the gross fiscal cost under each scenario as a proportion of the total NSI budget of 2010 (MMCLP$268,508) obtained from the Innovation Division of the Ministry of Economics. These results are showed in Table 19. However, if we consider the effects that a change in R&D could have over output (discussed in the previous section), we can expect an increase in the corporation tax bill, which ultimately reduces the overall fiscal cost of the incentive.

To calculate the corporation tax bill from an increase in output, we consider the sales of R&D performers in 2010 (CLP$17,380 billion) and apply the respective growth rate in output from Table 16 and Table 17. However, we need to know which proportion of sales corresponds to profit, which is the base over which the corporate tax is applied. From Banco Central de Chile (2010) we obtain the net profit margin for year 2008 as a percentage of sales by firm size (23.4% for Micro firms; 11.4% for SMEs; and 9.9% for large firms). We calculate a weighted average of the net profit margin using the proportion of firms by size on the total number of R&D performers. We do this because a simple average does not represent the composition of the sample of R&D performers. As larger firms mostly compose this group, we need to add more importance to their profit rate. From Figure 1 we know that large, SMEs and micro firms represent 66%, 31% and 3% of R&D performers respectively. Consequently we estimate an average net profit margin rate as follows:

$$Average\ net\ profit\ margin\ rate\ (\%\ sales) = 66\% \cdot 9.9\% + 31\% \cdot 11.4\% + 3\% \cdot 23.4\% = 10.78\%$$

We apply the average net profit margin (10.78%) to the sales increase from Table 17 for each scenario and then calculate the increase on corporation tax bill by applying a 18.5% rate valid for year 2012. That is, how much extra tax revenues the government is going to collect given the expected output increase. For example, if we consider scenario "A" on Table 20 (based on private elasticity) we obtain the following expected increase on the corporation tax bill for a change in R&D under situation (a)[48].

$$Corp.tax\ bill\ increase\ (A) = (2.29\% \cdot CLP\$17{,}380\ billion) \cdot 10.78\% \cdot 18.5\% = MMCLP\$7{,}933.87$$

The results indicate that the effects on output growth can reduce the fiscal cost of the incentive scheme, although the reduction does not offset the fiscal cost of the incentive. In the short run the net fiscal cost considering possible externalities from increased R&D levels (using social elasticity) can go from MMCLP$19,289.75 to MMCLP$43,456.61 in the long run, representing 7.2% to 16.2% of the total NSI budget of 2010 respectively. If we consider that only 50% of eligible firms make use of the tax incentive, the fiscal cost in the short run, based on a private elasticity, could reach MMCLP$22,175.16, around 8.3% of the 2010 NSI budget.

[48] The reported result might differ from the reader´s calculations due to the report of rounded numbers to 1 or 2 decimals. Our results considers all decimals.

## Table 19. Gross fiscal cost after an increase in R&D demand due to changes in the tax incentive

| Category of R&D Performer | Proportion of each category over all R&D performers in 2010 | Fiscal cost considering: | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | New levels of R&D in short run and 20% of novice R&D performers (MMCLP$) (a) | New levels of R&D in long run and 20% of novice R&D performers (MMCLP$) (b) | New levels of R&D in short run without 20% of novice R&D performers (MMCLP$) (c) | New levels of R&D in long run without 20% of novice R&D performers (MMCLP$) | 50% of new levels of R&D in short run and 20% of novice R&D performers (MMCLP$) (d) | 50% of new levels of R&D in long run and 20% of novice R&D performers (MMCLP$) (e) | 50% of new levels of R&D in short run without 20% of novice R&D performers (MMCLP$) (f) | 50% of new levels of R&D in long run without 20% of novice R&D performers (MMCLP$) (g) |
| Only intramural R&D performer (a) | 67% | 34,690.8 | 42,313.3 | 30,973.3 | 36,549.5 | 17,345.4 | 21,156.6 | 15,486.7 | 18,274.7 |
| Both intramural and extramural R&D performer (b) | 23% | 13,616.7 | 19,083.0 | 11,904.6 | 15,118.1 | 6,808.4 | 9,541.5 | 5,952.3 | 7,559.0 |
| Only extramural R&D performer (c) | 10% | 3,976.7 | 4,018.6 | 3,683.7 | 3,704.6 | 1,988.3 | 2,009.3 | 1,841.8 | 1,852.3 |
| **GROSS FISCAL COST UNDER EACH SCENARIO (a+b+c)** | | **52,284.2** | **65,414.8** | **46,561.6** | **55,372.2** | **26,142.1** | **32,707.4** | **23,280.8** | **27,686.1** |
| **As a proportion of 2010 NSI Budget (MMCLP$268,508)** | | **19.5%** | **24.4%** | **17.3%** | **20.6%** | **9.7%** | **12.2%** | **8.7%** | **10.3%** |

## Table 20. Fiscal cost of the tax incentive

| Category of R&D Performer | Fiscal cost considering: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | New levels of R&D in short run and 20% of novice R&D performers (MMCLP$) (a) | New levels of R&D in long run and 20% of novice R&D performers (MMCLP$) (b) | New levels of R&D in short run without 20% of novice R&D performers (MMCLP$) (c) | New levels of R&D in long run without 20% of novice R&D performers (MMCLP$) | 50% of new levels of R&D in short run and 20% of novice R&D performers (MMCLP$) (d) | 50% of new levels of R&D in long run and 20% of novice R&D performers (MMCLP$) (e) | 50% of new levels of R&D in short run without 20% of novice R&D performers (MMCLP$) (f) | 50% of new levels of R&D in long run without 20% of novice R&D performers (MMCLP$) (g) |
| GROSS FISCAL COST (a) | **52,284.2** | **65,414.8** | **46,561.6** | **55,372.2** | **26,142.1** | **32,707.4** | **23,280.8** | **27,686.1** |
| A. Corporation tax bill considering private elasticities and a rate of 18.5% (b) | 7,933.87 | 17,890.18 | 2,070.00 | 10,366.93 | 3,966.93 | 8,945.09 | 1,035.00 | 5,183.46 |
| B. Corporation tax bill considering social elasticities and a rate of 18.5% (c) | 11,900.80 | 26,835.27 | 3,105.00 | 15,550.39 | 5,950.40 | 13,417.64 | 1,552.50 | 7,775.20 |
| NET FISCAL COST UNDER SCENARIO "A" (a-b) | 44,350.32 | 47,524.59 | 44,491.61 | 45,005.24 | 22,175.16 | 23,762.29 | 22,245.80 | 22,502.62 |
| NET FISCAL COST UNDER SCENARIO "B" (a-c) | 40,383.39 | 38,579.50 | 43,456.61 | 39,821.78 | 20,191.69 | 19,289.75 | 21,728.30 | 19,910.89 |
| NET FISCAL COST UNDER SCENARIO "A" - % OF 2010 NSI BUDGET | 16.5% | 17.7% | 16.6% | 16.8% | 8.3% | 8.8% | 8.3% | 8.4% |
| NET FISCAL COST UNDER SCENARI "B" - % OF 2010 NSI BUDGET | 15.0% | 14.4% | 16.2% | 14.8% | 7.5% | 7.2% | 8.1% | 7.4% |

# 4 QUALITATIVE INTERVIEWS

To get an idea of how the business world regards and responds to the R&D tax incentive scheme, five interviews were conducted with companies from different sectors of the Chilean economy, using an open-end semi-structured questionnaire. The questions aimed at finding out how R&D is conducted in these firms and what are the reasons for applying (or not) for the R&D tax incentives. Two large, two medium and one small enterprise were approached, two of which had not yet applied for R&D tax incentives at the time of the interview. All of them do R&D activities on a regular basis.

The major lessons coming out of this low number of interviews are as follows:

- All respondents considered R&D and innovation as important for their own business as well as for the country as a whole.
- Regarding the rationale for introducing such a policy, the difficulties of finding qualified people to execute and to manage the R&D projects is often mentioned as a major obstacle to carry out R&D, more so perhaps than financial difficulties.
- Even though firms did not mention financial constraints as the main obstacle to carry out R&D activities, the incentive was in general considered as a step forward. Although other restrictions faced by firms related to the natural life cycle of businesses should be kept in mind and considered by the policymaker.
- Regarding collaborative R&D practices (relevant for the collaborative version of the tax incentive) some firms do collaborate with research organizations, mainly universities, some of which are located abroad. In general the experience is satisfactory and valuable, although in some cases it was mentioned that the difference of culture between the academic and business sector might constitute an obstacle (regarding timings and objectives of research). In some cases it was mentioned that local R&D capacities were a little difficult to find, but they are perceived as currently improving and developing.
- The interviewees were in general aware of the new R&D tax credit policy, although, especially for the small firms, they were not completely informed of all the stipulations of the policy. For instance, one respondent was not sure whether the policy applied to him because R&D was his primary business and most of the R&D services were exported; or another firm thought that the R&D tax credits could only be applied for when the firm had taxes to pay. SMEs seem to be less informed than large firms that have an existing R&D lab.
- Access to resources for small firms is often mentioned as one of the more salient qualities of the project. But it was also mentioned that the policy seemed to be less appropriate for short term and low scale R&D projects.
- The design of the scheme was considered reasonable and sufficiently motivating to apply, although the doors should be kept open to modify the policy later on. In general the tax credit

rate was considered quite reasonable and the cap was not thought as binding. The extension of the benefit to intramural R&D was highly valued by firms.

- More flexibility in the future use of the tax credit was suggested, as the needs and costs of the R&D project might change in the course of its execution. In some cases it was mentioned that a differentiation by size should be considered (proposed basically by small firms).
- A matter of serious concern was the time needed to apply for the tax credits. Especially for firms with little experience in applying before, to the old tax credit scheme or to R&D subsidies, the application process was considered to be cumbersome. The type of information required was sometimes considered difficult to provide. Some interviewees also suggested that the evaluation process could be more agile.
- The application costs were evaluated at somewhere between 2% and 5% of the return from this policy. Especially discouraging was regarded the application fee, and suggestions were made to make it payable only in case the application was successful.
- Often it turned out that the R&D project would have been carried out anyway, even without the R&D tax credit, and that the tax credit was rather considered as a gift from heaven enabling the firm to set up or strengthen the R&D department. A few times it was also reported that the project would be abandoned without the R&D tax credit, implying that the project was only marginally profitable.

# 5 REFERENCES


Banco Central de Chile (2010). Una caracterización de las empresas privadas no financieras de Chile. *Studies in Economic Statistics Nº83,* by José Perez Toledo.

Benavente, JM, De Gregorio, J., and Nuñez, M. (2006). Rates of Return and the Industrial R&D in Chile, Documentos de Trabajo Nº220, Universidad de Chile, Departamento de Economía.

Benavente, J. M., "The role of research and innovation in promoting productivity in Chile", *Economics of Innovation and New Technologies*, 15, 2006, 301-315.

Bloom, N., Griffith, R. and Van Reenen, J. (2002). Do R&D Credits Work? Evidence From A Panel Of Countries 1979-97, *J. of Public Economics*, 85, 1-31.

Cohen, Wesley, M. and Daniel A. Levinthal. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation, *Administrative Science Quarterly*, 35, pp. 128-152.

Cameron, A. C., & Trivedi, P. K. (2005). *Microeconometrics: Methods and applications*. Cambridge University Press.

Crepon, B., Duguet, E., and Mairesse, J. (1998). Research, Innovation And Productivity: An Econometric Analysis At The Firm Level. Economics of Innovation and new Technology, 7(2), 115-158.

Griffth, R., Redding, S., & Reenen, J. (2001). Measuring the Cost-Effectiveness of an R&D Tax Credit for the UK. Fiscal Studies, 22(3), 375-399.

Griliches, Z. (1981). Market Value, R&D and Patents, *Economic Letters* 7, 183-187.

Griliches, Z. (1996). *R&D and Productivity: The Econometric Evidence*, Chicago: Chicago University Press.

Hall, R. E., & Jorgenson, D. W. (1967). Tax policy and investment behavior. *The American Economic Review*, *57*(3), 391-414.

Hall, B. (2007). Measuring the Returns to R&D: The Depreciation Problem, National Bureau of Economic Research Working Paper 13473.

Hall, Bronwyn, Jacques Mairesse and Pierre Mohnen. (2010). "Measuring the returns to R&D", in the *Handbook of the Economics of Innovation*, B. H. Hall and N. Rosenberg (editors), Elsevier, Amsterdam, pp. 1034-1082.

Harris, R., Li, Q. C., & Trainor, M. (2009). Is a higher rate of R&D tax credit a panacea for low levels of R&D in disadvantaged regions?. *Research Policy*, *38*(1), 192-205.

Imbens, G. and D. Rubin. (2012). Causal Inference in Statistics and Social Sciences. Forthcoming.

Jorgenson, D. (1967). The theory of investment behavior. In *Determinants of investment behavior* (pp. 129-188). NBER.

Lokshin, B. and Mohnen, P. (2010) How effective are level- based R&D tax credits? Evidence from the Netherlands, UNU-MERIT Working Paper No. 2010-40.

Lokshin, B., & Mohnen, P. (2012). How effective are level-based R&D tax credits? Evidence from the Netherlands. *Applied Economics*, *44*(12), 1527-1538.

Mairesse, J. and B. Mulkay (2011). Evaluating the 2008 Reform of the R&D Tax Credit in France. Mimeo.

Organisation for Economic Co-operation and Development. (2002). *Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development*. OECD

Pakes, A and M. Schankerman (1984). The rate of obsolescence of patents, research gestation lags, and the private rate of return to research resources, in R&D, Patents and Productivity, Zvi Griliches (editor), University of Chicago Press, p. 73-88.

www.sii.cl

www.ine.cl

# 6 ANNEX

## 6.1 Construction methodology of the directory of potential R&D performers

The construction of the directory of potential firms engaged in R&D was done in 2010 by the Ministry of Economics with the support of the National Statistics Office (INE). The Ministry used three sources of information to identify the firms that were potentially engaged in R&D activities. The list was later sent to INE, who was in charge of harmonizing the information collected by the Ministry and of building the firm directory.

The sources of information used by the Ministry were the following:

### *1. List of R&D performers identified by the Ministry of Economics*

The list of potential firms engaged in R&D came from the following sources:

- **Public Funds:**
    - Firms that had their projects supported by the following agencies/programs between 2009 and 2010:
        - Innova Chile of Corfo
        - Innova Bío Bío
        - Invest Chile of Corfo
        - Program "Insertion of researchers in the Industry", of Conicyt.
        - Fondef of Conicyt (for years 2004 and 2009).
        - FIP (Fondo de Innovación Pesquero) of the Ministry of Economics.
        - FIA (Fondo para la Innovación Agraria) of the Ministry of Agriculture.
    - Technological Consortia from Innova Chile, Conicyt and FIA.
    - Firms that received transfers from Conicyt between 2005-2010.
    - Data base from INAPI, applicants of 2009 and 2010.
- **Innovation Surveys:**
    - Firms included in the R&D Census of year 2002.
    - Firms that appeared as R&D performers in the 4th and 5th Innovation Surveys.
    - Firms that appeared as R&D performers in the 1st Longitudinal Firm Survey (ELE).
- **Other sources**
    - 3 directories available in the internet: Industrial Association of Pharmaceutical Laboratories (ASILFA), Industrial Association of Chemicals (ASIQUIM), Chilean Association of firms in Information Technology (ACTI) and Association on Electric and Electronics industry (AIE).
    - Potential R&D firms identified through a survey conducted on a Seminar at SOFOFA.
    - Firms included in Government agencies publications on successful STI cases.

### *2. Third R&D Survey*

Firms that appeared as R&D performers in the Third Survey of R&D Expenditures and Personnel, collected in 2009.

### *3. List of firms built by the Ministry of Economics and INE*

The Ministry of Economics subcontracted the application of a survey[49] to a firm directory (provided by the tax office) of 10 thousand firms approximately with the aim of identifying those that had been engaged in R&D activities between 2005 and 2010. This exercise threw a total of 562 potential R&D performers to be included in the directory.

Using these sources of information a directory containing potential firms engaged in R&D activities was built by the INE. The effective number of surveyed firms in the Census totaled 914.

[49] The questionnaire is short and includes 8 "Yes/No/Not sure" answers.

## 6.2 Qualitative Interviews: Questionnaire for non-users

El objetivo de esta entrevista es recoger información sobre el nivel de conocimiento y la opinión de aquellas empresas involucradas en actividades de I+D que no han hecho uso del incentivo tributario a la investigación y desarrollo (I+D). Recomendaciones sobre cómo mejorar el instrumento serán elaboradas utilizando la información obtenida a partir de esta entrevista.

***Tema 1: Organización de la investigación y desarrollo en empresas***

1. ¿La empresa realiza I+D en forma continua u ocasionalmente?
2. ¿Qué entiende Ud. como I+D?
3. ¿Cuál es el rol de las actividades de I+D en la estrategia de la empresa? ¿Cuál es el objetivo de esta actividad dentro de la compañía?
4. ¿Han logrado los resultados esperados de las actividades de I+D?
5. ¿Cómo se organiza la I+D en la empresa? Por ejemplo:
    a. ¿Cuenta la empresa con un director de proyectos de I+D?
    b. ¿Tiene el departamento de investigación su presupuesto propio? ¿A cuántos años?
    c. ¿Quién toma la decisión última respecto de qué proyectos de I+D se llevan a cabo?
    d. ¿Cuántas personas trabajan en promedio en las actividades y/o unidad de I+D?. ¿Qué nivel de formación tienen estas personas?
        - Formación técnica
        - Educación terciaria (pregrado)
            - Magíster
            - Ph.D. / Doctorado
        - Postdoc.
        - Otro
    e. ¿La empresa cuenta con un laboratorio propio donde conduce actividades de I+D?
6. ¿La empresa subcontrata I+D a agentes externos a ella?
    a. ¿Qué motiva a la empresa a subcontratar I+D fuera de la empresa? ¿Es por falta de personal calificado? De ser así, ¿Por escasez o por tema de costos? ¿O más por un tema de proyectos puntuales que no requieren de mayor involucramiento de la empresa?
    b. ¿A quién? Ej. Otras empresas, universidades..
    c. ¿Localmente o en el extranjero? ¿Por qué?
7. ¿Cómo se da el balance entre investigación interna (intramuros) e investigación subcontratada (extramuros)?
8. ¿Cuál es la experiencia en general de la empresa respecto de la subcontratación de I+D?
9. ¿Qué obstáculos/problemas percibe al respecto?
10. ¿Cuál es el principal obstáculo que enfrenta la empresa para llevar a cabo actividades de I+D?

***Tema 2: Uso del incentivo tributario a la I+D***

11. ¿Está la firma al tanto de que el Estado ha puesto a disposición de las empresas que inviertan en actividades de I+D un incentivo tributario del 35% sobre el impuesto de primera categoría?
    (Si respuesta es "Sí" pasar a pregunta 11. De lo contrario saltar a pregunta 12)
12. Para aquellos que sí conocen el incentivo:
    a. ¿Cómo se enteró del incentivo?
    b. ¿Planea la empresa aplicar próximamente?
        i. Si no planea aplicar: ¿Por qué?
        ii. Si planea aplicar: ¿Cuál es la principal motivación para aplicar? ¿Por qué no ha postulado antes?
        iii. ¿Aplicará con un proyecto de I+D interno o mediante un contrato con un organismo de investigación externo? ¿Qué motiva una u otra figura?
        iv. Si se le rechazara la certificación del proyecto de I+D al que planea postular, ¿Lo llevaría a cabo igualmente?
13. ¿Usted cree que este instrumento constituye un real incentivo a que las empresas realicen más actividades de I+D? ¿A qué tipo de empresas usted cree que beneficia más?
14. ¿Qué opina es más efectivo? ¿Un incentivo horizontal como este o subsidios directos? ¿Por qué?
15. ¿Alguna recomendación final respecto al incentivo?

## 6.3 Qualitative Interviews: Questionnaire for users

El objetivo de esta entrevista es recoger información sobre la percepción de los usuarios acerca del funcionamiento del incentivo tributario a la investigación y desarrollo (I+D). Sugerencias para mejorar su funcionamiento serán elaboradas en base a las observaciones de los entrevistados.

***Tema 1: Organización de la investigación y desarrollo en empresas***

1. ¿La empresa realiza I+D en forma continua u ocasionalmente?
2. ¿Qué entiende Ud. como I+D?
3. ¿Cuál es el rol de las actividades de I+D en la estrategia de la empresa? ¿Cuál es el objetivo de esta actividad dentro de la compañía?
4. ¿Han logrado los resultados esperados de las actividades de I+D?
5. ¿Cómo se organiza la I+D en la empresa? Por ejemplo:
    a. ¿Cuenta la empresa con un director de proyectos de I+D?
    b. ¿Tiene el departamento de investigación su presupuesto propio? ¿A cuántos años?
    c. ¿Quién toma la decisión última respecto de qué proyectos de I+D se llevan a cabo?
    d. ¿Cuántas personas trabajan en promedio en las actividades y/o unidad de I+D?. ¿Qué nivel de formación tienen estas personas?
        - Formación técnica
        - Educación terciaria (pregrado)
            - Magíster
            - Ph.D. / Doctorado
        - Postdoc.
        - Otro
    e. ¿La empresa cuenta con un laboratorio propio donde conduce actividades de I+D?
6. ¿La empresa subcontrata I+D a agentes externos a ella?
    a. ¿Qué motiva a la empresa a subcontratar I+D fuera de la empresa? ¿Es por falta de personal calificado? De ser así, ¿Por escasez o por tema de costos? ¿O más por un tema de proyectos puntuales que no requieren de mayor involucramiento de la empresa?
    b. ¿A quién? Ej. Otras empresas, universidades..
    c. ¿Localmente o en el extranjero? ¿Por qué?
7. ¿Cómo se da el balance entre investigación interna (intramuros) e investigación subcontratada (extramuros)?
8. ¿Cuál es la experiencia en general de la empresa respecto de la subcontratación de I+D?
9. ¿Qué obstáculos/problemas percibe al respecto?
10. ¿Cuál es el principal obstáculo que enfrenta la empresa para llevar a cabo actividades de I+D?

***Tema 2: Uso del incentivo tributario a la I+D***

11. ¿Cuándo aplicó la firma al incentivo tributario en I+D?

12. ¿Cómo se enteró la empresa de la existencia de incentivo?
13. ¿Qué motivó a la firma a participar?
14. ¿Cómo se organizó el proceso de postulación? ¿Intervino algún mediador (bróker o consultora por ejemplo)? ¿Quién es la persona encargada de postular al beneficio? (el dueño, gerente, departamento de I+D, el departamento de contabilidad, ventas, u otro?
15. ¿Usted cree que este instrumento constituye un real incentivo a que las empresas realicen más actividades de I+D? ¿A qué tipo de empresas usted cree que beneficia más?
16. ¿Qué opina es más efectivo? ¿Un incentivo horizontal como este o subsidios directos?, ¿por qué?
17. Si a la empresa no se le hubiese adjudicado la certificación del proyecto de I+D, ¿Habría realizado el proyecto de igual forma?
18. ¿Cómo fue la experiencia respecto del proceso de postulación? ¿Simple/Complicado? ¿Rápido/Lento?
19. ¿Cuál es el grado de satisfacción con el proceso de aplicación? Responda usando escala 5: Muy satisfecho; 4: Satisfecho; 3: Indiferente; 2: Insatisfecho; 1: Muy Insatisfecho.
20. ¿En cuánto estima el costo de postulación? ¿Qué porcentaje del beneficio recibido representa este costo? (costo directo e indirecto; pecuniario y valorado)
21. ¿Tuvo la firma algún reparo respecto de posibles riesgos de filtración de su idea?
22. ¿Qué cambiaría y/o mejoraría del proceso de postulación al incentivo?
23. ¿Cuál es el grado de satisfacción con el diseño del instrumento? Responda usando escala 5: Muy satisfecho; 4: Satisfecho; 3: Indiferente; 2: Insatisfecho; 1: Muy Insatisfecho.
24. ¿Qué cambiaría del diseño del instrumento?
25. ¿Postularía otra vez? En caso de respuesta negativa, ¿Por qué?
26. ¿Alguna recomendación final respecto al incentivo?

## 6.4 Interview transcription

### *6.4.1 Interviewee: Juan Elizalde, Director of the R&D and Sales Department (Core Area of the firm)*

Date of interview: 11 December 2012.
Firm: Cramer. Is a Chilean family firm; aimed at the production of aromas for the food and cosmetic industries. Headquarters are in Chile and has subsidiaries in Perú, Brazil and Bolivia. Plus sales representatives in other Latin American countries, Europe and Asia. No relevant local competitors. Just a small one in the fragrance area and other small ones in the food area. Foreign competitors (MNCs) are more relevant, but they just have sales representation, they do not have the R&D labs in Chile. Mainly US and Swiss participation.
Size: Large, market participation of more than 50% in local market.
Application: Applied to the new version of the incentive in September 2012. 2year R&D project (intramural R&D project)

***Organization of Research and development***

1. The firm does R&D on a regular basis or occasionally?

On a regular basis.

2. Which is your definition of R&D?

Any creation or adaptation, in the area of the firm, of product formulas that fulfill the requirements of their customers.

Although R&D is aimed at satisfying customer needs, it is not necessarily reactive. For them the customer can be the market or even a current tendency in aromas. But they also do proactive R&D, proposing new aromas to their customers.

Some of their projects are very short, responding to a specific flavor requirement of a client. Sometimes they have the flavor, sometimes they have to adapt it, modify it (ie. from liquid to solid) or some other times to create it. Some other times the client does not know what exactly (s)he wants, so the firm gives advice based on market tendencies and sensorial panels for example (analogous to market studies but applied to sensorial tests on flavors and aromas).

They also have more “long term” R&D projects where their target is to create flavors and aromas they do not have, like avocado aroma (which is very difficult to develop as it is chemically very complicated). Also they set targets like making processes more efficient.

3. Which is the role of R&D in the strategy of the firm? Which is the aim of this activity within the company?

R&D is part of the core of the market strategy of the firm. They have the target each year of reaching a proportion of 10% of sales due to new products. For them the definition of new product is new to the firm (could already been available in the market).

But also they propose new products to their customers. For example they brought 4 years ago these flavored healthy water very trendy in Europe. This did not exist in Chile. They brought it and offered it to their customers helping to introduce a new product in the Chilean market, but already available abroad. This is also considered a new product for them. Also "stealing" a product to competitors.

4. Have you achieved expected R&D results?

Yes.

5. How is R&D organized within the firm?

The firm is organized in three main areas:

- Core area: R&D and sales. That connects with customers and the external environment.
- Logistics: production and control, which manufactures the product once the customer has agreed on it.
- Supporting areas: Finance, Informatics.

Strategy of the firm is based on the core area; it is the most important one.

a. Is there a director of R&D projects?

Yes, the director of the "Core" Area, of R&D and Sales. The interviewee is the director of it.

b. Does the R&D department have its own budget? On which time span?

R&D department does not operate with a budget because the owners consider it a core activity within the firm so they do as much as it is needed.

c. Who makes the ultimate decision to carry out an R&D project? Does the firm have an own laboratory? Among other related questions).

There is a directory (composed by the owners, as it is a family firm. Three members) that gather periodically. The interviewee joins them every 6 months to define long run guidelines regarding the direction the development of the firm. Long run R&D projects are part of this strategy.

d. How many people work, on average, in R&D activities? Which kind of qualification do they have?

Around 305 people work in Cramer. 45 people work in R&D (in lab). The director has a PhD in food. Others have masters. In general the R&D personnel are professionals in food engineering and biochemistry. Mainly coming from traditional universities (U. of Chile and U. Valparaíso). Around 5 masters and other 2 PhDs.

e. Regarding human capital hiring, is it easy to find within the local labor market of you have to turn to foreign labor markets?

It is difficult. In Chile there is no critical mass of people with experience because Cramer is almost the only firm doing what they do. And foreign firms do not have their R&D labs in Chile, so there is no local labor market in their area/sector. They have to form people from scratch in Chile. But in Brazil is not like that, local market has more professionals in the area.

So in Chile their strategy is to attract university graduates at their thesis stage. And if they like the person they start training him/her to keep him/her later on after they finish their thesis. But they do not care about the thesis because for them is not useful. Attracting graduates at thesis stage is just a recruitment strategy.

6. The firm subcontracts R&D externally?

No, they do everything internally.

   a. What motivates the firm to subcontract R&D? Which is the reason? Lack of own capacities/lack of time/not interested on getting involved in the R&D process/better capacities outside.

Does not apply.

   b. To whom the firm subcontracts R&D? Other firms? Universities?

Does not apply.

   c. Mainly locally or abroad? Why?

Does not apply.

7. Which is the balance of between intramural and extramural R&D?

Does not apply.

8. Which is the general experience of the firm regarding subcontracting R&D?

Does not apply.

9. Which obstacles do you see here?

Does not apply.

10. Which is the most important obstacle that the firm faces to carry out R&D?

They do not perceive any obstacle regarding intramural R&D. They have competent professionals, although they have to train them (a year or so). Money is also not an issue.

But they do face obstacles regarding extramural R&D. There are no adequate firms or research units in Chile that could satisfy their demand (remember they are almost a monopoly in Chile in their area). Also there is the issue of confidentiality when you are subcontracting something.

They do not face any financial obstacle. R&D is so important in the firm that they do not work with a budget and the owners re-invest a lot on money in R&D.

IPRs is not an issue, at least in the sector they work on. They do not patent, although it is easy to copy. They do not work like that, putting barriers through IPR. They have never felt the need to protect themselves with IPRs. They work a lot with suppliers; they buy ingredients from them (90%) and then they process them to produce the aromas and flavors they sell later. Suppliers have never put them a barrier with IPRs, and they don´t do it as well. Not a practice in the sector.

***Use of the instrument***

11. When did the firm apply to the R&D tax incentive?

    7 September 2012, under the new scheme. Intramural R&D.

12. How did the firm come to know about the R&D tax incentive?

    Through the media and universities (the interviewee has connections with the university). Also through CORFO as they had applied before to a Innova Chile instrument so they were in the mailing list and received the information from InnovaChile regarding the new tax credit scheme. His perception is that there was a lot of diffusion about the instrument.

13. What motivated the firm to apply?

    Even though they don´t have financial constraints, resources are always scant. At the moment they had the human resources, the motivation and willingness to apply. They did so and the cycle ended. But after that **they decided they would not apply again.**

14. How was the application process organized? Did any intermediary/broker helped in the application process? Who is the person in charge of the application?

    No, they applied using own capacities.

15. Do you think this instrument is a real incentive for firms to engage on R&D? To whom you think it benefits more?

    It is a good incentive, although it will benefit firms that have a critical mass in R&D. For example of a minimum of 15 researchers doing in house R&D. For these firms it makes sense.

    With no doubt this incentive should trigger more R&D engagement and higher levels of R&D. In fact this was the motivation of the firm to apply. For sure this initiative should motivate other firms to do R&D and even increase their current levels.

    A reduction in taxes is always a good incentive for firms.

16. What do you think is more effective? A horizontal incentive like this one or a direct subsidy? Why?

His experience with subsidy was very bad and would not apply again. But tax reductions are always welcomed.

17. Would the firm have carried out the R&D project anyway if InnovaChile had refused the certification of the project

Yes, they do not have financial constraints to carry out their R&D projects.

18. How was the experience of the application process? Was it easy/burdensome? Fast/Slow?

[The firm had applied earlier to another InnovaChile instrument (a grant on innovation), which is pretty similar to the application process to the tax credit instrument. By then they decided to collaborate with Fundación Chile (a Pb-Pv research organization) because they knew that the application was going to be very complicated.

The interviewee argues that the application was burdensome due to the form of the application. He recognizes that the information was easily available from the website and that application forms were easily downloadable from the website. But for somebody that has never applied for a project it turns to be very difficult. For example, during the application they were asked about milestones within the projects; and to report sequence of events they were not sure of in advance. They turned to F. Chile for help in that moment and they were not charged for this, although Cramer hired couple of small services from F. Chile in the agriculture area. Because the project was related to essential oils and F. Chile monitored the plantation process. They had a very good experience with F. Chile.

But after the experience they will never apply again to this instrument, not too much for the burdensome application process but due to the ex post financial inspection from InnovaChile. They felt “finger pointed”. They faced a lot of rejections on some expenditure they did and had to give back money. This is mainly due to the form, because they did not know clearly how to organize the financial information of the project. He says the experience was a little traumatic. He attributes this to some paranoia present in that period regarding some irregularities with the government related to the miss use of public money, so they were overly supervised and felt like they were doing something wrong. This occurred before in 2007-2009]

Now they applied to the tax incentive using internal capacities (did not collaborate with F. Chile). Even though they had the experience of applying before to another InnovaChile instrument (the one they will never apply again) it was still very burdensome and took a lot of time. The interviewee assured that he spent 4 days full time trying to apply inline and finally he could not do it. But an Innova Chile executive helped him to gather the correct information and finally accomplish the application.

The problem, according to him, has to do with the form and structure of the application form. It does not have a logical sequence; it is burdensome; it is little adjusted to the real firm dynamics; and very redundant. The interviewee, the director of the R&D area, mentions that he spent 3 hours daily writing down the project. Lots of times he was about to quit the application.

But after receiving the benefit he was satisfied about it. But still the process was very complicated. The application process implies a distraction for the firm, which takes the people away from their focus. They have the pressure of the directory that pushes for faster results for the ongoing projects while they are spending time with the formulation of the project. Is difficult to handle it and organize it.

Also they never knew they had to apply online, or that they had to pay a fee. So these are factors that start demotivating the firm through the application process.

Still they are satisfied with the time it took to receive the answer from Innova Chile to their application (2 months). The executive was very helpful.

19. Which is the degree of satisfaction with the application process? (Use Likert scale of 4: 1. Very Satisfied; 2. Satisfied; 3. Unsatisfied; 4. Very unsatisfied)

3, Unsatisfied.

20. Which is your estimation of the application cost? What proportion of the benefit represents this cost? (Pecuniary and non pecuniary)

He does not know exactly but he gives some hints. He spent around 3 hours daily writing and editing the project, for about 2 months. Plus 2 other people full time for 2 months. He estimates a cost of application of around USD10,000.

21. Which is the degree of satisfaction with the design of the instrument? (Use Likert scale of 4: 1. Very Satisfied; 2. Satisfied; 3. Unsatisfied; 4. Very unsatisfied)

4-5, Very satisfied-Satisfied. He thinks it is a very good model.

22. What would you change in the design of the instrument itself?

Overall he thinks it is a very good and fair model. The cap of 15,000 UTM is pretty fair and should not constitute a disincentive. He also considers fair the 35%. Considering R&D as expenses was already possible so they do not consider the deductibility of the 65% of R&D expenditures as an incentive per se.

He has a comment on small projects; mainly due to the minimum amount of R&D firms need to do to be eligible (over 100 UTM according to the law). He mentions that they have different ranges of R&D projects. Some of them are very reactive and short in time. They are not able to apply to these kinds of projects due to a timing constraint and to the minimum floor. So, he is able to include half of the researchers within the instrument, those that are working on larger and longer projects. But the rest of the researchers within the R&D department are working on short term and reactive projects that do not fit within the instrument. So they are left out from the incentive.

He also thinks the program should not charge a fee to apply, he considers it a disincentive. For them the fee was almost USD4,000, amount he considers high. And they had to pay it even without knowing if they were going to get the certification or not. It could be more understandable if they

had to pay it if the certification was granted. He considers this could be a disincentive especially for smaller firms.

23. Would you apply again?

No. Application process is too burdensome and takes too much time.

### *6.4.2 Interviewee: Fernando Nilo, Director.*

- Date of interview: 12 December 2012.
- Firm: Recycla Chile[50]. Founded in 2003; is devoted to the recycling of technological waste (computers, phones, electrical appliances, among other). They created the first recycling plant of electrical devices in Latin America (they call themselves as a first mover). Their slogan is "Innovation in environment" and they are constantly looking for innovations for environment. For example they are now studying the feasibility of recycling photovoltaics, given the expected increase in solar panels in Chile; also medicines.

  They receive the devices and take apart pieces and parts. They separate plastics, wires and metals from the dangerous parts like the batteries and screens. Then the deliver these raw materials to industries to be processed (mainly Europe). Metals stay in Chile.

  Their competitors in Chile are those organizations that collect waste, but should not take the electronics because they should be recycled; even the people in general are competitors because they keep technological and electronic waste at home (electrical appliances, phones, computers, etc.) instead of trying to recycle (because they pollute and are dangerous for the environment). Some international competition as well, but the difference is the value added they provide because they really do recycling (not just collecting waste).

  They define themselves as a social innovation as well. Because they offer jobs to ex female convicts, so they are not only doing environmental recycling, but social recycling as well.

  They also offer a "recycling certification" or recycling seal; available for companies that recycle their electronic devices (they want to patent this; they are checking if this seal is patentable or not). He has sold this certification to important MNCs like Lenovo and Enjoy.
- Size: Medium (based on sales).
- Application to tax credit: Not yet, but would like to apply soon.
- Use of other public funding: Yes, they started with Seed Capital from CORFO. It was very difficult, they got it, was a very traumatic experience and they would not apply again. He mentions that the firm applied and was rejected 3 times. On a meeting he saw the Executive Director of CORFO and told him "how are you talking about innovation is you don´t finance an innovative project like this one that has received international awards. I am collaborating with a European firm in the area and I am bringing experts to Chile". He mentions that the Director of Innova Chile agreed to evaluate his project for a 4th time and he finally got the seed capital. But the executive of Innova Chile in charge of his application gave the firm half the subsidy (20%) they commonly give to other firms (40%), in more conservative sectors, arguing that he still did not believe in Recycla Chile. But right now the firm is doing great and has received a lot of international and local recognition (in the area of social and environmental innovation) and their case has even been studied and replicated abroad. He argues that within executives from Innova Chile, and in Chile in general, there is a too conservative vision on how to do business. There is no recycling in Chile at all. And with his firm he is proposing

[50] http://www.recycla.cl/en/main/index/

firms to pay for recycling. Which seems too advanced for the local current mentality in the area. That is why he has not been supported as expected.

***Organization of Research and development***

1. The firm does R&D on a regular basis or occasionally?

   On a regular basis.

2. Which is your definition of R&D?

   His interpretation of research is related to the study of new procedures, new methodologies and new markets. Is related to the development of new prototypes, not only of products but also of services. For example, when recycling a laptop you have to offer the service of erasing the memory (data erase) of that computer. So is also related to the study of new related services. It implies a constant development of new products, services and prototypes plus the activities of trial and error.

3. Which is the role of R&D in the strategy of the firm? Which is the aim of this activity within the company?

   Is the mean through which the firm generates value added. Innovating constantly, identifying new market opportunities and reinventing itself permanently is crucial for the firm.

4. How is R&D organized within the firm?

   They don´t have a formal unit of R&D or innovation. The director of the firm mainly defines the innovation strategy. He is in constant collaboration with universities from abroad and receives students permanently. He also gives talks at universities (he has been in MIT, Harvard, Stanford, Catholic University of Chile). MIT for example designed their recycling plant. He is in constant collaboration with universities, mainly from abroad. He is constantly discussing with them new projects and new initiatives, so he has the window permanently open for new projects and ideas. For example, some time ago a Spanish firm, who copied the model of Recycla Chile, came to visit them and they discussed about the plant and some modifications they did. This gave him feedback. For him, being connected to universities, students and new ideas is crucial in their business model. The idea on recycling solar panels in Chile came from the discussion with this Spanish firm.

   a. Is there a director of R&D projects?

   Not formally, but it is the director of the firm, Fernando Nilo, the one that defines the direction of R&D projects and innovations within the firm.

   b. Does the R&D department have its own budget? On which time span?

   Not exactly. They spend as needed.

   c. Who makes the ultimate decision to carry out an R&D project? Does the firm have an own laboratory? Among other related questions).

The director of the firm.

d. How many people work, on average, in R&D activities? Which kind of qualification do they have?

They don´t have researchers internally, no technical internal capacities. They work with 7 voluntaries from universities, students.

e. Regarding human capital hiring, is it easy to find within the local labor market of you have to turn to foreign labor markets?

What he does is very new in Chile so there are no local capacities in technology recycling. There are some capacities (to execute) but the industry is inexistent, the business model is new in Chile (in general there is low recycling culture in Chile) so they tend to look abroad. They rely on students from universities.

5. The firm subcontracts R&D externally?

Yes. They work with these 7 volunteers from universities. They consider their model akin to the one of LG, that subcontracts ideas externally and then they decide what to do.

a. What motivates the firm to subcontract R&D? Which is the reason? Lack of own capacities/lack of time/not interested on getting involved in the R&D process/better capacities outside.

Cost. Having permanent technical capacities is costly (a PhD for example). They hire professionals when needed, to implement specific projects.

b. To whom the firm subcontracts R&D? Other firms? Universities?

Universities.

c. Mainly locally or abroad? Why?

Both.

6. Which obstacles do you see here?

Lack of capacities regarding the recycling technology, because the industry is new in Chile.

7. Which is the most important obstacle that the firm faces to carry out R&D?

Financing a more formal/permanent structure on R&D, marketing, human resources, etc. They are not able to afford a permanent structure on R&D to do intramural R&D.

They also see a threat in IPRs. Since they are a first mover in the industry they are a little afraid that their service about the recycling seal is copied. But they do not know if it is patentable or not, and how to apply to a patent. He is checking this right now.

***Use of the instrument***

8. Is your firm aware that the government provides a tax incentive of 35% on tax liabilities for those firms engaged in R&D activities? How familiar you are?

   Yes, but does not know how it works. He knows there is an incentive of around 33%-35%. He thinks one of the modifications is that the firm is able to do R&D funded by third parties (here I clarify how the instrument works).

9. For those that already know the R&D tax credit:
   a. How did the firm come to know about the R&D tax incentive?

      Through the newspaper.

   b. Is the firm planning to apply?

      Yes, soon. They want to patent their recycling seal. So he is mainly motivated by this to apply to the incentive (I explain that patenting costs are also covered now by the incentive).

      But also, as previously mentioned, they don´t have internal technical capacities. But he would like to have a more permanent R&D structure within the firm. He mentions that he has applied two times to CONICYT (public agency that executes the science and advanced human capital policy. Analogous to the Academy of Finland for example. While Tekes would be Innova Chile) for a subsidy aimed at the insertion of young researchers in the industry. He has been refused two times, despite the fact that his firm has won lots of prices within Chile and abroad. He thinks they might be formulating the project wrong. He argues that the program is benefiting larger firms because he knows a larger firm won this subsidy, even though it has the resources to finance highly skilled labor by itself. Still he is planning to apply again.

      So their main objective is to be able to build a more permanent R&D structure within the firm, which basically means hiring a staff of researchers they are not able to afford right now.

10. Do you think this instrument is a real incentive for firms to engage on R&D? To whom you think it benefits more?

    The R&D tax incentive is a step forward. But SMEs, he mentions, have constraints other than access to credit. For example, he had losses for 2 years (during the earthquake period in 2010) so he did not have to pay taxes. So in that situation the tax credit does not constitute an incentive for them (I explain they are able to carry forward any unused credit). So he says that he needs profit to benefit from the tax incentive.

    He argues that firms also require more access to human resources and more connection to universities and research centers. He would like universities to be more connected to SMEs' productive needs. He would like that research organizations go to firms and help them to build up their R&D projects together with the entrepreneur. Basically he would like more technical advice from research organizations.

So there are other needs than just access to credit. The tax incentive goes in the right direction, but it is not all.

Furthermore he makes an analogy with life cycle. At the beginning when you are born you need caring and support. With the firm is the same because at the beginning it does not have the capacities required for doing some things. The support given to firms should be according to their life cycle, to the stage they face. Furthermore, the application to benefits put smaller firms in disadvantage as larger firms have more internal capacities to apply and get subsidies. For a smaller firm is more difficult; competition for public funding is unequal.

When I mention that for innovative startups the option of angel investors is available he mentions that he was connected to angel investors from New York, who supported their entrepreneurship. Regarding venture capital, he participated in 2-3 rounds with capital investors organized by CORFO, but they were not interested in Recycla Chile. Investors are basically looking for the profitability of the project, which is all right, but he got the impression that the investors were too conservative in the sense they would privilege standard activities. Not an innovative idea for Chile like technology recycling. So he argues there is a lack of culture in Chile on innovative projects, even more in the environmental area. So he is left out for being a first mover. Furthermore, in Chile there is no legislation regarding recycling, there is no industry, so VC's are less prone to put their money in an almost non-existing industry.

This topic is worrying because Chile is an economy of 17 million people that has 22.5 million cellphones and there is no legislation to recycle the phones, he adds.

He mentions that VCs from abroad have understood and valued their business model. And they have received awards for this. But in Chile they have not received the same reception from local VCs.

The concept of social and environmental innovation is not developed in Chile; no culture on this. VCs do not understand these concepts and are locked-in the standard activities and sectors. They are still looking to economic profitability without caring about the social and environmental dimension.

11. If the firm were refused the certification of the R&D project, would the firm carry it out anyway?

Yes. The project is already ongoing. He is still making tests, but he is doing it and even expects to patent it. The recycling seal is what gives value to the firm. They charge firms to recycle their waste at $1. But they charge them $9 for the recycling seal. This is their value added, their business. They want to introduce this. They are going to do it with or without the incentive. The want to change institutions in Chile regarding recycling.

### *6.4.3 Interviewee: René Guttelman, Director of the R&D Department*

Date of interview: 14 December 2012.
Firm: CIS Semillas. It has three main areas: Research, Production (80% commercialized abroad and the other 20% is commercialized in Chile) and Commercialization. Production area managed more than 2 thousand production hectares. The focus of the research area is is genetic engineering; they work with conventional materials but also with transgenic. They work with firms within 5 continents. With Australia, Europe, Canada, Us, etc.
Size: Probably Medium but check.
Application: No

***Organization of Research and development***

1. The firm does R&D on a regular basis or occasionally?

   On a regular basis.

2. Which is your definition of R&D?

   Firstly, research and development are two different concepts. First, *research i*s related to the investment in resources starting from a base (not from 0) and you work and develop on this base adding something such that at the end it transforms into a new product. For example, the production of new hybrids and new varieties. The firm is specialized in corn, sunflowers, raps, linen, soya and vegetables.

   The time span of their research, once the start from "0" is of around 8-10 generations, through which modifications are introduced. Meaning that 8-10 times they have to sow the variety (i.e. corn or sunflowers) and work with it genetically. The percentage of success you have at the end is of about 4%, leaving the rest on the way. This explains the relatively high cost of the hybrid product derived from research. So, to sum up, research is to develop something new starting from the knowledge base you have.

   Now, *development* means taking this successful 4% thinking of it as a potential product and you start testing it in practical terms and check whether it will be useful for the customer or not. They test (screening tests) the product and along the process they select the varieties that would be interesting for the farmer. And check whether at the end it is possible to commercialize it. Development is related to testing and checking commercialization feasibility.

   All research of CIS Semillas is done in Chile. But the development (tests) is done abroad in the destiny of the customer. A little development is done in Chile because they produce and sell corn, but it is little as compared to what they export.

3. Which is the role of R&D in the strategy of the firm? Which is the aim of this activity within the company?

It constitutes the input for one important business area of the firm that nowadays generates profits. The department is selling around USD 1.8 million a year.

4. Have you achieved expected R&D results?

Yes. To be honest, in general R&D departments are the "poor relative of the family". In the sense that expenditures are high, but profits are low. Fortunately, the R&D department has obtained good results, not only in the technical part but also in economic terms. They are generating profits and have been able to conduct continuous investments.

5. How is R&D organized within the firm?

The firm is organized in three main areas: Research, Production and Commercialization. The R&D area receives requests from abroad, they develop the requests in here but the benefits from the research are exported. So the beneficiaries are universities and firms from abroad.

The production area does not benefit from the research area, or very little (2 little projects for the production area, that would represent 1-2% of what the research area does). The research area is a business itself (not a hobby anymore) that provides R&D services for customers abroad.

The R&D they do here is done using local capacities. So for every project there might be positive externalities for the sector. For example, for a specific project the firm might require to hire some hectares from a farmer. And the farmer as well will need to hire extra people and buy extra inputs.

Sometimes research projects, that may start small, end up in a production project once the customer has verified that CIS Semillas is a serious company and once trust is developed.

a. Is there a director of R&D projects?

Yes, the interviewee is the director of it.

b. Does the R&D department have its own budget? On which time span?

They have a "cost center" of their own, totally defined.

c. Who makes the ultimate decision to carry out an R&D project? Does the firm have an own laboratory? Among other related questions).

The interviewee leads the department and is the one that establishes the contacts with the potential customers. He receives the projects but is not the one that makes the ultimate decision. He presents the projects to the general management and together they verify if they are profitable. They have rejected projects when they verify that their critical mass and capacities are not enough and would imply a level of investment that would make the project not very profitable. Or that the scale of the project is not enough to justify the increase in investment (low returns). This is very interesting because it means that some projects are not profitable for the firm because it implies a high level of investment. But probably with the tax incentive this marginal projects would turn to be profitable and the firm will get involved in more projects.

d. How many people work, on average, in R&D activities? Which kind of qualification do they have?

The director is an agricultural engineer (no further graduate studies). Plus they have 2 full time technicians plus other 7 specialists full time in agriculture. Then it comes the labor that works in the fields and plantation. But "white apron" people are 3. Depending on the season they hire more personnel. Right now he has 30 people working in the department. For example, when they the do manual fertilization they hire until 70 people. Every year they invest in machinery and equipment.

They also collaborate with students from universities. Actually, CIS is one of few firms in Chile where university students can experience directly applied research in the field of agricultural engineering.

e. Regarding human capital hiring, is it easy to find within the local labor market of you have to turn to foreign labor markets?

It is difficult. See answer to Question 10 because labor is the main obstacle they face to do more R&D.

6. The firm subcontracts R&D externally?

No, they do everything internally. They are not able to subcontract what they do because they manage confidential information from customers. The receive primary information from them and then they develop a product that is going to be a business to the customer, so there is confidentiality and trust at a 120%. They think externalizing would not be well seen by their customers.

a. What motivates the firm to subcontract R&D? Which is the reason? Lack of own capacities/lack of time/not interested on getting involved in the R&D process/better capacities outside.

Does not apply.

b. To whom the firm subcontracts R&D? Other firms? Universities?

Does not apply.

c. Mainly locally or abroad? Why?

Does not apply.

7. Which is the balance of between intramural and extramural R&D?

Does not apply.

8. Which is the general experience of the firm regarding subcontracting R&D?

Does not apply.

9. Which obstacles do you see here?

No obstacles. It´s just that we are not able to do this due to confidentiality isues.

10. Which is the most important obstacle that the firm faces to carry out R&D?

Very simple. Adequate personnel for the fields are very hard to get. They could and would be willing to hire more personnel for the fields (agriculture workers), but they cannot find adequate labor. The problem is that CIS Semillas requires a more qualified field worker, it is not like harvesting plums. They do more complicated and delicate activities. The way they fill this gap is through subcontracting. But subcontractors charge twice what CIS Semillas pays to their personnel plus the quality of the people subcontractors provide is random. The firm is willing to train and hire people, but young people prefer to go to the city instead of staying to work in the fields. And it is not a matter of the salary because they already pay more to their people, but there are not enough people available to do the work. This limits sometimes the scale and quality of the projects.

Highly qualified labor, on the other hand, is not a problem necessarily. They could find somebody if they were looking for someone but he has to admit that still is a bit difficult. The quality of technicians in the area is a problem. Couple of times he had to fire technicians because of their poor skills and quality of work. He mentions that through time the country is producing technicians of lower and lower quality. (This is consistent with the diagnosis of intl. organizations and the innovation council related to the fact that in Chile there is a bias towards professional education and a serious scarcity of technicians.)

Money, finally, is not an issue, so no financial constraints necessarily. When projects arrive, if investment needs to be done, they do it. As long as they projects is profitable, they invest and they carry it on.

***Use of the instrument***

11. Is your firm aware that the government provides a tax incentive of 35% on tax liabilities for those firms engaged in R&D activities? How familiar you are?

    Yes, but does not know how it works (here I clarify how the instrument works). And thinks that the firm is not eligible to get it given that the R&D they develop ends up abroad.

12. For those that already know the R&D tax credit:
    a. How did the firm come to know about the R&D tax incentive?

       Through the newspapers. But never searched for further information.
    b. Is the firm planning to apply?
        i. If not, why? Why the firm did not apply before?

           They will verify if they are eligible, and if so they will apply. The firm has not applied because they think they are not eligible. Mainly because the R&D they do is exported abroad. They receive requests from firms around the world to develop varieties and they do in-house the R&D required to respond to this requests (the offer R&D services). So the result of the R&D does not stay in the country but it is exported. The interviewee has the idea that the incentive is available when R&D stays in-house.
        ii. If the firm plans to apply, which is the main motivation to apply?

Some projects that could not be carried out before (because the required investments and scale of the project implied low returns as mentioned before) may be turn to be profitable now.

The market is very competitive, and a request might be sent to a few companies (even though the number of firms that do genetics engineering in Chile is little; 2 or 3 competitors). So a tax incentive might allow them to charge a lower price and win the project (the tax credit would make them more competitive). Wining the project would imply a demand for higher capacities, more workers probably, firm growth and so on.

iii. Would the firm apply through an R&D contract (in collaboration with other research center) or through an internal R&D project?

Not through an R&D Contract since they cannot collaborate for confidentiality issues. But they would probably apply through the intramural R&D Project version.

iv. If the firm were refused the certification of the R&D project, would the firm carry it out anyway?

Not necessarily. Because now some request projects are rejected by them because the return is low. But if he were able to lower his costs, then he would be willing to do these projects. The tax credit might help turn some projects into profitable for the firm.

13. Do you think this instrument is a real incentive for firms to engage on R&D? To whom you think it benefits more?

Regarding the focus of the instrument, he thinks it should be SMEs. Because they are an important source of employment. They have less access to credit and resources. If SMEs could, through R&D triggered by the tax incentive, find new market opportunities and change their business strategy by including R&D activities, the instrument would then have had an important impact. Because there are a lot of SMEs. This could have a big impact in development.

Regarding the symmetry of the instrument (35% for all), he thinks “equality is dangerous”. In the sense that not all firms do their work seriously. His opinion is that it is risky that the government gives money to all firms without verifying before their quality, how they are organized, if they are serious. When I (Josy) mention that this could imply more monitoring and bureaucracy when applying to the instrument, he says he is ok with this; that it is fair if the government needs to verify first that the recipient of public money is really eligible to receive the money.

14. Which kind of instrument do you think is more effective: a horizontal incentive like this one or a direct subsidy? Why?

For him a subsidy and a tax credit is indirectly the same. It´s money.

15. Any last recommendation on the instrument?

Not really because I am not very familiar with the instrument.

### *6.4.4 Interviewee: Sebastián Monckeberg, Innovation, Research and Development Manager*

Date of interview: 16 December 2012.
Firm: Vilkun[51], is a firm located in the south of Chile (VII region) that produces dehydrated organic and conventional berries using a technology based on osmotic drying (using pressure difference; instead of heat application), which allows preserving the natural properties of the fruits. They have patented this technology and is part of the know how of the firm. They export to Europe and Asia and their products are used as an ingredient for healthy snacks, cereal bars, salad toppings, pastry making, among others.
The firm is an intensive user of Innova Chile of Corfo instruments. The firm started using seed capital, which allowed them to set up a laboratory and develop their technology, which was patented. Later on they built a pilot plant also supported by Innova Chile of Corfo. Their current plant (in a relation 1:40 to the pilot plant) required USD 7 million.
The firm was always seen as a big project so they required investors. By then the market of venture capital was not properly developed and they had to search for alternative investors in their sector. They made consequently a joint venture with San José farms, the largest berry producer in the southern hemisphere with five farms both in the north and south of Chile. San José provides the berries that Vilkun processes.
It is important to mention that the firm is not making profit yet.
Size: Small
Application: Yes

***Organization of Research and development***

1. The firm does R&D on a regular basis or occasionally?

   On a regular basis.

2. Which is your definition of R&D?

   For them, innovation projects are those that can be quickly developed and implemented with the knowledge they already have. The aim of these projects should fulfill any of the following objectives: to improve productivity; to increase product diversification; or to assure workers and environment safety. If a project does not tackle any of these objectives, then, it is not carried out. Currently, the firm has 8 ongoing innovation projects.

   Inside the innovation bag they have the sub-bag of R&D. And R&D projects should be also aimed at any of the three previously mentioned objectives. For them, any project that cannot be undertaken using current knowledge capabilities requires the creation of knowledge. This is research for them, the creation of knowledge required to solve a problem. It is not that they are inventing new totally new things to win the Nobel prize. The technologies they use already exist, but putting them together to solve a problem and discover new applications is considered new knowledge and consequently research.

[51] http://www.vilkun.com/

While development is associated with any already existing research that can be acquired and incorporated to develop something. It is related to already existing knowledge within the firm that can be used directly.

Anyway the separation line between them is more theoretical.

They have less R&D projects (3) as compared to innovation ones as R&D projects are more intensive in managing capacities. For example they are now developing a technology to extract the component from a small fruit called Maqui, that has antioxidant properties but even more important, it has regenerative properties. This is especially important for diabetic people. This research is financed (in part) by another public fund focused on the agriculture sector, FIA, and it has a time span of 7 years. The components of the Maqui also can be used in the treatment for Alzheimer, not in its final stage but at advanced stages. They estimate that 10% of world population will need treatment, so the potential market for them is huge.

*When I ask him the source of information for R&D projects:* The interviewee mentions that he spends more than 50% of his time reading journals and information. This is crucial. They also are hiring a service on patenting alert.

3. Which is the role of R&D in the strategy of the firm? Which is the aim of this activity within the company?

Simple. The survival of the firm is not possible without R&D and innovation. It is the only way to remain competitive.

4. Have you achieved expected R&D results?

Yes. The results have been ridiculously good. *When I ask if then this means that what they do is probably not very risky or uncertain, qualities inherent to R&D activities, he mentions that* what he means is that innovation projects have been very successful. In terms of R&D projects, he mentions that they are constantly facing problems that call for research to solve them. For example right now he is back from Germany where he had to go to find a solution to a technical problem. The first week the solution seemed not to exist, which was really scary. But after some extra efforts he, together with his collaborators from Munich, found a possible theoretical solution. He is back now to test it.

Right now they have three projects of R&D, but none of them has finished. So he cannot tell about the success in 1.5 years from now probably. But in general these projects are developing okay and so far they have managed to find solutions to the problems they have faced.

*When I ask with whom he collaborates and how he came to know about potential collaborators* he mentions that they are contacts on his own, that he has found due to his curiosity. He contacts people that might be interested in his business.

*When I ask why he is connected with people from abroad and if in Chile there are no capacities* he mentions that for the current problem they had there were no local capacities. But he recognizes that there is more and more quality research in Chile, some of this research very impressive, and he

is totally willing to collaborate with local universities and research centers. For example, the University of Talca.

They are currently developing some collaboration with the University of Valparaiso. They have tried to collaborate with the University of La Frontera but it has been very difficult. Basically because they lack agility. He mentions that the main mistake is the tendency to protect own objectives. The firm looks for its economic objectives, and the university for their academic ones. He says that it is important to merge objectives and understand the objectives of the other part. Once this is achieved, you try to get the other part involved in yours.

5. How is R&D organized within the firm?

   a. Is there a director of R&D projects?

Yes, the interviewee is the manager of innovation, research and development projects.

   b. Who makes the ultimate decision to carry out an R&D project?

There is an i+I&D Committee consisting on his partner and him. Together they discuss the projects and then present to the board of the firm (the interviewee and his partner have voice but no vote in the board. Three other people, external to the firm, are also part of the board and are external to the firm). The board is the one that makes the ultimate decision, but in general they have to stop one of the members of the board regarding R&D projects because he is very motivated with this (as an anecdote). They stop him because R&D projects require a lot of management capacities and prefer not to do too many things at the same.

   c. Does the firm have an own laboratory?

Yes.

   d. How many people work, on average, in R&D activities? Which kind of qualification do they have?

There are 3 food engineers in charge of each of the currently ongoing research projects (one of them is the interviewee). None with graduate studies. *When I ask if personnel with graduate studies are not required in the firm* he say that yes, they definitely do need them and are currently looking for somebody in the field of biochemistry. They are going to subcontract somebody. They also have some advisors with PhD studies in the genetics area. So the answer to my question is “yes, they do need them; no, they don´t have them directly; and yes, they have them indirectly”.

The firm has recently applied to the award on “The best place to work”. The interviewee say that they are not well payers (because the chose not to), but they aim at keeping their workers motivated. They start by training their field workers in basic knowledge on mathematics and physics for example.

Workers involved in the innovation, research and development processes sign confidentiality agreements.

6. The firm subcontracts R&D externally?

No, they have done everything internally so far but they are planning to do it soon.

a. What motivates the firm to subcontract R&D? Which is the reason? Lack of own capacities/lack of time/not interested on getting involved in the R&D process/better capacities outside.

And the motivation to do it is that internally they do not have the capacities in some areas and they do not need to do it by themselves. “They don´t want to buy the cow, just the milk”.

b. To whom the firm subcontracts R&D? Other firms? Universities?

For example they will start collaborating with couple of universities.

c. Mainly locally or abroad? Why?

They already collaborate with universities abroad, like one in Munchen, Germany. But they are going to start collaborating with some local ones.

7. Which is the most important obstacle that the firm faces to carry out R&D?

Clearly internal management capacities. Every R&D project requires to be managed, and they have limited capacities to do this. This is the binding constraint to engage themselves in more projects, and why they need to subcontract and collaborate with universities. In fact, they have some interesting projects that are willing to carry forwards, but they need to find the partners first.

Regarding the obstacles faced in ongoing projects: the main obstacle is to find the right partner. In one of them they already have it (the university in Germany) but in another one (in the osmotic drying process) they are trying to find a knowledge partner in the biochemistry and nutrition field. In the other one they are looking also for a knowledge partner.

*Is money an issue?* He mentions that the firm is very conservative and that the carry out projects that they are able to afford.

***Use of the instrument***

8. When did the firm apply to the R&D tax incentive?

They applied in September. They got the approval last week. It is important to mention that this project had won earlier an R&D subsidy from Corfo. So it is an ongoing project. The tax incentive applies to the part that is not financed by the subsidy. Also it is important to highlight that the firm is not making any profits yet. It is a small firm that is developing its technology, it has three ongoing projects and is promising. Probably Corfo is betting on this. To generate a sector that was inexistent.

9. How did the firm come to know about the R&D tax incentive?

He does not remember exactly but he got the same information from various sources from Corfo. He mentioned that he was invited by CORFO to participate. As the firm has applied to different instruments from Corfo[52], Corfo is aware that the firm is doing well, that they are developing new businesses and that they already have a functioning structure. So they were contacted by Corfo, who encouraged them to participate. He mentions that they are constantly being invited by Corfo to participate in different instruments to which they are eligible to participate.

In his opinion Corfo is very proactive. He has the impression that they are finally "understanding themselves". That they believe on the story that they are the future of Chile.

10. What motivated the firm to apply?

*Regarding my question about why he is eligible to be granted money from all Chileans to carry out R&D projects in the firm:* He thinks that the creation of knowledge is worthy in the long run. On the one hand, the innovation rate is going to provoke firms to pay more taxes. But on the other hand you will create a space and place for the creation of knowledge. He cites Israel as an example in which practical knowledge is the vehicle that is dragging the economy. In his particular case, through his project and the success they have achieved so far, he thinks that the firm contributes to the society by providing jobs, by educating and giving opportunities. They give the opportunity to their workers to develop themselves in their jobs and reach their dreams. He thinks that the immediate community wins, the region wins, Chile wins.

*Regarding my question about which was the opportunity they saw in the tax incentive:* They are currently carrying out the project related to the tax incentive. They have already been partly financed by Innova Chile through a subsidy. So they thought that once this project gives them profits, they are going to be able to get the tax credit. So they decided to apply even though the board said that the application was going to imply a lot of time and resources.

They are also planning to apply to the other projects they are carrying out. Knowing that it will not imply benefits for now, but once they are making profits.

11. How was the application process organized? Did any intermediary/broker helped in the application process? Who is the person in charge of the application?

No, they applied using own capacities.

12. Do you think this instrument is a real incentive for firms to engage on R&D? To whom you think it benefits more?

Yes, and he thinks it is going to benefit creative firms; to those that are looking for and want to do new things. To those firms that understand that to remain competitive they need to innovate. And this does not has to do with a decision at the top level that suddenly decides that from no onwards the firm is going to do R&D. There should be an internal promoter, a person that believes in the

[52] Every time he mentions Corfo, it is basically Innova Chile from Corfo.

importance of R&D and innovation that motivates the top managerial levels and achieves the commitment of them with this kind of activities. Firms need a "Sebastian" inside… (The interviewee).

*Regarding beneficiaries by size* he thinks that it should be aimed at SMEs. But large firms are also going to benefit from it as they already have their R&D structure working.

*When I ask why larger firms that do not face credit constraints to finance their projects should benefit from this incentive* he answers that the generation of knowledge at local levels is very valuable. *But what if that firm was going to carry out the R&D projects anyways such that the knowledge is created without the need of public funding …* he thinks that the incentive is going to motivate firms to carry out R&D projects that are relevant for society. For example: Do you think that Soquimich is going to invest on a project that studies the use of Lithium? Maybe not because they just prefer to put a plant on battery production. But now they have the option to go further, to bring people from abroad, PhDs, to get involved in this kind of projects. The tax incentive gives them the opportunity to do this.

He strongly believes that firms should be looking constantly for new ideas, new markets. Because it is exciting!

13. What do you think is more effective? A horizontal incentive like this one or a direct subsidy? Why?

Subsidies fit more on smaller firms, where the R&D structure is not developed and they are not making profits. But those firms that are already making profits, subsidies are burdensome and it is better a tax incentive. So it is related to the relation between the size of R&D and firms' economic results.

14. Would the firm have carried out the R&D project anyway if Innova Chile had refused the certification of the project

Yes, they were already engaged in the project. But still the tax credit might open new opportunities for them in the future (once they are tax liable for example) as they could be able to finance a new project due to the cost relief coming from the tax credit.

15. Did you have any fear regarding a leak of your idea?

Yes but they trust in Corfo.

16. How was the experience of the application process? Was it easy/burdensome? Fast/Slow?

Application was simpler than before. *But when I ask him to control for the skills already acquired through former application to Innova Chile instruments*, he agrees that his answer is determined by former experience (in fact, in prior instruments they had to hire an organization, Incubatec, to help them in the administrative management of the project). But still he mentions that he thought it was going to be easier. Mainly in the financial information required. He mentions that it is not just the fault of Innova Chile but also of them because the project was already running with a cost structure and they had to modify it to fulfill Innova Chile's requirements (those things that were missing).

Reporting on this financial information can be very complicated for those firms that have never done it before. It is not easy. But you have to see it from the "half-filled-side of the glass". That this opportunity is available in Chile, as compared to other countries, is very valuable. In his opinion there are fingered-counted countries that have functioning something like Corfo. In his opinion, the general support provided by Corfo and their aim of positioning Chile in the innovation map is very valuable. A lot of countries do not understand this. But Chile already understood this. And not just at the Government level but at the State level.

17. Which is the degree of satisfaction with the application process? (Use Likert scale of 4: 1. Very Satisfied; 2. Satisfied; 3. Unsatisfied; 4. Very unsatisfied)

4. Because it is always important to improve.

18. Which is your estimation of the application cost? What proportion of the benefit represents this cost? (Pecuniary and non pecuniary)

Without the fee, he estimates it on a 2-5% of the benefit (or 5% from the 35% of the cost of the project).

19. Which is the degree of satisfaction with the design of the instrument? (Use Likert scale of 4: 1. Very Satisfied; 2. Satisfied; 3. Unsatisfied; 4. Very unsatisfied)

4.

20. What would you change in the design of the instrument itself?

To improve rather than change: Despite Corfo has been very agile, but he would ask a bit more agility. Regarding their understanding of the project and the business involved. It implies a more agile technical understanding of what the firm is doing.

*When I ask about his opinion regarding the information asked:* He considers it is OK. The only aspect of his interest to improve is the flexibility regarding the use of resources. Because the project changes as problems and solutions emerge. For example, he reported X amount of expenditures on activity Y in the initial budget. But after this trip he is not going to do Y anymore, but Z. And the amounts are similar. He wants more flexibility in the use of resources because changes are for sure going to happen. So they need Corfo to understand why he needs to make some changes.

*When I ask about the design features of the instrument (35%)* he thinks is too low. He considers 50% could be totally feasible. But he is aware that this is impossible to apply due to political pressures. It might appear politically incorrect to benefit firms too much. Some people look this kind of initiatives like a demon, but this can really change the reality of the country. We need to turn more competitive. He is really impressed by the lack of discussion regarding the fact that we are not alone. There is poverty of political discussion. It is not about how much money you give to a firm, but how more efficient you want to be in the future.

He also highlights the restriction of 50% of expenditures subcontracted abroad. If the knowledge is not available in Chile because nobody is working on the technology they are using, and nobody is

even thinking about using it, why restrict it. This is an obstacle for them because abroad is the only place where they can find the solutions to some of their problems such that they can move on.

But overall he thinks it is a great instrument.

21. Would you apply again?

Yes, totally. In fact, they are planning to do it for another of their R&D projects.

### *6.4.5 Interviewee: Francisco Lozano, Marketing and Innovation Manager, Innova Arauco.*

Date of interview: 18 December 2012.
Firm: Arauco, is around the 20th largest firms in Chile and belongs to the Angelini economic group. It has 45 years and belongs to the forestry and manufacturing sector. Chile has a comparative advantage in the forestry sector, as the growth rate in the southern hemisphere is higher than in the northern one (35-40 years in the north to 20-22 years in the south). But customers are far and transport costs turn to be higher, which calls for an efficient business model.
Arauco will reach in 2015 a balance in the planting and harvesting rate. Until now it was planting 10 times, 7 times, and so on, more than what it was harvesting. Arauco extracts different products from the tree. From cellulose to biofuels that generate 5% of the energy consumed by Chile (through Arauco Bioenergía). The mix of its business lines in an efficient way allows them to be a competitive firm in the world market. For example, in the cellulose market, Arauco has between 7-10% of the world market (the 2nd largest firm in that market).
The firm has a long history of innovation, not only in products but also in the business model. In 1990 it created an applied research center in forestry research, Bioforest, with the aim of developing and applying technologies that would maximize the productivity of the forestry natural resource. Bioforest supplies the research needs from the different divisions within the Arauco holding. Later, in 2011 Arauco Innova was formed as a way to systematize innovation (introduce a methodology) and to align innovation projects with the strategic objectives of the firm. Through an internal brainstorming process, they identified strategic challenges and conceived innovation projects to face them. Some of them are in the prototype stage; some of them require applied research, some others do not. Two of these projects required R&D and they were applied recently to the R&D Law (the tax incentive). T
They also have some initiatives aimed at the local community, like the Educational Foundation Arauco, a private-private agreement aimed at training teachers from schools with limited resources.
Size: Large.
Application: Applied to the older and new version of the incentive.

***Organization of Research and development***

1. The firm does R&D on a regular basis or occasionally?

   On a regular basis.

2. Which is your definition of R&D?

   Research is a search, from state of the art knowledge to new applications aimed at solving specific problems or difficulties. And development is using this state of the art knowledge and the research you are undertaking to solve specific difficulties, and put them forward, implement the solution based on the research. Research is probably more passive; development is attached to a solution, to an application, to a challenge.

3. Which is the role of R&D in the strategy of the firm? Which is the aim of this activity within the company?

   Applied R&D is considered the development axis of the firm.

4. Have you achieved expected R&D results?

Yes, Bioforest can be considered a successful research center that has fulfilled for more than 20 years all R&D needs from the Arauco. They do not know exactly the rate of failure and success of projects because there are too many, but in general they are satisfied with R&D results achieved by Bioforest.

But in general he thinks failure rate is low; basically because they try to identify failure as soon as possible (also in Innova Arauco).

5. How is R&D organized within the firm?

Arauco has a research center since 1990 that provides applied research to all business areas (Bioforest). In 2011 Innova Arauco was created, with the aim of identifying strategic challenges faced by the firm in its different business units and develops innovation projects to tackle them. Some of these projects will require applied research, and some others do not. Innova Arauco also collaborates with Bioforest, helping them to systematize research and innovation projects. The objective of projects should always be in line with the strategic challenges faced by the firm.

e. Is there a director of R&D projects?

Yes, the director of Bioforest. Although the director of R&D projects applied to the tax incentive is the head of Innova Arauco (the interviewee).

f. Does the R&D department have its own budget? On which time span?

Yes, Bioforest has its budget, annually. But this does not mean that projects are of 1 year of course. Some of them have a life span of 20 years. Planning involves more medium and long term, but budgets are adjusted annually.

g. Who makes the ultimate decision to carry out an R&D project?

The manager of Bioforest reports to a board of directors. Together with the director of Innova Arauco decide which projects for example are going to be applied to the tax incentive. For example, through Innova Arauco, an internal brainstorming was organized to identify challenges faced by the firm. They raised around thousand opportunities and picked 17 after a filtering process. Then 13 of them are in the prototyping stage, and two required applied research so they collaborated with an applied innovation center and applied to the tax incentive with them.

h. How many people work, on average, in R&D activities? Which kind of qualification do they have?

In Bioforest there must be around 40 researchers, plus other 20 people in innovation. So there should be around 60-70 people devoted to research and innovation. There are some PhDs and people very specialized in the area.

6. The firm subcontracts R&D externally?

Yes.

a. What motivates the firm to subcontract R&D? Which is the reason? Lack of own capacities/lack of time/not interested on getting involved in the R&D process/better capacities outside.

Basically because one of the innovation models they are currently applying is *open innovation*. It is not possible to do everything internally. So you need to look out for the best quality. You need to operate within a newtwork. Bioforest is a good internal research base, but if there is a project for which Bioforest lacks the required expertise you need to turn outside. Or even if you have the expertise, you cannot manage everything. The innovation philosophy is based on open innovation, so this motivates alliances.

b. To whom the firm subcontracts R&D? Other firms? Universities?

With a lot of universities; also with other firms in the forestry sector; Innovation centers.

c. Mainly locally or abroad? Why?

Both. They collaborate with local universities and firms but also with organizations from abroad. For example, they have subsidiaries in Brasil and Argentina, among other countries in the world. And they have collaborated with Argentina and Brasil. Also with the US and Canada.

7. Which is the balance of between intramural and extramural R&D?

They do both, but in general it is more local; it depends on the project really.

8. Which is the general experience of the firm regarding subcontracting R&D?

In general is fine but not always is easy. Research centers sometimes do “research just for research”, with no application. In this sense, objectives from universities and the private sector are different. The university wants to publish papers (they incentives for this), but the firm wants applications and economic returns. Universities lack the vision of scalability and impact, which is the vision of the industry.

Arauco works with different universities and they always need to be sure that the objective is understood, otherwise the research might just end up filed up with no application (and there are a lot if these examples).

But they are very open to collaborate with universities. Of course it requires a special management considering all the collaborative projects they have with different universities and consultants. But they have a quite “porous” structure, as he puts it.

9. Which is the most important obstacle that the firm faces to carry out R&D?

Management capacities, both internal and external. R&D and innovation projects need to be managed. And subcontracting them does not mean that you are relieved from the management of the project. You still need to follow them up; it still requires an internal counterpart to the project.

*When I ask if financial constraints constitute an obstacle for them* he answers ”multiple needs, scarce resources”. We don´t have an infinite budget…

***Use of the instrument***

10. When did the firm apply to the R&D tax incentive?

He does not remember when the previous projects were applied, but he knows there are 3-4 projects under the old version of the tax incentive. And now, they applied to 2 more on September the 10th, 3 days after it was launched. One of them (a longer one) was applied through the intention figure. They have not received the answer yet from CORFO, but are positive they are going to be approved.

And they are evaluating which other projects they can apply with.

11. How did the firm come to know about the R&D tax incentive?

The thinks that sometimes universities come to the firm offering some projects and they inform the firm they can apply to an instrument. In particular, regarding the new version of the tax incentive, he was aware of it since March of last year. He knew it from the Undersecretary of Economics, Tomás Flores (they coincided on a flight). It was also published in the newspaper. And also they received the visit of the Director of the R&D tax incentive Program, Isabel Salinas. She made a presentation, explained to the firm how the incentive worked and invited them to participate.

12. What motivated the firm to apply?

Because it facilitates the firm to carry out R&D projects. You are more prone to do more projects, and this multiplies the knowledge and capacities of your ecosystem.

13. How was the application process organized? Did any intermediary/broker helped in the application process? Who is the person in charge of the application?

Using internal capacities; no intermediary. Each project has a director in charge, and each of them was responsible of uploading the application.

14. Do you think this instrument is a real incentive for firms to engage on R&D? To whom you think it benefits more?

Without a doubt. This is a good incentive to carry out more applied research, and also allows to smaller firms with less access to resources to get involved in this kind of projects.

*When I ask to whom, in his opinion, the instrument benefits more* he answers to both large and small firms. He thinks it is a matter of scale. Not because a firm is large it has infinite resources. A large firm also has large costs. But probably it benefits more to SMEs. This could be a good incentive for small firms such that they are able to focalize and specialize themselves in research activities. He thinks it is a good incentive for SMEs.

*When I mention that the benefit works once a firm is making profit* he mentions that "well, if a firm does not have profits, then it will hardly have resources to finance part of the costs of doing R&D".

*When I ask his opinion about a differentiated incentive by firm size* he thinks that the instrument is okay as it started. Although in the future you can introduce some differentiation. In fact, in his opinion, SMEs should have a tax rate of almost zero at the beginning. This is a way to support SMEs. Because they complain as regulation is the same for large and small firms. But a SME that is starting, should have a relief in the taxes it pays. Something similar he would do to foster training of teachers. First, he would provide training for free after they are graduated. And second, he would exempt them from paying taxes for 10 years. This would put and incentive and turn the teaching career attractive.

15. What do you think is more effective? A horizontal incentive like this one or a direct subsidy? Why?

He finds it great that there are a lot of options to apply to Corfo (to other instruments that foster specific things). But they are okay with the tax incentive. The fact they are able to carry out applied research and that they can reduce their taxes is great and constitutes an incentive for them.

16. Would the firm have carried out the R&D project anyway if Innova Chile had refused the certification of the project

Right now, considering the current overall economic situation in the world, he does not think they would carry out the two projects they have applied for the new incentive. Maybe they would do them later.

17. Did you have any fear regarding a leak of your idea?

Not the firm, but the interviewee was a bit frightened about it. Given some questions about the project during the application process, he had the doubt about how this information is managed inside Corfo. He assumes, or expects, that the executives that evaluate the projects sign confidentiality agreements.

18. How was the experience of the application process? Was it easy/burdensome? Fast/Slow?

They did not have problems. For them was very easy. *When I ask about his opinion on the kind of information requested* he only mentions there are more internal problems in the sense that when a project has two directors, then it needs the signature of both, and to certify legally that these two people had the power to sign, etc.; more administrative things. The point is that this firm is large, and there is internal bureaucracy.

19. Which is the degree of satisfaction with the application process? (Use Likert scale of 4: 1. Very Satisfied; 2. Satisfied; 3. Unsatisfied; 4. Very unsatisfied)

He did not apply himself, so he cannot say.

20. Which is your estimation of the application cost? What proportion of the benefit represents this cost? (Pecuniary and non pecuniary)

He knows they paid around CLP $700 thousand as a fee (seems he tells it as if it was little money). He estimates the overall cost, including workforce hours, would be around 3-4% of the benefit. And in time, he would say it took them around two weeks to formulate the project. But they made it very simple; they even did not report some costs they were incurring because they wanted to make it easy and fast.

21. Which is the degree of satisfaction with the design of the instrument? (Use Likert scale of 4: 1. Very Satisfied; 2. Satisfied; 3. Unsatisfied; 4. Very unsatisfied)

He is very satisfied with the new version of the tax incentive since the restriction on extramural R&D was a straightjacket. They consider it vey practical, easy to apply and the response rate has been very satisfactory.

22. What would you change in the design of the instrument itself?

He considers the evaluation a little slow, but it might be because the number of executives is low for now or they received too many projects. But still he thinks the flow of the application process has been quite adequate.

He thinks they should innovate in the evaluation process. They should be able to identify quickly if "this is able to fly or not".

But he did not apply himself, so he cannot make recommendations on the application process itself. But he was told it was very easy.

*When I ask more about the design, for example regarding the 35% and the 65% in expenses* he thinks it is fine, more probably would be too much. *What about the change in the cap, is it binding?* Not at all, he affirms.

In general he thinks its fine; although in the future it could be improved.

23. Would you apply again?

They are going to apply again.