

**PUBLIC FINANCE OF THE R&D ACTIVITIES IN ENTERPRISES: ROLE AND  
IMPACT OF THE SPANISH LOW INTEREST CREDITS FOR R&D**

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## **INTRODUCTION<sup>1</sup>**

This document is a broad summary of my PhD Thesis presented in may of 2000 at the Department of Applied Economics (Faculty of Economics and Business Science-Complutense University, Madrid)<sup>2</sup>. The **central subject** of this paper is the evaluation of the low interest credits for R&D provided by the Centre for Industrial Technologic Development. The objectives are, on one side, a global evaluation of the role and impact of the projects, financed by the CDTI, within the firms, and, on the other side to measure the importance of the CDTI for the Spanish productive structure.

The Centre for Industrial Technological Development (CDTI) is an institution of the Ministry for Industry and Energy created by a Royal Decree 38/1977. It has been consolidated as one of the central agents for the promotion of the innovation and technological development within the Spanish enterprises. The CDTI funds do finance almost 7% of all R&D expenditures of the Spanish private sector and has a central role for the implementation of the Spanish, European and international technology policy measurements. The CDTI manage a huge part (roundabout 50%) of the funds designated to the support of innovation within the Spanish firms and promotes and co-ordinates the Spanish participation in most of the international programmes. All this means that the CDTI is one of the basic pillars within the sub-system of technology policy.

The study of **the importance of the CDTI within the production structure** will be analysed by the total volume of the CDTI funds in comparison with the R&D expenditures by the private enterprises and the diffusion of the CDTI within the productive structure. The characteristics of the CDTI firms will be compared with those of the innovative firms that didn't participate in the support programmes of the CDTI. The **impact and role** of the CDTI projects, **within the supported firms**, are analysed by several aspects like the financial importance of the support, the technical and commercial objectives and their accomplishments, the impact on the innovative culture and the improvement of the technological capabilities and co-operative attitude.

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<sup>1</sup> Critics, questions or suggestions are welcome on my E-mail number [joost@ccee.ucm.es](mailto:joost@ccee.ucm.es)

<sup>2</sup> The director of the Thesis is José Molero Zayas and the tribunal that evaluated my work did consist of Rafael Myro (President – UCM), Mikel Buesa (Secretary, UCM), Julian Pavón (Universidad Politécnica de Madrid), Knut Koschatzky (Fraunhofer Institute for System and innovations Research) and Xavier Vence (Universidad de Santiago de Compostela).

To put the conclusions of the study in a broader context and to overcome ad-hoc interpretations the results will be contrasted with several evaluation studies that analysed the actuation of the CDTI (Busom, 1991; Fontela et al, 1992; IESE, 1995 y Acosta, 1996) and also with the results of other evaluation studies, that analysed similar programmes, carried out in Spain or other countries.

The thesis is based on a research project carried out by the Institute of Industrial and Financial Analyses (IAIF)<sup>3</sup> about the actuation of the CDTI in the period 1984-1994 (See Molero/Buesa; 1995a, 1995b). In the analysed period 1922 firms had obtained financial help, services or consultants from the CDTI in support of their technological development –including the financial support of international programmes-. The initial study analysed a broad spectrum of aspects of the CDTI performance using the administrative information of the CDTI and public databases. To complete this general information a questionnaire was carried out , covering the 1354 CDTI firms that participated in the national programmes. This questionnaire has a part exclusively dedicated to the evaluation of the impact and the importance of the CDTI support measurement.

### **Structure and methods**

The first chapter “the justification of technology policy: a methodological approach” offers a conceptual framework for the evaluation of R&D policies.

The central part of this study is developed in chapter two till five which presents the analysis of role and the impact of the CDTI in the Spanish firms and production structure. Chapter two offers a study of the financial importance of the public support for R&D projects. The third analyses the technological and commercial objectives and results of the CDTI projects and its level of goal achievement and chapter four analyses the generic impact of the CDTI projects. And chapter five analyses the diffusion of the CDTI within the production structure and the financial volume of its credits in relation to the Spanish R&D expenditures. The last chapter contains the main results and final conclusions.

Each of the empirical chapters has a similar structure based on the methods used in this study. The introduction of each chapter contains a short description of the aspects that will be analysed followed by a brief description of the main indicators used in existing studies and the main conclusions of those studies. The second part presents indicators used in the PhD thesis and first exploration of the statistical results based on tests of association (contingency tables) describing the main results and characterising the kind of firms with a-typical behaviour. Afterwards a multivariate qualitative response model (Logistic regression model) will be used to contrast those results. The main results and final conclusions will be presented in chapter six.

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<sup>3</sup> The research team which carried out this project consisted of: José Molero y Mikel Buesa (Directors); Carlos Manuel Fernández y Juan Carlos Jiménez (Investigators); Keith Pavitt, Vincent Lerville y Daniele Archibugi (Asesores); y Miguel Carrera, Antonio Fonfría y Joost Heijs (Research assistants). I am in debt by all the persons mentioned before due to their valuable comments and their personal involvement and support.

So the study of the performance of the CDTI and the impact of its projects is based on two types of statistical tests. First, an explorative study (association tests) which analysis the correlation between each of the independent variables and the variable to explain. Those associations are studied for the whole group of CDTI firms but also will be carried out analysis of control. The tests of association, based on the Pearson's  $X^2$  will be repeated for several sub-groups maintaining some basic fixed<sup>4</sup> variables. But these control analysis can not take in account all the possible interactions between the independent variables that's why I introduced a second statistical analysis based on a logistic regression model. This method takes in account the simultaneous effects of the independent variables on the variable to explain, revealing possible apparent relationships not detected in the test of associations. In each chapter are presented the main statistical results of each method and afterwards in chapter six will be given an interpretation in the light of other evaluation studies.

It can be pointed out that both methods, the test of association and the logistic regression models, are complementary. The logistic regression model not only should confirm if the found associations are real and not apparently relationships, reflecting an indirect relationship caused by a third variable. But the logistic regression model also can detect new variables associated with the dependent one, and not detected by the Pearson's  $X^2$ . Evaluation studies try to offer data useful for the policymakers to adjust the instruments. So both methods can supply criteria to improve the implementation of the policy instruments. It must not be forgotten that the public agencies do not really care too much about the fact if a relationship is apparent or not, the most important thing is that they can improve their performance by manipulating a variable. So they are also interested in an apparently relationship in the case that it can serve to develop additional measurement to improve or adjust technology policy programmes.

The objective of the logistic regression models presented in this PhD thesis is not to develop a model that contains all causal relationships. The models are used to identify the critical characteristics of firms that have an influence on the impact of R&D projects and to study if the relationships between one particular independent variables and the variable to explain can be confirmed taking in account the simultaneously other independent variables. For this reason the description of the results of the logistic regression models is very short without entering in details of the model and its econometric aspects.

The analyses are referring to the whole group of CDTI-firms but are also carried out by types of projects, dividing the sample in two groups. Those firms who did participate in co-operative projects ("*concerted projects*") financed by the National Plan of R&D and those firm that only has participated in no co-operative projects ("*Technological projects*") financed by own funds of the CDTI.

Like already mentioned the results and conclusions of the study will be contrasted with those of other evaluation studies. First because of the lack of an existing theoretical framework that includes the role of the public intervention, based on the theory of technological change and economical development, with clearly defined hypothesis contrastable in the practice. The knowledge about causal relation between government interventionism and technological development are not based on a coherent theory that explains clearly causes and effects but is more based on different partial contribution from the theory of technological change and other scientific disciplines.

The second reason is the absence of generally accepted indicators and methods. Like will be explained in the second chapter, most of the evaluation studies do count with an internal coherent and reliable methods. But are en general isolated studies with a broad range of methodological applications. The evaluators are using a broad number of methods and indicators following ad-hoc criteria's<sup>4</sup>. This problem makes more difficult the comparison between studies based on different indicators.

The third reason to include case studies is to initiate a learning process based on policy experiences in other countries. Although, this learning process is limited due to the differences in the systems of innovation and the economical-social circumstances. Although, a best practice doesn't exist for technology policy the comparison of experiences can offer valuable information about the possibilities and limits of certain instruments. The impact of technology policy depends on the interaction of the policy instruments with their environment, and any determination of policy lessons or "best practices" must take contextual differences into account. It is only possible to learn from foreign experiences if the foreign systems are properly understood. Strategies based on naive copying should be avoided, and institutional learning across national borders stimulated.

Due to those facts -and the absence of a scientific discipline that has established general accepted method and indicators to follow for the evaluation of technology policy- the comparison of my own results with other studies is very important. It should create, in certain way, a reference frame for a correct interpretation and to put the used methods and indicators in a broader context. Although I underpinned the difficulty to compare studies based on different methods and indicators at the end it is the only way to avoid ad-hoc interpretations.

As a last remark about the case studies it can be mentioned that it will not be an exhaustive study analysing all the methodological aspects within a representative group of studies. The aim of my analysis is to synthesise, from a critical point of view, the main results and conclusions in order to interpret the results of my own analysis.

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<sup>4</sup> Although in general the decision about the methods and indicators to use are based on practical criteria (availability of data, compatibility of sources of information) the lack of standard methods and indicators could imply, in certain circumstances, that evaluators select methods taking in account the results they like to obtain.



## CHAPTER 1

# JUSTIFICATION OF TECHNOLOGY POLICY : A METHODOLOGICAL APPROACH

### 1.1 Introduction

Technology policy attempts to promote structural change in the economy, with the ultimate objective of strengthening economic growth and creating or reinforcing competitive advantages for a country, region or sector through technological change. In recent decades, policies promoting technological development and innovation have become an integral part of public policy, and have accounted for an increasing percentage of public budgets.<sup>5</sup> This attention, has been based on the assumption that new higher technologies, are an important factor, determining the competitive positions of the three leading global regions (East Asia, North America and Western Europe) and has been an important factor in the decisions of European central governments to intensify their technology policies in the 1980s.

Although, the majority of developed countries have implemented technology policies the evaluation of the instruments is still an underdeveloped activity<sup>6</sup> and the scientific level of the studies have been criticised (Meyer-Krahmer, 1989; Nauweleers/Reid, 1995; Meyer-Krahmer, 1995). There is a growing pressure on the policymakers to justify their programmes. Governmental budgets are increasing, technological progress can more and more be seen as a solution of the global problems (environment protection, new diseases, and the lack of energy and materials.) and the innovation is being recognised as a key factor for competitive position of nations.

It seems to be clear that studies with a proven methodology, carried out professionally, could improve the use and development of existing instruments but, such studies are not as

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<sup>5</sup> There has been visible growth in financial and other support for technology, especially in the highly industrialised economies, although public budgets for R&D now seem to be stabilising. See OECD, *The Impact of National Technology Programmes*, OECD DSTI/SPT 1993 (3), January 1993 and OECD, *Main Science and Technology Indicators*, OECD, Paris, 1995.

<sup>6</sup> The evaluation of such policies is still minor activity. Maybe the United States and Germany are carrying out evaluation studies with more frequency followed by Canada and the United Kingdom. Other countries which are evaluating frequently their support measurements are Sweden, Switzerland, France and the Netherlands (Kuhlmann/Meyer-Krahmer, 1995; Meyer-Krahmer, 1995). In Spain most instruments of the technology policy were developed in the last decade and their evaluation is almost non existent. Some studies evaluate the Spanish technology system and the general characteristics of the instruments used, but only a few studies analyse particular instruments.

common as they should be<sup>7</sup>. The use of evaluation studies depends on the quality of the study and its recommendations and the willingness and openness of the politicians and the publication of the studies, but most of them are never published or maintained in secrecy. The problem is that evaluation studies often are only used to defend or justify policies and the improvement of existing policies is rather a marginal objective (Nauweleers/Reid, 1995). A second problem, directly related with the former one, is that most of the studies contracted by the public administration are focused on partial subjects. Due to the lack of a theoretical framework concerning economic development and technological change that includes the role of the public government, most of the studies do not include a comprehensive analysis of the coherence between the instruments of the technology policy, and do not analyse them as an integral element of the national and regional systems of innovation (Koschatzky, 1994; Nauweleers/Reid, 1995; Kuhlmann, 1995). It will only be possible to carry out such integral study after a long period of incremental theory building, but policy makers can not wait until scientists offer such integral framework and must work with the tools available at this moment.

## 1.2 Justification and evaluation of technology policy

The role of governmental interventions in the economical and industrial developments is a continuous discussion of modern economic theory. Already since the beginning of the industrialisation there was broad support for non-interventionism and laissez-faire (Smith, 1776) but also for active role for public forces to assure a fast process of industrialisation (Hamilton, 1791; List, 1846). Within the literature about the theoretical foundations of technology policy several points of view can be recognised to study this item. The neo-classical point of view based on assumptions of perfect competition and market failures<sup>8</sup> (Smith, 1776), the strategic trade policies;<sup>9</sup> the new growth theories<sup>10</sup> and the evolutionary perspective<sup>11</sup>. But conversions of these theoretical arguments as

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<sup>7</sup> Germany, United States are some of the few countries which analyse frequently their policies but even in those countries large numbers of instruments were never or seldom analysed. Kuhlmann and Meyer-Krahmer found out that in Germany 80% of the evaluation studies are concentrated in a few technological fields which reflect only 40% of the total number of technology policy measurements (1995, P. 11)

<sup>8</sup> The characteristics of the innovation as a process implies market failures - prevent the attainment of Pareto equilibrium -like the high level of risk -due to the uncertainty of future markets and technological outcomes-; imperfect information (asymmetric distribution and lack of transparency); the problems of appropriability related with externalities and the concept of public goods and indivisibility's the advantages of scale and the critical mass. Such failures conduce to an situation of under investment in R&D and public intervention could increase the social welfare

<sup>9</sup> See among others Spencer/Brander, 1983; Brander/Spencer, 1984; Dixit, 1988; Beath/Katsoulacos/Ulp, 1989; Corden, 1991

<sup>10</sup> See among others Romer, 1986/1990; Lucas, 1988, Grossman/Helpman, 1991; Aghion/Howitt, 1992

<sup>11</sup> See among others Rothwell, 1983; Pavitt, 1984; Kline and Rosenberg, 1986; Dosi/Freeman/Nelson/Silverberg, 1988; Molero, 1994; Malerba/Orsenigo, 1995. Nelson/Winter, 1982; Winter, 1984; Porter, 1990; Dosi, 1988; Hall, 1994; Freeman, 1994; Dosi et al., 1995

useful measurable indicators are still one of the main problems in the practice of evaluation studies. Most literature about the foundations of R&D policies does justify such intervention but none of them offers clear solutions about the design of such policies and how to evaluate its effectiveness. Several studies indicate that the policy measurements depend on the structure of the market. But on the other side the technological changes have some impacts on those structures, which means that the policy instruments should be revised continuously to assure a correct set of instruments for each market in each moment.

Another problem is that the political arguments to justify technology policy do not always agree with the theoretical foundations. From a theoretical point of view technology policy can be justified if it generates a higher level of social welfare but in the practice the policy is focussed on an improvement of the competitive position of the enterprises or the country as a whole. Although, both objectives are not totally excluding to each other. These main objectives are normally pursued by intermediate objectives like the promotion of R&D expenditures, speeding up of the innovation process of key technologies, acceleration of the diffusion of new technologies or the improvement of the national and regional innovation system. This last objective is, among others, pursued by the creation of research institutes technology, transfer centres and the promotion of collaboration and co-ordination.

The evaluation of each technology policy instrument should analyse the main objective, improvement of the social welfare, by an analysis of the costs and benefits of public intervention. Only in the case that the costs –including the opportunity costs, and the costs of the negative externalities for not supported firms- are lower than the benefits in social welfare the policy can be justified. The calculation of the net social benefits is an almost impossible task. About this questions exist actually only fragmental and partial answers. It can not be forgotten that the technology policy intervenes in complex systems in which the causal relationships are not clear. In the last decades, important advancements have been made for the development of a theory of technological change and economic growth (see among others Griliches, 1986; Lichtenberg/Siegel, 1991; Fagerberg, 1994), but still there is no comprehensive theory which explain all the relationships between the technological change and the dynamic of economic development. There exists a good understanding of some crucial factors and their relationships but their use in the empirical studies is not always successful. The two main problems are the lack of good data sets and the exogenous character of the innovation as a phenomenon within the macro economic models. Moreover a comprehensive theory of the technological change and economic development that includes the role of public interventions or a macro economic model that includes the role of public policies still doesn't exist (Nelson/Winter 1982; Nelson, 1984; Dosi/Freeman/Nelson, 1988; Capron, 1993).

Due to those theoretical and methodological problems the role and the importance of the state for the process of innovation can only be analysed making a large number of assumptions about the relationships –causes and consequences- between public and private activities. The justification of technology policy is, in most of the evaluation studies, based on indirect indicators. Most of those studies analysis the impact of the public support on some economic variables of the supported firms (R&D expenditures, productivity of the investments, growth of sales etc.) without taking in account the impact on the economic system as a whole. Other studies are analysing the achievement

of secondary goals like the development of new technologies, new products or the acceleration of the technology transfer. But the problem of the measurement of those kinds of impacts is the difficulty to separate the impact of the public intervention from the results that should have been generated in the case that the government didn't support the firm. Evaluation of the technology policy is still an activity of trial and error involved in a learning process.

Although the utility of technology policy for the firms and for the economic development has been evaluated for a long time, the net impact of the public support on economic development and social welfare, and the analysis of costs-benefits of the public intervention don't have a long and clear tradition within the economic sciences. Interdependent complex linkages connect the processes of innovation, economic development and social welfare and the evaluation of technology policy on social welfare are mostly based on several assumptions about those linkages. Most of the studies are using implicitly the next sequence of arguments.

1. Expenditures in R&D generates a positive effect on economic growth and social welfare
2. Public intervention generates an **additional** growth on the investments on R&D
3. So the public support will have an additional positive effect on economic growth and social welfare.

There is no reason to doubt the first argument due to the fact that a lot of studies proved the importance of R&D for the benefits to firms level (Mansfield, 1968; Griliches, 1984; Griliches/Lichtenberg, 1984) and its influence on economic growth and social welfare (Fagerberg, 1994)<sup>12</sup>. The existing literature does not offer a clear answer about the reliability of the second argument. The conclusions of the empirical studies about the fact that public finance of R&D generates extra private R&D investments are not totally conclusive. Some studies indicated that firms are using the public funds to substitute their own private investments while other studies are indicating that public aid generates additional private investments in R&D<sup>13</sup>.

Even in the case that the first two arguments are right the third is difficult to prove due to the fact that it has to deal with the impact on a complex system. Its verification will only be possible by a quantification of all costs and benefits for each project supported

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<sup>12</sup> Although several studies have indicated that the impact of public R&D expenditures on economic growth and productivity growth were lower than the impact of private R&D expenditures (Leonard, 1971; Terleckyj, 1974, 1980a, 1980b; Allen et al., 1978; Ettl, 1982; Griliches/Lichtenberg, 1984; Griliches, 1986) the final conclusions of those studies are not clear. Some authors did comment more precisely those pessimistic conclusions, for example Griliches (1980) did not find any evidence that private R&D should generate a higher level of productivity growth. Most of the studies did not take in account that the public financed R&D generally implies basic R&D, projects with a high level of risks, which means that the impact on economic growth is more indirectly. So it isn't correct to compare directly the results of private and public financed R&D. Among others, two important aspects that have to be taking in account: the kind of R&D that has been financed and the sectors or technological fields that were supported by public intervention.

<sup>13</sup> The main results of those studies will be presented in the next chapter

by the government. Also in the case that we assume that the first two arguments are true the impact on social welfare still can be positive, neutral or negative. For example, if a project supported by public money with a high degree of additional private investments, generates a negative impact on other firms and a high rate of return of private benefits without the creation of externalities or social benefits then the utility of the public intervention can be questioned. Another example can be the public support of a project with a low level of additional investments. But, if this project generates a high degree of externalities it can create a substantial improvement of social welfare. So the evaluation of the technology policy should be focussed on the measurement of the effects on the production system as a whole –not only the impact on the benefited firms- which will be an expensive and slow activity.

To justify the public support on R&D the following questions should be answered positively in a simultaneous way (See also scheme 1)

1. The public intervention generates additional private investments?
2. The project generates new technologies, an improvement of its application or an acceleration of their diffusion?
3. These are converted in new products introduced on the market?
4. This introduction does not mean the substitution of existing similar technologies?
5. The costs of the policy (including the opportunity costs) and its implementation are lesser than the social benefits?

A positive answer for each of those questions means the existence of a net growth of social welfare and, in that case, the technology policy instrument can be justified.

If we would require, for the justification of R&D policy, the Pareto assumptions –the government can only intervene if it could improve the social welfare without the existence of a negative effect on other agents of the economic system- the analysis would be even more difficult. The state should find some equilibrium between the support of key technologies or key sectors whose development could generate extraordinary externalities and the protection of the free market mechanism.

The first question analyses if the firm really uses the public support to broaden its R&D activities or, on contrary, if the public support is used as a cheap manner to finance projects that would have been carried out anyway.

The second and the third question do measure, in an indirect way, if the supported projects do generate externalities. So they try to find out if the projects do generate new technologies and if those are introduced into the market. A large number of evaluation studies and publications of the governmental institutions do present the technical and commercial results as a direct effect of the public support. In my opinion this is not correct, because, the state intervention is limited to finance the projects but does not intervene directly in the realisation of the projects. This does not mean that such results should not be analysed in evaluation studies. The difficulty to quantify the impact of public support in terms of social welfare converts these results into an important indirect indicator to justify the technology policies. Good technical and commercial results are necessary, although not sufficient, to generate externalities.

The fourth question analyses the negative externalities. Therefore it has to be found out if the introduction implies the substitution of existing similar technologies. Often the innovation is a race between firms to obtain a new patent or several firms do develop different technologies for similar applications. In most of these cases the technologies are substitutes. Public finance of such “substitutes” do not generate an added value for the production system as a whole and, of course, do not raise the social welfare, so has to be avoided. The fifth question should be based on quantification of the results found in the first four questions and include the costs of the implementation of the technology policy –including the opportunity costs.

If all answers are positive then the policy has raised the social welfare and the public intervention could be justified.

In the practice of the economic science it is almost impossible to specify the net effect of technology policy on the economic growth and social welfare. Therefore, as in most evaluation studies, in this PhD I analyse thesis the policy impact on a microeconomic level. Studying the impact of the publicly funded impacts in the firm without taking in account their impact in other firms, the production system as a whole or in the social welfare.

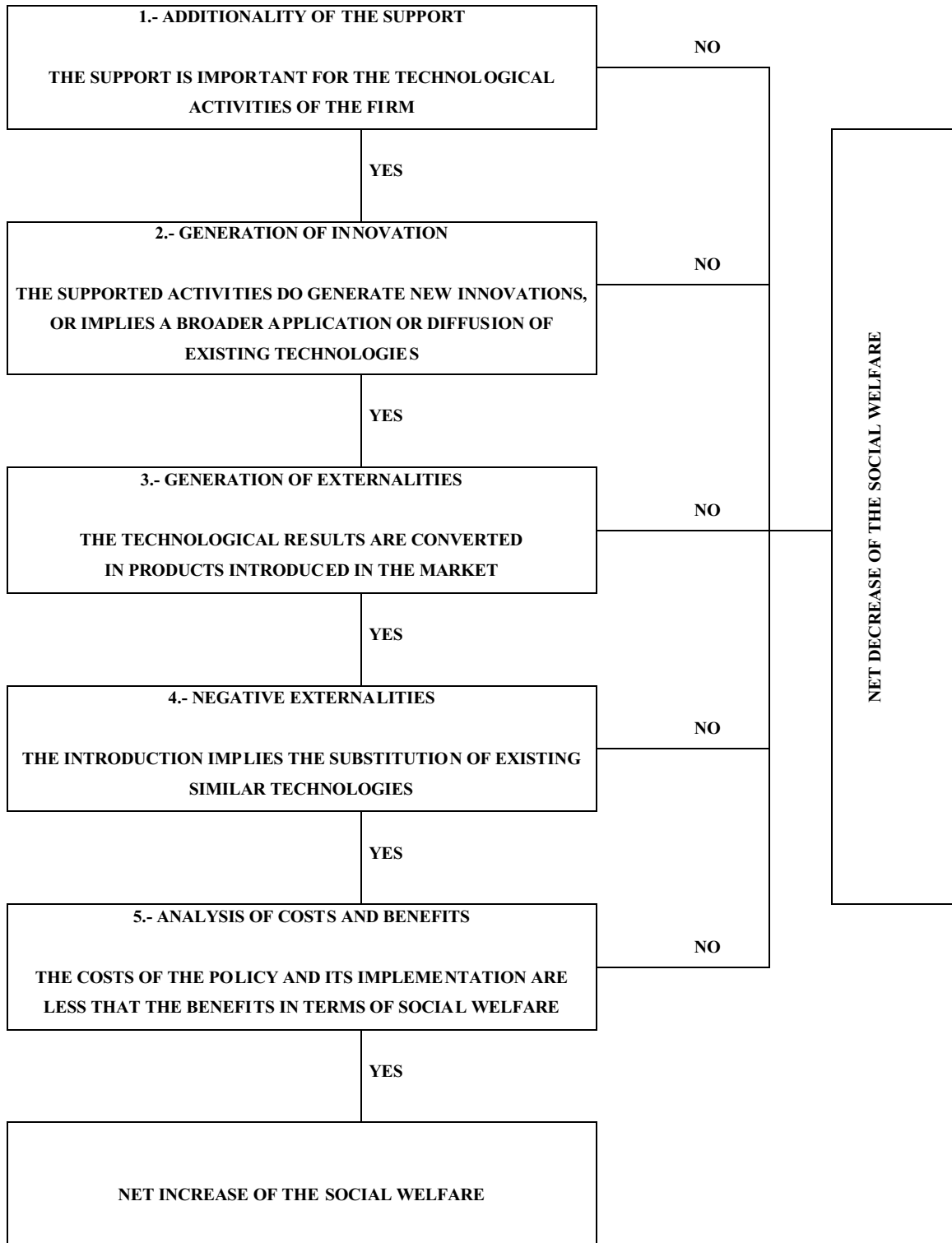
In this PhD study I try to find answers on the first three questions of the conceptual framework –the additionality, the technical and the commercial results-. Moreover, I analysed the impact of the projects on the technical capabilities of the firm and the diffusion of the CDTI support scheme within the Spanish production system.

The improvement of the technical capabilities of the firms is often used as an argument to justify the technology policy. As the interactive model of technological change indicates such capacity is an fundamental factor for the firm’s competitive position or the competitiveness of the nation as a whole.

The study of the diffusion of the CDTI within the production structure has to find out if the CDTI has been a neutral agent of the financial system or if they had a clear policy supporting certain kinds of firms and in this way do bias the free market system.

**Scheme 1:**

**An conceptual framework for the evaluation of the public finance of R&D in enterprises**



## CHAPTER 2

### THE IMPORTANCE OF THE PUBLIC POLICY PROGRAMMES FOR THE R&D ACTIVITIES IN THE SUPPORTED FIRMS

#### 2.1        **Additionality: a theoretical introduction**

In this document I will centre the attention to the incentive power of the public finance of R&D in enterprises reflected by the concept of additionality. Georghiou (1994) defines the additionality as something that is be obtained due to public intervention, and that shouldn't exist without it and responds basically to the incentive effects of the public policies. From an neo-classical point of view, the existence of market distortions implies that firms do not invest enough in R&D. This fact justifies the public support for R&D and additionality will be generated in a automatic way. From an evolutionary point of view the generation of additionality is not an automatic process but depends on each situation.

The study of the additionality in the technology policy instruments has a central place in the evaluation studies<sup>14</sup> although its conceptualisation and importance to justify technology policy is not totally clear. Leaving aside the methodological difficulties to measure and quantify the additionality it has to be pointed out that the justification of technology policy only because of the existence of additionality is not correct. As mentioned in chapter one, additionality has to be completed with a high level of externalities which implies that a large part of the production system can take advantage of the support given to one or some individual firms. We can imagine to extreme cases, on one side we can imagine a project -supported by public funds- that generates a high level of externalities, but that also should be initiated and developed, on exactly the same way, without the public support. In this case we can not assign the increase of the social welfare to the public intervention and additionality can be considerate as a necessary condition to improve the social welfare. On the other side, we can imagine a project that is carried out due to the public support. But in the case that such a project lacks economic interest, doesn't generate externalities and makes it clear that additionality isn't sufficient to justify the support. So additionality is a necessary but not a sufficient condition and has to be accompanied by the generation of externalities.

The main problem of the additionality is how to translate it in a measurable concept, workable in the practice of evaluation studies. First of all it is almost impossible to establish a virtual situation -the non-existence of R&D policies- and compare it with the real situation. A second problem is that the global idea of additionality not always corresponds with the objectives of the technology policy instruments. For some

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<sup>14</sup> Like we will see in the next section most evaluation studies analysed the additionally by qualitative indicators, other studies tried to measure, indirectly, the additional effects of public support studying the increase of the personal in R&D, investments in R&D, sales etc.

instruments the increase of the private R&D investments isn't a prime objective. For example the objective of the public aid schemes for co-operation between firms and R&D institutes is the establishment of a research network. Which is an important aspect for the future innovative capabilities of a region or a country. The evaluation of such instruments should take in account if the industry obtains results that improves their competitiveness and if the public support programme stimulates the co-operation between firms and research institutes improving the articulation of the national innovation system (Urzay, 1999).

Buiseret, Cameron y Georghiou are proposing three concepts of additionality. The first one is the financial additionality that can be divided in the total additionality and partial additionality. Total additionality implies that the supported research activity should not have been initiated without the public support. Partial additionality implies that the project is being carried out sooner or in a more extensive form than initially planned without the public support. The second form, defined by those authors, is the additionality of results, related with the technological results of the project. The third form is the behavioural additionality which implies the changes in the innovative attitude of the firms and improvements related with the process of learning and the training of R&D personnel (Buiseret et al., 1995).

In my opinion the last two concepts of additionality can not be considered like an effect generated by the public aid. As explained before, the technological and commercial results and improvement of technological capabilities generated by the supported projects are, without any doubt, an important aspect to be analysed by evaluation studies. But it would be wrong to conclude that these types of impact are generated by public intervention. Those results are depending on the technological and commercial capabilities of the firms and it can't be expected that those should be different in the case that the project would be carried out without public finance.

Although we can't deny that the technological and commercial results are important for an evaluation study. They are important determiners to create the externalities that are a necessary, although not sufficient, condition to ensure a social benefit of the support programmes for the whole production structure. Of course such externalities only can exist if there a large number of projects that have generated good technological results which are converted in commercial products on the market. But the failure of a high number of projects cannot be considered directly as a problem because innovation is an activity with a high level of risk.

The measurement of the technical and commercial impact of the support projects is also important because of the difficulties to quantify the externalities generated by the support programmes. It is almost impossible to quantify the impact of the public support in economic terms and to carry out a cost-benefit analysis in terms of social welfare. So positive technological and commercial results are used as an indirect argument to justify the public support.

Urzay (1999) is arguing that the concept of additionality is being used in an extremely mechanical way, searching for a direct casual relationship between the concession of public aid and an increase of the investment in R&D. This traditional way of thinking is based on the neo-classical view (market failure) in the linear theory of technological change. The modern theories of technological change show that the reality is more

complex, which should imply a broader concept of additionality. Urzay indicates that the additionality should take in mind three aspects. The influence of the aid schemes on:

- The decisions about investments in R&D (Volume of investments and the speed up of the realisation of projects).
- The organisation and management of technology and innovation in firms. Changes in the role of innovation within the firm, the decisions about "to make" or "to buy", and the learning effects.
- The innovation strategy of the firm. Selection of R&D trajectories, diversification, and the strategies of collaboration and coalitions.

Besides that, the study of the additionality, in the case of large firms, should include an analysis about the impact of the global configuration of projects and technological fields of the firm (Buiseret et al, 1995).

The importance that Buiseret et al., (1995) and Urzay (1999) assigned to those aspects of the additionality can be defended from an evolutionary point of view and of course evaluation studies should take them in mind. But these forms of additionality can not justify on their own, the technology policy instruments. The technology policy instruments can only be justified if those effects should not be obtained without the public intervention.

## **2.2 Additionality: empirical studies**

### *2.2.1 Indicators used to measure the additionality*

The incentive power of the public R&D funding, expressed by the generation of additional investments in R&D, is one of the basic items in most evaluation studies. Some studies indicated that the firms used the public funds to substitute their own private investments while other studies are indicating the clearly powerful incentive of public aid schemes.

There exists a large number of studies that try to prove and quantify, by econometric models, the additionality -or not- of the public aid schemes. Its conclusions diverge enormously and depend on the variables used in the models. So the conclusions of those empirical studies about the fact if public finance of R&D generates extra private R&D investments are not totally conclusive and reliable. For example Carmichael (1981), Griliches (1986) and Lichtenberg (1987) indicates that public finance for R&D do not generate extra private R&D expenditures. Other studies pointed out, at least partially, a positive effect of public finance on private R&D investments (Levy/Terleckyj, 1981, 1983; Scott, 1984; Switzer, 1985; Antonelli, 1989; Busom, 1992). Other studies did criticise these conclusions indicating that the presence of the substitute effect is related with differences in the supported sectors or depends on the type of R&D and the market structure (Link, 1982; Levin/Reiss, 1984). The studies of Blank/Stigler (1957), Shrieves (1978), Carmichael (1981) and Switzer (1985) are reflecting confusing results about the existence of additionality. On one side they are denying the incentive power of public financial support on R&D. But, on the other side, they found some differences taking in

account variables like sector or type of R&D. Some other studies are pointing out that both forms of R&D funding are complementary (Griliches, 1979; Mansfield, 1984; Scott, 1984).

Other studies didn't quantify the additional investments generated by the public support measurements but are using qualitative indicators. They point out the percentage of firms that, due to the public aid funds, has increased their own private efforts of investments in R&D. Table one reflects the indicators to measure the importance of the public aid schemes on R&D for the innovation activities of the supported firms. Those indicators, used in a large number of evaluation studies, can be resumed in four basic ones<sup>15</sup>.

- 1.- Substitute effect or crowding out
- 2.- Existence of alternative financial sources
- 3.- Impossibility to carry out the project without public aid
- 4.- Importance of the quantity of the public aid

The first basic indicator, substitute effect, implies that the public finance has given the firm the opportunity to decrease its own efforts in R&D in relation to the level initially foreseen. So the firms didn't use the total amount of public aid to increase the R&D investment. The absence of the substitute effects implies that the public finance of R&D has an additional or complementary role and means an increase of the total resources that the economic system assigns to innovation activities. This item plays a central role in the evaluation studies about the public finance of R&D in enterprises (See among others the evaluation studies of Röttingshöfer/Sprenger, 1976; Meyer-Krahmer/Gielow/Kuntze, 1982; Warkow/Tourigny, 1982; Siegert et al, 1985; NSF, 1985; Mansfield, 1986; Becher et al., 1989; Becher et al., 1990; Gilchrist/Deacon, 1990; Buesa/Molero, 1994; Molero/Buesa, 1995).

Although in most studies the substitute effect is analysed by a direct question there are two indicators that are directly related with the net effect of the public support on the private efforts in R&D. The acceleration and the enlargement of the projects implies, in a certain way, the absence of the substitute effect. Those two variables indicates implicitly that the firm has increased its efforts in R&D. Although the acceleration of the project does not mean automatically that, on short term, the expenditures in R&D are increasing, the earlier conclusion of the project liberates human capital and financial resources that can be used for new innovation projects.

It can be pointed out that public finance of R&D has a social relevance if the support generates an increase of the private investments in R&D or if the support implies an acceleration or enlargement of the projects. So such relevance exists if the net innovative efforts of the firm depends on the public financial support schemes.

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<sup>15</sup> It has to be pointed out that this taxonomy is based on variables and indicators found in a limited number of studies and is not a product of a theoretical exercise to define a classification with excluding and totally different groups. This fact explain why the four indicators are not totally exclusive but, like will be pointed later, each of them underlines a different aspect of the financial additionality.

**Table 1: Indicators used to analyse the freerider attitude<sup>16</sup>**

	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5 <sup>a</sup>	CASE 5 <sup>B</sup>	CASE 6	CASE 7	CASE 8 <sup>17</sup>
<b>1.- SUBSTITUTION OF PRIVATE BY PUBLIC CAPITAL</b>									
Substitute Effect		16%	15%				18%	25%	*
Acceleration of the project (in time)			43%		33%	27%	*	23%	13%
Enlargement of the project			57%					26%	22%
Enlargement or acceleration of the project									6%
The support made it possible to carry out additional activities limiting the projects risks (quality control, consultancy of experts, etc.)					4%	0%			
<b>2.- EXISTENCE OF ALTERNATIVE FINANCIAL SOURCES</b>									
Existence of alternative financial sources or Difficulty to finance the project without public aid		19%		3%	52%	31%		18%	
<b>3.- IMPOSSIBILITY TO CARRY OUT THE PROJECT WITHOUT PUBLIC AID</b>									
Without public aid the project should have been carried out the same way	9%				12%	4%		7%	18%
Without public aid the project would not have been possible	23%		18%				14% <sup>2</sup>	22%	41%
The public aid made it possible to carry out the project in the form an extensity					35%	62%			
<b>4.- IMPORTANCE OF THE QUANTITY OF THE SUPPORT SCHEMES</b>									
The quantity of the public aid was not very important		8%	13%	*					

Source; own based on Fontela et al, 1992 (Case 1), Buesa/Molero, 1995 (Case 2); IESE, 1995 (Case 3);, Buesa/Molero, 1994 (Case 4); Kulicke et al, 1997 (Case 5); Meyer-Krahmer, 1989 (Case 6), Becher et al, 1990 (Case 7); Siebert et al, 1985 (Case 8).

The second basic indicator, also often used, is the existence of alternative financial sources. The existence of such alternatives implies also a substitution of private capital by public capital but there is some clear difference with the former indicator. The first indicator, in general, refers to the own capital of the firm, while the second one refers generally to financial sources from outside the firm<sup>18</sup>. So both indicators are not totally excluding but are underpinning different nuances of the substitute effect, being two complementary indicators.

A third indicator to measure the importance of the public support on R&D, frequently used in evaluation studies, is based on the variables that are reflecting in some way **the impossibility to carry out the project without public aid**<sup>19</sup>. These variables are reflecting that the project would not be carried out without public aid, but do not explain

<sup>16</sup> In each case are indicated the percentage of firms that reflected each aspect.

<sup>17</sup> Most of the studies the firms answered for its of the indicators on a independent way. In this study uses excluding options what implies that the total of all possibilities sums 100%

<sup>18</sup> The study of Kulicke et al. indicates that the alternative financial resources, mentioned by the firms, are bank-loans (mentioned by 83% of the firms) capital from new partners (10%). Only 28% of the firms met their own capital as a possible alternative.

<sup>19</sup> Based on general questions like: Without public support the project would be carried anyway, would be carried out in the same way or would be impossible?

why. Although from a theoretical point of view these questions could reflect the absence of a substitute effect or alternative financial sources they have a more general character. A large number of reasons can explain why the firm does not carry out the project without public aid. The study of Siegert et al. found out that the project would not be carried out without public financial support because:

- the firm can not finance the project by its own and co-operation or financing it by other sources would be dangerous for the firm's independence.
- the economic risks are too high
- it could only be done with a contract by clients
- it would not be profitable
- other projects would have had priority
- there would not be enough money to finance other important projects
- the internal management would not accept the project

So this indicator, on his own, is not a good way of measuring the economic importance of the public aid in social welfare terms. Such questions should be answered by the reasons why the projects are not carried out.

The fourth indicator that reflects the importance of the financial support for the supported firms is the *importance of the quantity of the financial funds*. If a firm indicates that the quantity of the financial support is not important it could be deduced that its technological development is not depending on the public aid. Even in the case that the support had generated extra investments in R&D.

These four main indicators are identifying, in some way, that the firms withdraw importance on the public funds for R&D and, also each of them implies a certain attitude of "*freeriding*". In this thesis I will use this concept for those firms whose innovative efforts are not depending on the public aid. These freerider firms would have carried out the same innovative activities without having received public funds for R&D. The objective of this study is to measure how many firms have a freerider performance and to identify the characteristics of the kind of firms with a higher probability of such behaviour.

### 2.2.2 *Main result of existing evaluation studies*

Due to the differences in indicators and methods used by the different evaluation studies its difficult to compare the quantitative figures of firms whose technological development depends on the public support measurements. But analysing in detail the results of the eight case studies (see also Table 3) some tendencies can be mentioned. Approximately 17% of the firms reflect a substitute effect and between 18% and 30% of the firms indicate that they had alternative possibilities to finance the project<sup>20</sup>. But as

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<sup>20</sup> One exception with an extreme low percentage of free riders is the support of industrial design that can be explained by the limited size of the supported firms (38% of them had less than 20 employees and 88% less than 100 employees). One exception with an extremely high percentage of free riders is offers the innovation projects analysed by Kulicke et al. (1997). In this case a possible interpretation is the fact that those projects are close to the market, whit a low level of risk.

already mentioned the direct comparison of those percentages is not reliable, so the interpretation should take in account the characteristics of each instrument, the innovative level of the supported projects and the exact questions used in the questionnaires. For example, the two evaluation studies analysing instruments that are supporting radical innovations (case 3 and 8) are indicating more problems for the firms to carry out their projects without the support programmes than the supported firms of those programmes that are supporting applied R&D projects. So it seems to be confirmed that it is more difficult to finance projects of more complicated technological activities, often related with higher economical and technological risks, than projects close to the market.

In the eight case studies I found that the use of different indicators could turn out in somewhat different results. This means that the use of only one indicator, to measure the importance of the support schemes, is not satisfying because it only identifies a particular group. To identify simultaneously all firms that are withdrawing importance on the public support a combination of different complementary indicators should be used. In this way one unique indicator could be created to express simultaneously the different forms of freerider attitude and describe the general profile of the so-called freeriders.

Most of the case studies didn't offer a broad analysis of the correlation between the characteristics of the firms and the freerider attitude. Except in relationship with the size of the firm, only the studies of Meyer-Krahmer (1989); Becher et al. (1989) and those of Molero/Buesa (1994, 1995) offered a broader analysis. Here I will point out the most important conclusions in relation with the freeridership that I found in the eight case studies. As already said the use of different indicators can lead to some nuances in the results that's why the following conclusions are mainly based on the variables belonging to the main indicator "substitute effect". The firms who's technological development and R&D efforts are depending on the public support schemes and are using the support to broaden their innovative activities can be described by the following characteristics:

- Small and, in lesser extend, medium sized firms (Becher et al., 1989; Becher et al., 1990; Molero/Buesa, 1995; Kulicke et al., 1997; IESE, 1995)
- Firms of the R&D intensive sector (Meyer-Krahmer, 1989)
- Not belonging to a group of firms (Becher et al., 1990)
- Firms that frequently participate in public support programmes (Meyer-Krahmer, 1987; Molero/Buesa, 1996)
- Firms with higher efforts in R&D (Meyer-Krahmer, 1987)<sup>21</sup>
- Firms with a strategy based on their market position (Meyer-Krahmer, 1987)
- Firms that consider the innovation as a central aspect of the global firms strategy (Becher et al., 1989)
- Firms that frequently carry out innovative activities (Becher et al., 1989; 1990)
- With larger projects (Becher et al., 1989; IESE, 1995)
- With a high percentage of innovative products over sales (Meyer-Krahmer, 1989)

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<sup>21</sup> The evaluation study of the IESE (1995) did not found such relationship

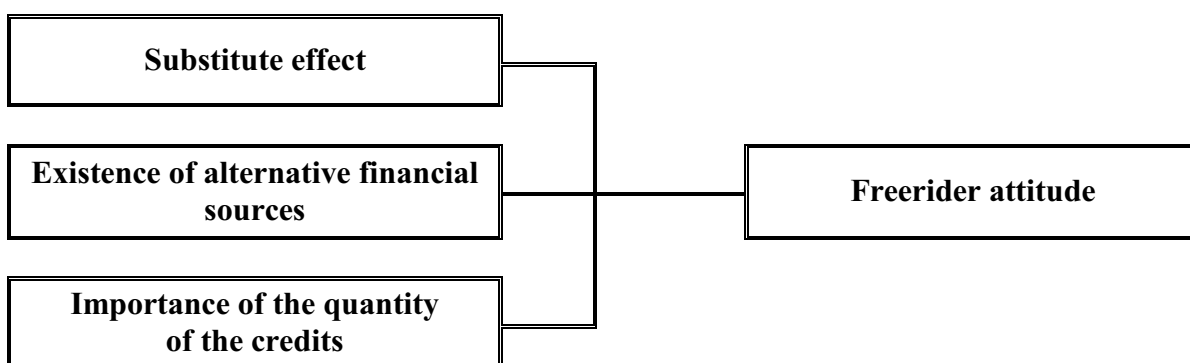
The firms that are reflecting with major frequency a freerider attitude have the contrary profile

### 2.3 Evaluation of freerider attitude between the firms supported by the low interest credits for R&D provided by the CDTI

#### 3.1 Methodological aspects and global results<sup>22</sup>

The importance of the financial support, provided by the CDTI support programmes, for the benefited firms will be analysed initially by three indicators, of the CDTI/IAIF survey, that reflect several forms of the freerider attitude. Based on those three indicators a new variable will be constructed that reflects the so-called freerider attitude reflected by at least one of three individual indicators (See scheme 1).

Scheme 1 Different forms to analyse the freerider attitude



A first form of freeriding includes the firms that are using the support scheme for replacing own financial sources by public funds. So they do not use the aid for increasing the total budget of R&D efforts. The support of the CDTI has permitted 52% of the firms to increase their own effort in R&D and 32% maintained their expenditures on the level initially foreseen. So 84% of the firms did increase the total expenditures in R&D with at least the amount of money obtained by the CDTI while 16% of the enterprises did substitute private capital for public financial sources.

<sup>22</sup> The reader has to take into account two important methodological remarks. First all the relations and empirical results mentioned in the analysis of the role and impact of the CDTI for the firms, in each of the chapters, are statistically significant except if it is denied explicitly. The second remark is that all the relations and results of the analysis of the pick up rates, presented in the following sections were controlled on the possible influences by three variables (size, expenditures on R&D as a percentage of the sales (ERDs) and type of project. Repeating the analysis by each of the following sub-groups (*Size*: up to 50 employees, from 51 to 250, from 250 till 500 and more than 500 employees; *ERDs*: up to 1%, more than 1% and less than 3% and more than 3%; *type of firm* concerted projects versus technology development projects

Taking in account that the support scheme is designed to support firms with problems to finance their R&D activities, a second form of freeriding could be defined. This form of freeriders includes the firms that are using public credits but could finance their projects on the private capital market or by using their own funds. Almost 20% of the firms did admit the **existence of alternative financial sources**, and over 80% of the firms indicate that they would have real problems to finance their projects in the market. This means that the instrument reached one of its main objectives resolving the problem to finance R&D activities.

A third indicator that reflect in certain way that the firm could do the project also without public support is **the importance of the quantity of the financial support**. This indicator reflects that over 91% of the firms considered the quantity of the credits as important or very important and only 8.7% of the firms indicated that the quantity was not important at all.

#### METHODOLOGICAL TREATMENT OF THE VARIABLES THAT INDICATES FREERIDER ATTITUDE

1. The existence of **the substitute effect** was measured in the CDTI/IAIF questionnaire with the following question: The financial support of the CDTI allowed the firm: (1) To increase the amount of R&D financed in relation with the budget initially foreseen by the firm; (2) To bring down the amount of R&D financed by the firm over the initial budget; (3) To contribute exactly what was initially foreseen. Those firms that are bringing down their own R&D efforts are being classified as firms with a substitute effect.
2. A second way to evaluate the importance of the support scheme for the technological development of the firm is measuring the difficulty to find **alternative possibilities of finance**. The IAIF/CDTI questionnaire asked the firms to auto-evaluate that difficulty on a scale from 0 (not difficult) to 5 (very difficult). Those firms that have indicated that it was not difficult to obtain other forms of finance for the project (from 0 till 2 points on a scale of 5) are being considered like firms with alternative financial sources.
3. In the questionnaire the firms were asked to evaluate **the importance of the quantity of the credit** provided by the CDTI. The quantity was measured according to their level of importance (From 0, not relevant, to 5 very important). Due to the fact that this indicator is difficult to interpret I decided to be discrete and only classify the firms that consider the quantity as not relevant or not important (0 or 1 point) like freeriders.
4. **Freerider behaviour: a combined indicator** Based on these three forms to measure the importance of the CDTI credits for the benefited firm I created a new combined indicator. This one classifies all firms as freerider that at least in one of the three indicators did indicate that the CDTI support wasn't important. The freerider behaviour can be defined as those firms on which the support scheme did not generate any additional effect on their technological development and innovative activities

Summarising the results of the three individual indicators that express in several ways the importance of the support for the R&D activities of the support firm it can be stated that 80 firms admitted a substitute effect, 103 firms did have possibilities to finance their projects in the market and 45 firms considered the quantity of the credits as irrelevant. Combining those three groups we found 177 firms that indicated that they could have developed their R&D activities without the public support of the CDTI. So 34% of the firms that benefited from the CDTI show a freerider behaviour by at least one of the three individual indicators.

The creation of the combined indicator is important because each of the individual indicators is measuring different aspects of the freerider behaviour and, like we saw, its results are complementary. Besides that the combined indicator solves one of the main problems of questionnaires. Some of the firms are, especially in the case of direct questions, prone to overestimate the importance of the public support measurement. So the use of the several questions to analyse the freerider behaviour is not only based on their complementarity but also serves as a control system for the answers.

The habit to exaggerate the importance of the public support could under-estimate the absolute percentage of firms with freerider behaviour. But it will not disturb the profile of the firms with a higher or lower level of freeriding because this profile is based on a comparison of the characteristics of the firms with a lower or higher level in relation with the average for the total group of CDTI firms. The objective of the following analysis is not to find out the exact percentage of freeriders in certain types of firms but to find out which kind of firms differ from the average.

2.3.2 *The profile of firms that denies in certain way the importance of the public support for their R&D activities.*

In the following sections I will present the profile of the firms that shows more frequently freerider behaviour. This section offers simultaneously the results of the explorative analysis (association tests) and the confirmative analysis (logistic regression models). I didn't include an exhaustive summary of the contingency tables and the corresponding association tests but the main results are reflected in Table 2<sup>23</sup> while the results of the logistic regression models are presented in Table 3.

2.3.2.1 *The profile of firms with alternative financial sources*

As mentioned before, 20% of the firms revealed that they could have financed their project in the market. The test of association offers a first way to detect the characteristics of the firms with a higher or lower percentage of freeriders. As can be seen in the Table 2 the large firms or the ones with a high number of employees dedicated on R&D do have less problems to finance their activities somewhere in the market. An outstanding group of firms are those that do not have their own employees dedicated to R&D, over 52% of them indicate that they could have financed their projects on the market. Other type of firms with an above average of alternative financial sources are the firms with foreign capital, with a better competitive position, older firms, and firms with a low level of expenditures in R&D related to their sales (ERDs). The firms that indicate more dependency on the public finance are the suppliers of traditional intermediate goods, the firms of the service sector, and the firms with a high effort level of innovation.

The logistic regression model did point out five variables that simultaneously could explain the existence or not of financial alternative sources: the size of the R&D unit, the type of the project, the importance of R&D, the competitive position and the age of the firm. Other variables that were selected by the association test as significant to explain the dependent variable were rejected by the model. That should imply that their correlation with the existence of alternative financial sources should be apparent.

**Table 2: Summary of the results reflected in the contingency table<sup>4</sup>**

	FINANCIAL ALTERNATIVES	IMPORTANCE OF THE QUANTITY	SUBSTITUTE EFFECT	FREERIDER BEHAVIOUR
Small firms (up to 50 employees)	15%	8% (*)	16%	32% (*)

<sup>23</sup> Those results can be consulted in Heijs, 2000. All percentages mentioned in the following sections are statistically different from the general average

<sup>24</sup> The analyses are referring not only to the whole group of CDTI-firms but are also repeated for those firms who did participate in co-operative projects ("*concerted projects*") financed by the National Plan of R&D and those firm that only has participated in no co-operative projects ("*Technological projects*") financed by own funds of the CDTI. It is supposed that the co-operative project implies basic R&D, higher budgets and a higher level of technological and economical risk than the technological projects.

Large firms (over 500 employees)	34%	18%	24%	53%
Firms owned by foreign capital	26%			
Public enterprises		17%		47%
Mass production assemblers	26%		21%	42%
R&D based sectors			10%	
Suppliers of traditional inter-mediate goods	10%	2%		20%
Service sector	13%			
Market leaders	25%			41%
Firms created before 1961	26%		***	
ERDs (less than 1%)	24%			44%
ERDs (from 3% to 5%)	15%			24%
ERDs (over 5%)	17%			32%
Low R&D orientation of the firm <sup>25</sup>	22%	14% (b)		39%
Firms without own employees in R&D	52%	22%		63%
1 till 25 employees in R&D	17% (*)	7% (*)		33%
Over 25 employees in R&D	30%	12%		42%
Firms with co-operative projects			12%	28%
Firms with only technological projects			18%	37%
Firms with more than two supported projects		5%		30%
Project budgets between 101 and 250 million pesetas			10%	
<b>Total sample</b>	<b>20%</b>	<b>9%</b>	<b>16%</b>	<b>34%</b>

Source: own elaboration based on CDTI/IAIF questionnaire. The data with a shadow reflecting a clear below average figures, the data with a shadow and marked by a (\*) shows an average level and those without shadow an above average figure. All figures mentioned in this table reflect differences that are statistically significant.

The explorative analysis did point out that the size of the firm is an important variable to explain the existence of alternative financial sources. The larger the firm the more financial alternatives are available. Over 34% of the firms with more than 500 employees indicates that they could have financed their projects on the market. But the above average figures for the large firms were only confirmed by the logistic regression models estimated for the sample of firms with co-operative projects. Although if we remove the variable “number of employees dedicated on R&D” the size will recover its explanatory power<sup>26</sup>.

The firms owned by foreign capital indicate more frequently that they could finance their project somewhere else, but the logistic regression model does not confirm this. So this tendency should be explained by its interaction with other explanatory variables like their size, or innovative level.

**Table 3: Freerider behaviour: an logistic regression model.**

	FINANCIAL ALTERNATIVES			SUBSTITUTE EFFECT			FREERIDER BEHAVIOUR: AN COMBINED INDICATOR		
	Sample	Co-operative projects	Technology projects	Sample	Co-operative projects	Technology projects	Sample	Co-operative projects	Technology projects
<b>FIRM'S CHARACTERISTICS</b>									
Small (up to 50 employees) versus medium sized and large firms (over 50 employees)		+2,09** (0,16)			+1,79** (0,14)				
SME's (up to 500 employees) versus large firms (over 500 employees)		+0,55** (0,17)		+0,21* (0,09)	+0,71*** (0,29)		+0,23** (0,10)	+0,39*** (0,22)	

<sup>25</sup> These figures correspond to the variable “importance of the basic R&D for the firm” but in one occasions (b) it respond to the variable “importance of applied research”.

<sup>26</sup> This fact could imply co-linearity between both variables but due the fact that there are no relevant changes between both estimated models the high correlation between number of employees and number of employees dedicated on R&D can not be considerate as problematic.

<b>Year of creation of the firm</b>	-0,33*** (0,14)		-0,42*** (0,18)						
<b>Competitive position in its main market</b>	-0,27** (0,07)	-0,92*** (0,20)						-0,77*** (0,22)	
<b>Social Capital</b>									
<b>Sector</b>									
Producers of traditional consumer goods									
Suppliers of traditional intermediate goods									-0,79*** (0,08)
Specialised suppliers of intermediate goods and equipment									
Mass production assemblers									
R&D based sectors		+0,20* (0,08)							
Services									
<b>TECHNOLOGICAL ORIENTATION AND EFFORT LEVEL</b>									
Expenditures in R&D on sales (ERDs) (up to 1% versus 1% or more)								-0,50* (0,04)	
Expenditures in R&D on sales (up to 5% versus 5% or more)									
Personal in R&D (up to 25 versus 25 or more)	+1,06*** (0,12)							+0,97** (0,09)	+1,11** (0,13)
Importance of basic R&D carried out by the firm (OT1)	-0,32*** (0,13)		-0,53*** (0,20)	-0,16* (0,04)		-0,23* (0,08)	-0,20** (0,09)		-0,29*** (0,04)
Importance of applied R&D carried out by the firm (OT2)									
Importance of the technological development carried out by the firm (OT3)									-0,42** (0,17)
Importance of the own R&D in general (OT4)						+0,24* (0,07)			
% of sales corresponding to the introduction of new products or new processes in the last five years		-0,42** (0,15)							
<b>CHARACTERISTICS</b>									
Type of project	+0,59* (0,04)			+0,53* (0,7)				+0,56* (0,07)	
Number of projects financed by the CDTI								-0,19* (0,04)	
Total budget of the financed projects									
% of the credit on the total budget of the project						-0,53* (0,09)			
<b>Constant</b>	-0,93 <sup>NS</sup>	1,5 <sup>NS</sup>	-0,23 <sup>NS</sup>	2,51***	-1,74***	-2,24***	-0,36 <sup>NS</sup>	1,46*	-0,17 <sup>NS</sup>
<b>Correctly classified</b>	81%	70%	71%	79%	80%	73%	65%	78%	62%
<b>Chi square of the model</b>	34,9***	34***	34,2***	11,2**	22,8***	7,1**	42,0**	44,0***	17,5***
<b>Number of firms of in the model</b>	435	165	270	427	162	265	425	161	262

Source; own elaboration based on the IAIF/CDTI questionnaire. Level of significance (\* 10%; \*\* 5% and \*\*\* 1%). The estimated models did contain several variables not reflected in this table because they were rejected. For the ERDs are used three dummy variables (up to 1%; between 1% and 5%; more than 5%), for the social capital were used four dummies (individual national firms, firms belonging to a national group, firms with foreign capital and public enterprises) for the personnel in R&D were used three dummies (Up to 10 employees, from 11 to 25, over 25 employees). Most of them were rejected by the model because they were no statistically significant. It is worth to mention that the variables of technological orientation and efforts can be substituted by each other. Excluding OT1 from the model implies the entrance of other variables like OT2, OT3 or OT4. But this substitution implies a lower level of statistical significance, a lower number of correctly classified firms or a lower chi-square for the model. This could imply that the model has some problems of co-linearity due to the variables of technological efforts and orientation (the same could be said for the variable personnel in R&D in relation with the variable employment) but during the construction of the model, and earlier estimations, I did not find any evidence or indications that this is a real problem.

Both the association tests and the logistic regression model included two variables, statistically significant, that could express the financial credibility of the firm, being the competitive position and the age of the firm. As could be expected the most competitive firms and those have already survived for a long time in the market have more credibility with the private financial institutions than those firms which are struggling to survive.

The explorative analyses pointed out that the less innovative firms (ERDs less than 1% and a low innovative culture) are revealing more frequently that they could have obtained alternative financial funds. A tendency confirmed by the logistic regression models. So the technology activities of the more innovative firms are depending more on the public support than those activities of the less innovative firms. Taking in account the variable that reflects the number of employees dedicated to R&D this tendency can be analysed more deeply. The logistic regression model indicates that

more R&D intensive firms are depending more on the support schemes but if their R&D unit reach a certain level (25 employees) the finance of its projects seems a less important problem.

Maybe the relatively simple entrance for the less innovative firms to the financial market could be surprising due to their lesser level of technological management capabilities. But this tendency can be explained by the low technological complexity of its projects, which are maybe more orientated to applied research project, close to the market with lower economical and technological risks.

The contingency tables did not find a statistically significant correlation between the indicator that reflects the existence of alternative financial sources and the characteristics of the supported projects (type of projects, number of projects, budget of the projects, credit of the CDTI as % of the total budget). But the logistic regression model include one of those variables. Taking into account simultaneously all the explanatory variables it can be pointed out that firms with co-operative projects showed less frequently the existence of alternative financial sources. This can be explained by the fact that those projects are normally orientated to basic R&D and implies higher economic and technological risks.

The estimation for a sample of only firms with co-operative projects shows a very similar picture as the estimation for the whole sample. Also in this model the size of the firm, the technological orientation and the financial credibility of the firms (competitive position) are explanatory variables. The most important difference is the inclusion of the sector based in R&D as such a variable. Estimating the model on a sample with firms that carried out co-operative projects the firms of the R&D based sectors indicates with more frequency that they could have financed their projects also with other financial sources than could be expected taking in account the other explanatory variables, including their size and their innovative efforts and orientation.

The model estimated for the firms with only technology projects is much more concise. Only the age of the firm and its technological orientation explain simultaneously the existence of alternative financial sources. Older firms have more access possibilities to the financial markets and technology orientated firms had less opportunities to finance their projects in private financial institutions.

#### *2.3.2.2 The profile of the firms with a substitute effect*

As can be observed in Table 2 the group of firms that, due to the public financial support, has diminish their own R&D efforts in relation to the initial foreseen level is very homogeneous. The profile of the firms with a lower or higher level of substitute effect can only be characterised by the firm's size, sector and the type of projects.

Almost 16% of the CDTI firms revealed a substitute effect. The firms with an above average percentage are the larger firms (24%) and the mass production ensamblers (21%). The smaller firms with up to 50 employees, the R&D based firms and the firms with co-operative projects has a below average percentage. Also the firms with project budgets between 101 and 250 million pesetas showed in general a low substitute effect. The estimated logistic regression confirms the explanatory power of the size, type of project and accumulative budget of the supported projects, exclude the sectoral

variables and include, like new explanatory variables the age of the firm and the technological orientation of the firm.

Also analysing this form of freeriding it can be pointed out that the more innovative firms are using more frequently the public support to extend their R&D activities than the less innovative firms. Within the group of variables that reflects the technological orientation and efforts the variable “importance of the basic R&D” seems the one with the highest explanatory power. Other variables of this group should enter in the case that the importance of the Basic R&D should be removed from the estimation without any change in the set of variables that do not belongs to the group of indicators of the technological orientation and effort<sup>27</sup>.

The variables reflecting the sector to which the firms belong are excluded from the logistic regression model. This fact has to be interpreted as it’s not the sector that is determining if a firm shows a freerider attitude (substituting private money for public funds). The real reason has to be sought in the other explanatory variables included in the model (like the size of the firm, its innovative orientation or age) and that shows clear sectoral differences.

The explanatory power of the type of projects carried out by the firms is confirmed by both ways of analysis (contingency tables and the logistic regression model). The firms that are carrying out more complex and more basic orientated projects are more prone to use the public funds to enlarge their R&D activities. So the firms with co-operative projects are substituting less frequently the private funds with public money than the firms that only carried out technological projects.

For both type of models (co-operative projects and technology projects) I have repeated the estimations but the results of both models are very concise. Within the model of co-operative firms none of the variables that reflects the orientation and effort in R&D has explanatory power. This can be explained by the fact that almost all the firms with co-operative projects are very innovative. Within the model of firms with only technological projects the only variables with explanatory power are those belonging to the group that reflects the technological orientation and effort. So in this group we can distinguish to types of firms. First very innovative firms that use the public support to deepen their R&D activities and the less innovative firms that use the public funds as a cheap way of financing their already planned activities.

### *2.3.2.3 Profile of the firms with a low valuation of the importance of the quantity*

The profile of the firms that consider the importance of the quantity of the CDTI credits as not important can only be described by the results of the explorative analysis. Only a few number of firms (9%) do consider the quantity as not important. This percentage is higher between the group of large firms (18%) and the public enterprises (17%), firms

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<sup>27</sup> This fact is very important because it confirms the idea that there is no problem of co-linearity between the independent variables of the model. It has no to be forgotten that the problem of multi co-linearity can affects the size and the sign of all the independent variables not only the ones which are interrelated, causing the multi co-linearity, but also the coefficients of other not inter-related variables.

without own employees dedicated to R&D (22%). And this percentage is lower for the firms that are suppliers of traditional intermediate goods (2%) and those who frequently participate in the CDTI programmes (5%). The indicators that reflect the technological orientation and efforts of the firms seems to point out that the more innovative firms consider the quantity more important, but the differences are not too big and the correspondent association tests do not always reach the desired level of statistical significance.

So this profile is very concise and is far from conclusive. The low number of firms that do consider the quantity as not very important impede the estimation of a logistic regression model.

## **2.4 Profile of the firms with a freerider behaviour**

The statistical results of the CDTI/IAIF questionnaire indicate that approximately 34% of the firms shows -at least in one off the three indicators used in this study- a freerider behaviour. The firms that are diverging quite a lot from this average (see table 2) are the large firms (53%) and the public enterprises (47%). Other firms with an above-average figure are mass production assemblers, market leaders, less innovative firms (R&D expenditures up to 1% of their sales –ERDs- and a low orientation to basic R&D), firms that only had one project and firms with a high accumulative budget (over 750 millions) and a very low accumulative budget (less than 100 millions). The suppliers of intermediate traditional goods reflect a clear below-average freerider behaviour. Furthermore the firms with co-operative projects (28%) are less pronounced to a freerider behaviour than the firms that only carried out technology projects are. This profile, based on the explorative analysis is not totally confirmed by the logistic regression model. Studying the results of this model it can be pointed out that the number of variables that explains simultaneously the freerider behaviour are the size of the firm, the type of project, the number of CDTI projects and its technological orientation and efforts.

The model also presents the partial correlation between the dependent and each of the independent variables, representing -in certain way- the explanatory power of each variable. But in general they are very similar.

It can be pointed out that the size of the firm is a clear explanatory variable related with the freerider behaviour. A fact also confirmed by other studies (Becher et al., 1989; Becher et al., 1990; Molero/Buesa, 1995; Kulicke et al., 1997; IESE, 1995). The results indicates that almost 32% of the SME's don't consider the public support as important for their innovative activities while for the larger firms this percentage went up to almost 53%. On one hand, it can be concluded that the CDTI should restrict the participation of the large firms but, on the other hand, it should not be forgotten that over 47% of the large firms indicates that their R&D effort depends on the public support mechanism. To solve this problem the CDTI could require from the large firms a higher interest rate, more close to the market. By this way they don't exclude large firms from the programmes but at the same time freerider attitude will be avoided.

Ostentatious is the appearance simultaneously of both variables (size and number of employees dedicated to R&D) within the estimation for only the sample of firms with

co-operative projects and their absence the model estimated for the firms with only technology projects. It is supposed that the co-operative project implies basic R&D, higher budgets and a higher level of technological and economical risk than the other types of projects. So this model makes clear that especially in this kind of risky and expensive projects the small firms have more problems to finance their projects.

The case studies pointed out that the high level of R&D efforts and a more innovative orientation is correlated with a lower level of freeriding (Meyer-Krahmer, 1987, 1989; Becher et al., 1989, 1990; Molero/Buesa, 1996; Kulicke et al., 1997)<sup>28</sup>. On one side, the statistical results of the CDTI-IAIF questionnaire confirm these conclusions, but on the other side are indicating that the relationship between the freerider behaviour and R&D and the innovative level of the firm has an asymmetric U-form. This can be seen clearly in the contingency tables of the explorative analyses (See Table 2). The less innovative firms show most frequently a freerider attitude but at the same time the most innovative firms -that reach a certain threshold of innovative activities, like ERDs over 5% and with more than 25 employees dedicated to R&D- also indicates a high level of freeriding. Also in the logistic regression model we can observe this tendency. The variables that indicate the innovative level by qualitative variables (importance of basic R&D, ERDs) confirms that the most innovative firms are less pronounced to a freerider attitude. The variable that offers an absolute measure of the R&D level (number of employees dedicated to R&D) confirms that R&D activities of the most innovative firms, with over 25 employees dedicated to R&D) do not depend so much on the public support measurements<sup>29</sup>.

The fact that the less innovative firms have more possibilities to develop their innovative activities also without the public aid programmes could be the result of the kind of R&D activities undertaken by those firms. It seems that, in general, the character of their innovation projects is applied R&D close to the market with a low level of technological and commercial risks, easier to finance . The more innovative firms are carrying out more ambitious projects with long-term objectives what implies a higher risk level.

The relatively higher level of freeriding by the innovative firms that reached a very high R&D level that could be explained by two reasons. First, possibly the innovation is an key aspect of their global corporate strategy and an important aspect for their competitive position on the markets where they operate. So they are obligated to carry out their projects anyway. A second explanation could be the fact that those firms have showed well developed technological capabilities and that they built up a situation of mutual trust with the financial institutions.

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<sup>28</sup> Although Kulicke et al (1997) did check this relationship within sub samples based on the size of the firms. They confirmed this relationship for the medium sized and the large firms. For the sub sample of small firms they found an opposed relationship. Small low-tech firms do have more problems to finance their projects in the market than the small high-tech firms.

<sup>29</sup> Although this variable could be interpreted as an indicator of the size of the firms it has to be pointed out that this aspect (number of employees of the firm) is included as an explanatory variable in the corresponded logistic regression model.

Some conclusions of the case studies should be revised. The results of the IAIF/CDTI-questionnaire do not confirm that the firms belonging to the R&D intensive sectors are less pronounced to a freerider attitude (Meyer-Krahmer, 1989; Becher, 1990). Also the above average freerider attitude showed by the firms belonging to a group of enterprises (Becher, 1990) is not confirmed by the CDTI study.

The tests of associations indicates that public enterprises are more prone to freeriding (47%) than the average firm, but this result is not confirmed by the logistic regression models and should be explained by explanatory variables. Although it's possible interaction with other independent variables is difficult to interpretate. On one side, we could argue that the rejection of this variable in the logistic regression model is the result of correlation between the size of the public enterprises and the freeriding. A large number of those firms belonging to the group of large firms and that could explain its above average freerider behaviour. But on the other side, most public enterprises are participating in co-operative projects that generally reflects a low level of freerider attitude. It was not possible to analyse the interference between those variables and other explanatory variables.

Two indicators are reflecting, in certain way, the credibility of the firms: the competitive level of the firm and its age. The explorative analysis and the logistic regression model corresponding to the existence of financial alternative indicates that the R&D activities of more competitive and older firms are depending less on the public support programmes than young and less competitive firms. In relation to the combined indicator of freeriding, the explorative analysis also indicates that market leaders are more pronounced to freerider behaviour but the logistic regression models do not confirm this tendency. So taking in account simultaneously the impact of the independent variables (like the size, type of the projects etc.) on the freerider attitude of the more competitive firms and the "older" firms that do not diverge in their behaviour from the average firm. It seems that the initially found relationships are apparent and should be explained by their interaction with other statistically significant variables.

From the variables that are characterising the projects carried out by firm only the type of projects and the number of CDTI projects are included in the logistic regression model that analysis the freerider attitude. The firms with co-operative projects are depending more on the public support schemes than the firms with only technological projects. As already mentioned before the higher level of complexity of the co-operative projects can explain this tendency. Such projects are carried out in collaboration with public research centres and should be focussed on basic R&D. The firms that are carrying out only technological projects seems to have an innovative orientation dedicated to applied R&D. They are carrying out low-budget and short-term projects with results close to the market, which implies a lower level of technological and economical risk. So in this case it should be easier to carry out the project also without public support.

Like done in the earlier sections here I have also repeated the analysis by sub-samples of firms in accordance to the type of projects carried out. The logistic regression model estimated by the sub sample of **firms with co-operative projects** confirms that the size and innovative orientation are important explanatory variables. In this model the relation between the innovative efforts and orientation, on one side, and the freeriding attitude, on the other side, shows the same U form as detected before. In this sample of

firms, with co-operative projects, is also detected an explanatory variable that wasn't included in the logistic regression model for the whole sample of CDTI firms. It seems that the firms with a better competitive position show a higher level of freeriding than the less competitive firms.

The logistic regression model that analyses the freerider attitude for the firms that had carried out **only technology projects** is almost empty. This model, with very concessive results, indicates only the firm's characteristics that are correlated with a low freerider attitude being: the firms belonging to the suppliers of traditional intermediate goods and the firms with a low innovative orientation. It is worth while to highlight that the size of the firm and the variable that reflects the number of employees dedicated to R&D are not included in the model as explanatory variables.

## 2.5 Conclusions

None of the case studies presented in the first part of this chapter offered a combined variable to describe the firms that in one way or an other are reflecting an freerider attitude. So the 34% of the firms with such an attitude are not comparable to other studies but, looking to the

**Table 1** we can compare some of the results of the individual indicators.

This table shows that the number of CDTI firms with a substitute effect (16%) do not diverge much of the results reflected in other studies. The number of CDTI firms with alternative financial sources (20%) seem to be low in comparison with the German studies. So it seems that the technological development of the Spanish firms depend more on the public support measurements than the R&D activities of the German firms. Maybe this can be explained, partially, by the fact that the German financial system is probably more used dealing with the finance of R&D with a high-risk level than the Spanish one.

The identification of the firms with a relatively high level of freerider attitude was aimed to the improvement of the policy implementation. It should offer the CDTI, or other public policy agencies, data to establish requirements criteria or priorities aimed on the improvement of the selection mechanism used for the evaluation of the projects. But the analysis almost didn't offer results that can be converted in clearly defined requirements applicable in the practice of project evaluation and that can be defended politically.

The only variable directly convertible in a practical requisite for obtaining credits could be the size of the firm. But as already said it must not be forgotten that 47% of Spain's largest firms indicate that they need the public support to maintain their R&D efforts. Other variables related with the different indicators for freerider attitude are not convertible requirements useful in the practice of policymaking. For example it does not seem reasonable to exclude firms with a low level of ERDs or those that consider the R&D as very unimportant. But those variables can serve to revise or improve the internal process of project evaluation, carried out by the public agencies.

An last remark that can be made is the fact that the freeriders not only do not need the public support to maintain their R&D activities but, as will be explained in the following chapters, the projects of the free rider firms have worse results. The dates of the CDTI-IAIF questionnaire pointed out that the firms with a freerider attitude do have a lower level of goal achievement in relation to the technical and commercial objectives of the supported projects. Besides that those firms also indicate a lower impact in the form of a learning process, improvement of its innovative culture or extending their collaboration with other agents of the innovation system.

## CHAPTER 3

# TECHNICAL EFFICIENCY AND COMMERCIAL SUCCESS OF THE CDTI FUNDED INNOVATION PROJECTS

### 3.1 Introduction

In this chapter I study the objectives and the results of the publicly funded innovation activities. Most studies, and especially political reports, do present those results as a direct effect of the public intervention and use them to justify the policy. As discussed in chapter one, such interpretation isn't correct. The impact of the projects on the technological capabilities, the technical results and their conversion in the market are not depending on the government support. The role of the government is basically limited to the finance of the projects and almost doesn't intervene in their development. Doubts about if the firms would have made the same R&D efforts and would have obtained the same results also without public aid always exist.

Studying the technological and commercial impact of the projects is important for two reasons. The first, already mentioned before, is that a certain level of success in the development of new technologies and their introduction in the market is necessary to generate externalities and to accelerate the economic growth in the long term. This is the only way to generate an improvement of the social welfare, which should be the ultimate goal of the public policies.

A second reason to analyse the technical and commercial results should be the identification of the type of firms whose results are far below average. In this way are identified the firms that not only need financial help but that are demanding, implicitly, a broader set of support measurements (like training, technical consultancy, market analysis etc.). A study about the innovative firms of Madrid (IMADE, 1992) reflected that most of them demanded financial support (over 80%) but they are also demanding other kinds of support. Over 40% demanded technical support and consultancy, more than the half of the firms did indicate the need of training for their employees and over 33% demanded training for their managers. So inclusive within a group of innovative firms it seems that financial support alone is not enough.

The revised literature offers a broad range of indicators and variables that tries to measure the technical and commercial impact of the firms. Those can be classified in four categories:

- 1.- Technical objectives and results (includes the analysis of the technical orientation)
- 2.- The impact on the technical capabilities
- 3.- The impact on the firm's development in the market
- 4.- The impact on the internal development of the firm

The analysis of the *technical objectives and results* (including the analysis of the technical orientation) highlights, on one hand, the technical innovations generated by the projects like for example new products, new production processes, patents and models, prototypes etc. On the other hand, includes the analysis of the orientation of publicly funded projects, studying the type and novelty of the innovations, the technological fields or complexity of the projects etc.

*The impact on the technical capabilities* refers to the learning process that implies the displacement of the technical frontier of the firms. As will be explained in the next chapter, such a learning process is normally not the main objective of the publicly funded R&D projects. Although the improvement of the technological capabilities is considered as a derived effect it could be a very important result of the projects

*The impact on the firm's development in the market* (competitive position, conversion of the innovations in products, increase of sales etc.) is a very important aspect of the impact of publicly funded projects. The main objective of public policies is the improvement of the social welfare. The technology policy tries to achieve such improvement generating a technical advance in benefit for the production system as a whole and such benefit can only be reached if the innovations are available on the market. So it has to be clear that the conversion of the technical results in products and their introduction on the markets is as important as the technical results on it self.

*The impact on the internal development* refers to improvement of the firm's efficiency reflected by cost reduction, mechanisation and automatisisation, diminishment of inputs, improvement of the productivity etc.. But also includes the project's impact on the firm's general situation like, for example, the improvement of general profitability and efficiency or number of employees for R&D. Although some of these aspects of the impact can be considered as a part of the technical objectives of a project I decided to study them apart. It has to be reminded that this taxonomy is based on variables and indicators found in a limited number of studies and is not a product of a theoretical exercise to define a classification with excluding and totally different groups. This fact explains why the four indicators are not totally exclusive but each of them underlines a different aspect.

For example the cost reduction and the impact and the development or improvement of production processes are not exclusive but can be seen as two different approaches to study the impact of the projects. To clarify the different approaches we could suspect on one hand that the main objective of the innovation project is cost reduction. In this case this aim can be reached by the modification of the production system or by other changes in the production system like cheaper materials or lower loans etc. On the other hand it can be suspected that the main objective is to develop a new production process in which the cost reduction is just one of the advantages. Other advantages or aims of such new process can be the improvement of the flexibility, mechanisation of the production, or including such new processes can be aimed at the introduction of new products. It has to be clear that the introduction of new product or processes implies, in most cases, the development simultaneously of a new production process. In this case cost reduction is only one of the multiple facets that has to take in account and isn't an aim on itself.

A particular way to compare the efficiency of the publicly funded R&D activities and the privately financed R&D activities is the comparison of the firm's economic development. A broad number of studies did compare the profits or the productivity of the firms that had taken advantage of the public funds for R&D with the same characteristics of a group of firms that did not received public funds. In the same way they also studied the externalities generated by the firms.<sup>30</sup>

A large number of studies indicates that the projects financed by public funds had almost no effect on the economic increase or productivity of the firms while the privately funded projects did have a clear positive effect on the economic growth of the firms (Leonard, 1971<sup>31</sup>; Terleckyj, 1974, 1980a, 1980b; Allen et al., 1978; Ettlíe, 1982; Griliches/Lichtenberg, 1984; Griliches, 1986, Lichtenberg/Siegel, 1991), although some of those studies did distinguish those results. The general problem of those studies is that most of them did not take in account the differences between the types of R&D financed by the government and by private investors. The public administration is financing more basic R&D, high risk activities in key sectors or important technological fields which influence the economic growth more indirectly and on long term (Link, 1981; Griliches, 1986; Siegel, 1991; Reiss 1990; Capron, 1992).

The objectives of the public R&D (Prestige and defence) and its type of activities (long term basic R&D) could influence the results found in most of the studies. The private investments are guided by the market, profit maximising, and if there are no expected benefits or the risks seem too high they do not invest. Some studies, -taking in account these aspects- did not find evidence at all that productivity of publicly funded R&D is less than that of privately financed R&D (Griliches, 1980; Cunéo, 1984). A study of Reiss (1990) did find some differences but indicated that they were very small.

## **3.2 Technological and commercial impact of publicly funded R&D projects: a review of existing evaluation studies**

### *3.2.1 Technological objectives and results and goal achievement*

Most of the revised studies analysed the orientation of the publicly financed R&D activities. For the conceptualisation of the orientation of the projects has been used a broad number of indicators and variables like the complexity of the project, technological field, development versus improvement of new products or processes, incremental versus radical innovation, novelty of the results (new for the firms, sector or economy as a whole; new for the region, country or for the world). Some studies did point out if the firm enters in a new technological field, if they used new materials or if

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<sup>30</sup> Leonard, 1971; Terleckyj, 1974, 1980a, 1980b; Griliches, 1980a, 1986; Levy/Terleckyj, 1983, 1989; Griliches/Lichtenberg, 1984; Reiss, 1990; Lichtenberg/Siegel, 1991.

<sup>31</sup> This study analyses the economic growth in different industrial sector. Pointing out that the productivity growth is lower in the defence and aerospace sector, being areas with a high level of public support. Leonard indicates that this is a result of the lack of market pressure in these sectors.

the project implies new technologies or knowledge not available in the firm. Almost none of studies analysis if the technological orientation has been changed and if such change is a consequence of the public support or a normal behaviour induced by the changing economic and technological circumstances. The influence of the public aid in the re-orientation of the firm is only analysed on a marginal way. Some case studies, analysed in this thesis, did study this subject by a very general question<sup>32</sup> but none of them studied this matter exhaustedly.

As can be seen in Table 4 the evaluation studies made a broad analyses of the technological impact of the projects and used a large number of indicators and variables to measure it.

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<sup>32</sup> For example: the public support did serve to decide which particular kind of R&D was carried out?

**Table 4: Technological objectives and results**

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
<b>1.- Technological Objectives</b>								
Development of new products, processes or services					*			
Differentiation of the product palette								*
Development of new products	*	*		*				
Development of new processes	*	*			*			
Improvement of existing products	*	*			*			
Improvement of existing processes	*	*			*			
Adaptation of acquired technologies		*						
Improvement of quality	*			*			*	*
Improvement of the design (7 aspects)	*			*				
Adaptation to new international quality norms				*				
Adaptation to changes in the demand side				*				
Adaptation of the product to new norms or standards			*					
Satisfaction of specific demand of clients			*					
<b>1.- Technological Results</b>								
Improvement or development of new processes or products					*			
Development of new products	*	*	*	*	*			
Development of new processes	*	*	*					
Improvement of existing products	*	*			*			
Improvement of existing processes	*	*						
Access to new applications					*			
Adaptation of acquired technologies		*	*					
Improvement of quality	*		*	*				
Improvement of the design				*				
Adaptation to new international quality norms				*				
Adaptation to changes in the demand side				*				
New design	*							
Improvement of the performance or possibilities of the product	*		*					
Substitution of external technologies			*					
Adaptation of the products demanded by clients								
<b>Degree of goal achievement (in % or by general indication)</b>	<b>79-84</b>	<b>alto</b>	<b>73</b>	<b>alto</b>				<b>58-78</b>

Source: Own elaboration based on Fontela et al, 1992 (Case 1), Molero/Buesa, 1995a (Case 2); IESE, 1995 (Case 3); Buesa/Molero, 1996 (Case 4); Kulicke et al., 1997 (Case 5); Meyer -Krahmer, 1989 (Case 6), Becher et al., 1990 (Case 7); Siegert et al., 1985 (Case 8).

The results of the evaluation studies pointed out that the most valued objective was the development of new products or processes and the product diversification (Siegert, 1985; Becher et al., 1990; IESE, 1995; Buesa/Molero, 1994; Molero/Buesa, 1995; Kulicke et al., 1997). The problem is that such orientation can be the result either of the innovative strategy of the firms or of the criteria for the application and selection of the projects by the public agencies responsible for the aid programmes. It sounds logical that most of the publicly support programmes are selecting the projects with a high innovative levels while the possible cost reduction of the projects is not always an important criteria of the selection mechanism.

Anyway it seems that the benefited firms have, in general, a strategy based on innovation. In the case of the CDTI firms a study of Heijs (1999) made clear that within a group of innovative firms, the most innovative ones are participating more frequently in the public aid programmes, than the firms with a less articulated innovative attitude. Moreover the IAIF/CDTI-questionnaire indicates that the CDTI firms consider the

quality of their products and their innovative level as better than those of the national and international competitors. At the same time they indicates that the level of the price of their products are much more close to the average level (Molero/Buesa, 1995a). Also the study of IESE (1995) indicates that the CDTI firms are considering the innovation as an integral and important aspect of their global strategy although the price competition do accompany it.

A large number of studies exist that analysed the technological impact in a quantitative way, like for example the number of patents generated en the projects, the prototypes developed, the increase of R&D employees, sales or R&D expenditures. In relation with the analysis of those results –including the technical and commercial impact- it has to be pointed out that most studies only enumerate them and did not study till which point they were pursued. The lack of such information that could serve as a reference point are frequent in most of the case studies. In this way the evaluation of the results is limited to a descriptive enumeration and could impede the analysis of the goal achievement.

This methodological problem can clarified by the example of patents. The generation of one or more patents do not offer indications about the economic importance –for the firm or in terms of social welfare-. The value or importance of a patent depends on its conversion or application in products. Besides there exists several forms of protecting the inventions and there are sectors that almost do not use the patent system which implies that the lack of absence of patents isn't a good measurement for success of the projects. An other example could be the increase –or lack of increase- of sales. Especially when the project is aimed at the improvement of a product. It could be that such a project that does not generate an increase of sales but does avoid the lose of market segments and a decrease of sales. It would not be correct to compare the growth of sales of a project aimed on the increase of market quotes with those of a project initiated from the defensive attitude.

The number of patents or other absolute indicators are even worse if they are used to compare sectors or include different types of firms of the same sector. Sectors do differ in their way of protecting their innovations. But even within the same sector firm's have different strategies to protect their inventions<sup>33</sup>. The most innovative firms whose strategy is based on technical advances and quality do protect better their results but those firms who's strategy is based on following the leader are less proned to defend their, most incremental, innovation.

A survey designed for a evaluation study should include reference points to be able to analyse if the project was developed successfully or if they failed in their goal achievement. Unfortunately most of the studies did analyse the goal achievement in a very global way using some general questions that do not offer the possibility for the firms to distinguish their answers. Most analyses are based on direct general questions,

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<sup>33</sup> The CDTI/IAIF-questionnaire did point out that the pharmaceutical sector is the one in which the firms value the patents as mechanism to protect inventions as in no other sector. But even in this sector a 30% of the firms that are doing CDTI projects considers the patents as not important at all. While in the meantime a 24% considers at as important and 46% considers the patent system as very important.

for example: did your firm reached the objectives. Without specifying the exact objectives or give the opportunity to distinguish the answer. Some studies did only giving the opportunity to answer yes or no. This kind of methodological problems are especially important for this kind of questions. Firms or managers are prone to say yes because no to them is like to admit a total failure. Besides that most of the firms do reach some of their goals although not always all of them. Most of the times on the moment to initiate the researchers are very optimistic and do pursue objectives extremely difficult to reach. In my opinion an evaluation study should include questions about the goal achievement of several aspects and give the opportunity to distinguish the answer.

As a last remark about this item it can be mentioned that the evaluation studies do point out that a very high level of goal achievement (Fontela et al, 1992; Molero/Buesa, 1995<sup>a</sup>; IESE, 1995) but most of the studies did not analyse the characteristic of the firms with a low or high level of goal achievement.

### 3.2.2 *The commercial objectives and results of the projects*

The case studies did use a broad number of indicators or variables to analyse the commercial impact of the projects on the firm (see Table 5 and Table 6). This fact makes difficult the comparison of the results of the studies and the correct interpretation of the conclusions. The goal achievement of the objectives has been analysed in only a few studies but the methodological problems of those analyses have already been commented before. So in this part I will offer only a description of the found indicators and some brief references about the conclusions of the studies.

## **The influence on the internal development of the firm**

The influence on the internal development of the firm like could be the cost reduction, the improvement of the efficiency or the increase of sales and employees didn't have been analysed frequently. As can be seen in Table 5 most of the studies did analyse those aspects using very few indicators.

**Table 5: Internal commercial objectives and results<sup>34</sup>.**

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
<b>OBJECTIVES</b>								
<b>I.- Rationalise the production process</b>								
Rationalise the production process								*
Improvement of the flexibility of the production							*	
Need to modify the production technology			*					
Cost reduction of the production process		*		*			*	

<sup>34</sup> The studies did not always offer conclusive information if the analysed aspects were objectives or results. The classification is based on the reports and -if available- on the questionnaires used. If it is clear that the report was asking for the objectives or motives of the project the aspect was classified as an objective of the firm. If it is clear that the study analyses a result or in case of doubt the element is classified as a result.

Increase of the production capacity							*	
<b>2.- Saving or incorporation of new inputs</b>								
Saving of inputs							*	
Saving of energy							*	*
Use of new materials	*							
<b>3.- Social aims</b>								
Protection of the environment					*		*	*
Improvement of the working conditions							*	
<b>4. General commercial objectives</b>								
Increase efficiency or productivity							*	
Improvement of the profitability								
<b>RESULTS</b>								
<b>1.- Rationalise the production process</b>								
Increase of automatism and mechanisation	*							
Improvement of the flexibility of the production							*	
Reduction of production time			*				*	
Reduction of production costs		*	*				*	
Improvement of the organisation	*							
Diminishment of the use of fixed capital	*							
<b>2.- Inputs</b>								
Use of new more efficient inputs	*							
In/decrease of the use of energy	*							
In/decrease of the use of materials and components	*							
Use of new materials	*							
<b>4. General commercial objectives</b>								
Increase of R&D expenditures					*	*		
Increase of R&D personnel	*		*		*	*		
Improvement of profitability		*		*				
Creation of work	*						*	
Rationalisation of the labour								
Number of indicators used	10	3	4	2	2	2	12	3

Source: own elaboration based on Fontela et al, 1992 (Case 1), Molero/Buesa, 1995a (Case 2); IESE, 1995 (Case 3); Buesa/Molero, 1996 (Case 4); Kulicke et al, 1997 (Case 5); Meyer-Krahmer, 1989 (Case 6), Becher et al, 1990 (Case 7); Siegert et al, 1985 (Case 8). The\* means that the study analysed the corresponding objective or result.

The analysed aspects can be classified in four groups:

- Rationalise the production process (for example by improvement of the flexibility or accuracy, just in time production, mechanisation and automatism)
- Rationalisation of the inputs (saving or introduction of new inputs)
- Introduction of Social aspects in the production process (improvement of work conditions, environment protection or saving energy)
- General firms objectives or results (optimising the employment, sales, R&D efforts etc..)

In almost all studies the indicators here mentioned were found in several isolated parts of the study. So it can be concluded that none of the studies analysed systematically the influence on the internal development of the firm<sup>35</sup>, The differences in indicators, variables and the presentation used in the evaluation studies makes it impossible to

<sup>35</sup> Only the study of Fontela et al (1992) offers a broader evaluation of the influence on the internal development of the firms.

compare the results or conclusions of the different studies and present some general tendencies.

### **Influence on the firm's development in the market**

Most of the instruments of the technology policy are focussed on R&D. So the measurement of the technological results should be an important aspect of the evaluation studies. Nevertheless the analysis of how those R&D efforts are being converted into products introduced in the market isn't less important (Rothwell/Zegveld, 1981). As reflected in Table 6, there are a number of possible commercial objectives and results that have been analysed and the case studies pointed out that those results are generally satisfying.

It has to be underpinned that in all the revised studies the analysis of the influence of the projects on the market position is analysed from the point of view of the benefited firms. The analysis of the projects on the production system and markets as a whole wasn't studied by any of the evaluation studies. This aspect could be important for evaluation studies to detect negative externalities. For example the project of one benefited firm could generate the expulsion of an other firm with similar technologies. Or the expansion of innovation activities could generate a increase of salaries for R&D personnel for all the firms that are competing for the same scarce resources, being the small group of experienced researchers-. So it has to be underpinned that the positive commercial results can not serve as a justification of the public policy measurements if the effect on the production system and market as a whole is not analysed.

**Table 6: Commercial objectives and results for the market**

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
<b>OBJECTIVES OF THE FIRMS IN RELATION TO THE MARKET</b>								
Differentiation of products								
New opportunities for on the market			*					
Opening of new markets (geographical)				*				
Opening of new markets (products)		*						
Improvement or maintenance of the commercial position in relation with competitors (in general)		*		*				*
Improvement or maintenance of the commercial position in relation with competitors (national)		*		*				*
Improvement or maintenance of the commercial position in relation with competitors (international)		*		*				
<b>RESULTS OF THE FIRMS IN RELATION TO THE MARKET</b>								
Opening of new markets (geographical)				*				
Opening of new markets (products)		*						
Improvement or maintenance of the commercial position in relation with competitors (in general)		*		*				*
Improvement or maintenance of the commercial position in relation with competitors (national)		*		*				
Improvement or maintenance of the commercial position in relation with competitors (international)		*		*				
Differentiation of products								
Successful introduction in the market of new products					*		*	
Importance of the new products/processes en relation with the total sales of the firm					*			
Commercialisation en relation with the firm's sales								*
Increase of sales due to the project	*							
Increase of exports due to the project	*							
Increase of technology transfer								

The evaluation of the project's influence on the market position of the firm are centred in three aspects. The first one would be the product differentiation, the second should be the opening of new markets and the third aspect should be the improvement or maintenance of the market position in relation with other –national or international– competitors. An indirect way to analyse the influence of the projects on the firm's development in the market is the impact of the project on firm's sales, exports or transfer of technologies market .

The interpretation of the results should take in mind the moment of the evaluation studies. In most cases the studies were carried out when the projects of some of the analysed firms were still not completed or finished just before answering the questionnaire. This means that the penetration of the new products in the market isn't totally developed. In spite of a methodological problem the studies are pointing out a high degree of goal achievement in relation with the commercial results (Becher et al., 1990; Buesa/Molero, 1996; Molero/Buesa, 1995a; IESE, 1995)<sup>36</sup>

The barriers, which could impede the commercialisation of the new products almost, aren't analysed. Although the absence of this aspects could be perfectly justified it has to be clear that such analyses could offer worthy information to improve the set of support measurements. The study of Becher et al. (1990) indicates that the most important problems were, errors in the estimations of future markets and the expected technological problems<sup>37</sup>. Other problems that were mentioned were the wrong estimation of the total costs of the project, the introduction of similar inventions in the market by competitors and less cost reduction than expected.

Also the IESE (1995) analysed the problems related to the commercialisation of the results. The problems mentioned by the firms were the: difficulties and costs related with the future technical development of the results (24%), economic and technical irrelevance of the results (respectively mentioned by 7% and 3% of the firms), difficulties to finance the R&D activities needed to obtain a product (17%), difficulties to finance the production (26%), uncertainty on the future demand of the new product (42%) and changes in the competitive situation during the development period of the project (34%).

Due to the big variation of indicators and variables used to analyse the commercialisation of the results in the market and to avoid an enumeration of an endless number of data it impossible to compare the results or conclusions of the different studies and present some general tendencies.

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<sup>36</sup> An exception are the results reflected in the study of Siegert et al, 1985. This study analysing a support scheme for basic R&D projects did indicate less successful commercial results.

<sup>37</sup> Mentioned by respectively 34% and 27% of the firms

### 3.2.3 *Conclusions related to the technical and commercial results*

In general the results are considered by the firms as very satisfactory. But like already mentioned before most of the studies do only enumerate the technological and commercial results and do not analyse if those are the effects off clearly pursued objectives. The lack of such reference points limit the quality of the studies and let them be a merely descriptive enumeration of results instead of a real evaluation that can point out if the projects were successfully or not. For example a number of studies analysed the patents or increase of sales due to the funded projects. But, like already explained, such purely quantitative information does not indicate the degree of success of the publicly funded projects and do not serve as an evaluation of the impact of public support programmes. On one side it has to be analysed in which way those results were pursued by the project, and on the other side, the importance of the results for the firm's technological or commercial development has to be studied.

Like we saw before the increase of the sales as an absolute number does not indicate anything at all. So a better way to study the project's impact on sales could be based on the following question: What was the importance of the project for the sales of the firm or for its commercial position. In this case we will obtain information about the importance of the results for the firm avoiding problems of interpretation like in the case of absolute numbers.

The very positive high level of goal achievement in relation with the technical and commercial objectives can be seen as surprising. The innovation is a highly complex and difficult activity with a high risk of failure. So a relatively high number of unsuccessful or less successful projects could be expected. Unfortunately the evaluation studies do analyse the goal achievement in a very simple general way which made it impossible to distinguish the results.

An other methodological comments is related with the indicators used in the evaluation studies. In the chapter about the free rider attitude we saw some standardisation of the used indicators but in the case of the technological and commercial impact the studies used a broad number of indicators or variables. Due to this problem it was impossible to compare the results of the different evaluation studies, to obtain general conclusions and to point out the found tendencies. So the science of policy evaluation has still to develop a good framework of standardised indicators that can be used in most of the studies.

The characteristics of the firms with worse results almost aren't analysed in the evaluation studies.

## **3.3 Technological objectives and results of the CDTI projects**

### 3.3.1 *Introduction*

Like has been indicate before to justify the public aid for technology and R&D the supported projects have to generate externalities and an increase of social welfare. To assure such impact the supported projects have to develop new products or processes

and introduce them in the market. The R&D is an activity with a high level of economical and technical risks so a certain number of failed projects can be expected. This means that increase of the social welfare due to the technology policy instruments can not be evaluated by the analysis of some individual projects but has to be analysed for the whole group of supported projects. A necessary although not sufficient condition to justify the technology policy is a certain number of successful projects. It is almost – if not, totally- impossible to study the impact of the supported projects on the social welfare. An indirect way to deduct a positive impact should be the analysis of the technological and commercial results.

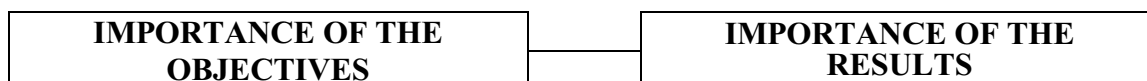
Therefore in this part will be analysed the technological and commercial results of the CDTI projects. Not only will be analysed in which degree the firm reaches its technical aims, but also will be analysed the commercial goals and impact of the CDTI funded innovation projects.

To study the technological impact of the CDTI projects the CDTI/IAIF-survey offers five indicators (See Scheme 1). First the firms were asked for a self-evaluation about the importance for the firm of five possible technical objectives (Development of new products, Development of existing products, Development of new processes, Development of existing processes, adaptation of acquired technologies). In a second independent question they were asked for the importance of the technical results using the same five modalities. The importance was reflected on a scale from zero points (not important at all) to five points (very important).

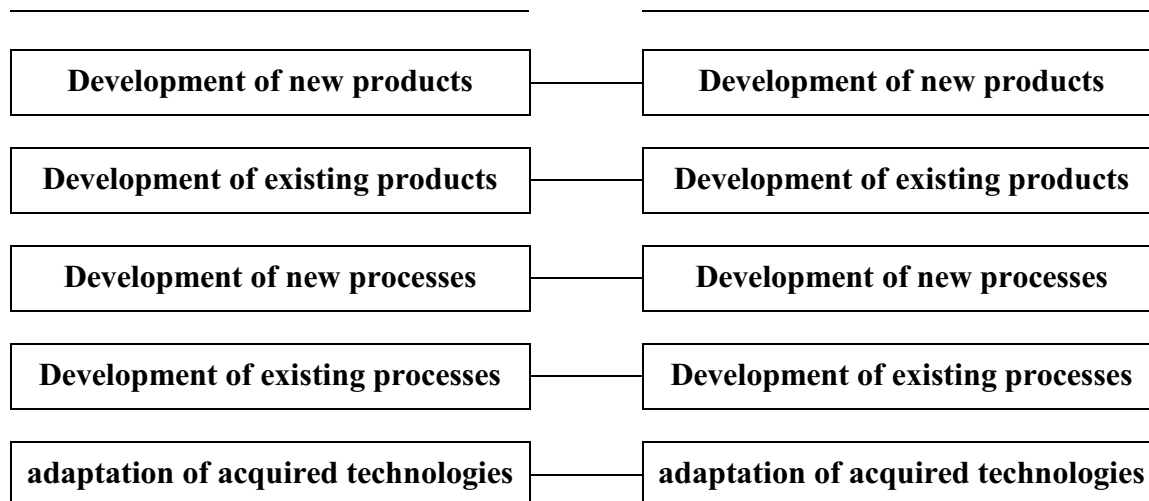
As can be seen in Table 7 the most important objective has been the development of new products, followed by the development of new products and the improvement of existing products or processes. The adaptation of acquired technologies has been a less pursued objective in the CDTI projects

As can be concluded, the development of products has been especially important for the smaller firms, followed by the medium sized ones. While the larger firms consider those objectives as less important. In relation to the improvement of the products was found a similar but less pronounced tendency. For the development or improvement of production processes there was found the opposite relationship. The smallest firms considers these objectives as less important while the medium sized and large firm gives a higher value to the importance of this kind of objectives. The adaptation of acquired technology was considered as a less important objective by all the firms without any significant difference by size. These tendencies are not only found for the objectives of the project, but also for the objectives in relation to the general firm's technological strategy.

**Scheme 1: Technological objectives and results<sup>38</sup>**



<sup>38</sup> The question incorporated in the IAIF/CDTI questionnaire was evaluate the following aspects, arising from the CDTI project, according to their level of importance (From 0 not relevant to 5 very important)?



**Table 7: Importance of the technological objectives by size**

(Average valuation based on a scale from 0 (ir-relevant or not important) to 5 very important)

Size by employment	technological Objectives									
	Product				Process				adaptation of acquired technologies	
	New		Improvement		New		Improvement			
	Project	Firm	Project	Firm	Project	Firm	Project	Firm	Project	Firm
0-50	3.52	3.49	2.23 <sup>(D1)</sup>	3.40	2.01	2.26	1.57	2.50	0.80	1.00
51-250	3.16	3.76	2.35 <sup>(D1)</sup>	3.61	2.47	3.10	2.01	3.34	0.72	1.50
251-500	3.15	3.76	2.29 <sup>(D1)</sup>	3.81	2.56	3.00	1.97	3.48	0.92	1.71
over 500	2.67	3.27	1.82 <sup>(D2)</sup>	3.28	2.46	2.97	2.18	3.51	0.78	1.84
<b>Total</b>	<b>3.24</b>	<b>3.59</b>	<b>2.22</b>	<b>3.52</b>	<b>2.28</b>	<b>2.73</b>	<b>1.85</b>	<b>3.04</b>	<b>0.79</b>	<b>1.37</b>
$\chi^2$	***	**	D*	***	*	***	**	***	N.S.	***

Source: Own elaboration on the IAIF/CDTI-survey. The column project indicates the average assessment of the objective as a clear objective for the CDTI project. The column firm indicates if the objective has been important within the general innovative strategy of the firm. These average worth are on an indicators. There was not carried out a test on the differences between the averages but the statistical test is based on the  $\chi^2$  of Pearson calculated on the contingency tables between the size and the assessment of each of the objectives

\*\*\* Pearson's  $\chi^2$  statistical significant at 99%

\*\* Pearson's  $\chi^2$  statistical significant at 95%

\* Pearson's  $\chi^2$  statistical significant at 90%

NS Pearson's  $\chi^2$  not statistical significant

An comment referred to Table 7 is that for the smaller firms the differences of the importance of the objectives for the firm and for the CDTI-project was very small while for the large firms where found very huge differences. This means one side that for the smaller firms the CDTI projects are much more important and often are related with their central R&D activities. On the other side this fact could imply that CDTI projects of the large firms do not have an important role within their innovative activities as a whole. This does not mean automatically that those projects are marginal ones, but it seems that most of these firms have other projects of the same importance or even much more important.

3.3.2 *Degree of goal achievement referred to the technical objectives*

Like mentioned before, an important methodological problem to analyse the degree of goal achievement is the need of a reference point. Which are the criteria to considerate the results as positive or negative. For example if we do not take in account such a reference point it can be concluded that, in relation to the development of new production processes, the smaller firms had worse results that the larger ones. But in reality they have a very similar degree of goal achievement but for most of the smaller firms this objective is not important.

Therefor I analysed, in a first moment, each modality of the technological results of the CDTI projects for three groups of firms, maintaining the importance of the corresponding objective as a constant factor. So for each of the technological objectives I studies the technical results for three isolated groups or sub-samples. First those firms that did indicate that the corresponding objective wasn't important (0 or 1 point). The second group includes the firms that indicate that the corresponding objective had some importance (2 or 3 points) and the third group includes the firms that consider the corresponding objective as very important (4 or 5 points). The results presented are in general reflecting the statistical data of the third group although when necessary or desirable the results of the first two groups will be mentioned<sup>39</sup>.

A second way to resolve the methodological problem is to calculate the number of firms for which the importance of each of the pursued objectives was clearly higher that the importance of the obtained results. In this way a reference point will created by the construction of a new variable indicating the level of goal achievement for each of the technical –and, later on, the commercial- objectives. This level will be calculated subtracting, for each of the firms, the value of the objective from the value given to the results. If the outcome of this calculation is negative the firm did not achieved its' initially pursued goal. If this calculation is zero or positive then the firms reached their aims or the results are more important than initially expected.

**Table 8: Accomplishment of the technical objectives of the CDTI projects**

<b>Commercial objectives</b>	<b>Number of firms that pursues each objective</b>	<b>Percentage of firms that fulfil their objectives</b>	<b>Percentage of firms that do not fulfil their objectives</b>
<b>Development of new products</b>	343	87%	13%
<b>Improvement of existing products</b>	204	84%	16%
<b>Development of new processes</b>	219	88%	12%
<b>Improvement of existing processes</b>	159	85%	15%
<b>Adaptation of acquired technologies</b>	57	74%	26%

<sup>39</sup> I used this third group because of the methodological problems. Some of the sub groups of firms that indicate that certain objectives were not that important or not important are very small. Due to this fact it wasn't always possible to obtain reliable statistical test.

<b>Combined indicator<sup>40</sup></b>	<b>545</b>	<b>75%</b>	<b>25%</b>
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Source: Own elaboration based on the IAIF/CDTI-survey The average level of goal achievement is calculated taking in account only the firms that considers the objective as important (3 or more points on a likert scale of 5 points).

Although it could be argued that a negative result of –1 also implies that the objectives weren't totally fulfilled I decided to consider only the firms with a negative value of at least two points as firms who's project did not achieve the initially pursued goals. This decision is based on two reasons. First, the measurement of the importance of the objectives and results is reflected by qualitative ordinal variables. Calculations with such variables are methodologically correct but for the interpretation of the results a discreet behaviour is recommended. Second, in most R&D projects the objectives, initially established are very optimistic and difficult to achieve. So if the objectives are almost achieved the project could be considered as successful. So in the following analysis of the characteristics of the firms with a low degree of goal achievement I will only consider the firms who's results are clearly beneath the expectations or objectives of the project<sup>41</sup>.

Table 8 indicates that for each technical objective, taking in account only the firms that consider the objective as important, at least 74% and a maximum of 87% of the firms did achieve their objectives. The projects directed to the development of new products or projects did reflect the highest level of goal achievement followed by the projects aimed at the improvement of existing products and processes. The lowest level of goal achievement is obtained by projects aimed at the adaptation of acquired technology.

**Box 1: An example of the explorative analysis carried out in the PhD thesis: Goal achievement by size**

Studying the importance of each of the five technical results analysed by the IAIF/CDTI-survey (maintaining the importance of each of the corresponding objectives as a constant factor) some differences by size can be pointed out. Analysing the group of firms that considers each of the objectives as very important it can be pointed out that the medium sized firms consider the results in form of the development of new products or the improvement of existing ones has been considered as most important. Followed by the smaller firms while the large firms do consider these modalities of results as less important. This tendency, an asymmetric inverted U-form, is somewhat more pronounced in the case of the impact by improvement of existing products which was especially low for the largest firms (over 500 employees). The same tendency is found for the development or improvement of new processes. The results in form of the adaptation of acquired technologies seems not to be related with the size of the firm.

The analysis of the combined variable that indicates if the firms are achieving simultaneously all five pursued objectives indicate similar results, which can be characterised by a asymmetric inverted U-form. The goal achievement level of the smallest firms is nearby average (73%), the medium sized firms (with 51 till 250 employees) has the highest level of goal achievement (81%), firms with 251 till 500 employees has average level again and for the largest firms this percentage clearly beneath average (64%).

The low level of goal achievement of the largest firms was also found in the control analysis for different sub samples of firms based on R&D expenditures by sales (less than 3%; 1% till 3% and over 3%) and for the sub sample of firms that did carry out co-operative projects, mostly implying basic R&D. For the sub sample of firms with only technological projects the association between the size of the firms and the level of goal achievement was similar but in this case not statically significant.

<sup>40</sup> Firms that are fulfil simultaneously all the technological objectives This percentages calculated for all 545 CDTI firms.

<sup>41</sup> The group of firms that consider their results as more important than the initial expectations are very heterogeneous and it is almost impossible to find some special characteristics of those firms.

Size by Employment	% of firms that are achieving simultaneously all five pursued objectives	Importance of the results including only the firms that considers each of the objectives as very important				
		Products		Processes		Adaptation of new acquired technologies
		New	Improvement	New	Improvement	
0-50	73%	82%	74%	69%	74% <sup>D1</sup>	56%
51-250	81%	90%	80%	88%	85% <sup>D1</sup>	68%
251-500	73%	75%	71%	83%	75% <sup>D1</sup>	54%
Over 500	64%	72%	41%	65%	62% <sup>D2</sup>	85%
Total	75%	83%	73%	78%	76%	63%
Number of firms	545	343	204	219	159	57
$\chi^2$ of Pearson	**	***	*	**	* <sup>D1/D2</sup>	N.S.

Source: Own elaboration on the IAIF/CDTI-survey. The first column of data indicates the percentage of firms that are achieving simultaneously all five pursued objectives. The other five columns are indicating the percentage of firms that considers the results as very important ( 4 or 5 points on a scale from 0 till 5) including only the results of the sub sample of firms that considers each of the objectives as very important ( 4 or 5 points on a scale from 0 till 5) (\*) Pearson's  $\chi^2$  statistical significant at: \*\*\* = 99%; \*\*=95%; \* = 90%; NS = not statistical significant.

The small number of firms that do not achieve each of the objectives make difficult the statistical analysis especially in the case of the control analysis, using small sub groups of firm by size, type of project or their level of expenditures in R&D. Therefore I created a new combined variable based on the results of the calculation of the goal achievement of each of the five technical objectives. This combined variable identifies two kinds of firms. On one side the firms who obtained results, for each of the objectives, which were at least as important as the importance of the objective initially pursued. On the other side identifies the firms for which at least one of the results did not satisfy the initially pursued expectation or objective.

The combined variable indicates that 75% of all the firms included in the IAIF/CDTI-survey did achieve simultaneously all five technical objectives.

### 3.3.3 *Characteristics of the firms with a low level of goal achievement referred to the technical objectives*

#### **Introduction**

The characterisation of the firms with a low level of goal achievement is carried out, in a first moment by an explorative analysis. This analysis reflect the results of association test (Pearson's  $\chi^2$ ) analysing the correlation between the level goal achievement and each of the characteristics of the firm or the projects carried out by the firms. Afterward I will contrast the findings of this analysis with the outcome of a logistic regression model. The second form to analyse the goal achievement takes in account the interaction between different explanatory variables. This model is not used to explain the exact relation between the independent and dependent variables but is carried out to confirm the results of the association tests. The objective of the logistic regression model is to find out which characteristics of the firms has a negative influence on the goal achievement.

The logistic regression models are based on the combined variable that reflects the percentage of firms that achieves simultaneously all five technological objectives<sup>42</sup>. Therefore I will discuss in this summary the main results of the association test based on this combined variable. Although, if necessary, I will complete it with the results of the analysis based on the sub samples including only the firms that considers each of the objectives as very important.

The combined variable reflects that 25 percent of firms do not achieve all their technological objectives. The association tests indicate that the following kinds of firms are diverging from this average. Firms that considers their own developed technologies as less important (45%); firms belonging to the service sector(41%); firms with relatively new innovative activities (40%); large firms (36%); R&D based sectors (36%); firms that considers the co-operation with users or suppliers as less important (respectively 35% and 30% ); more competitive firms (21%); producers of traditional consumer goods and traditional intermediate goods (19%); Firms with between 50 and 250 employees (19%); firms with only one CDTI project (15%) and mass production assemblers (13%). Not associated with the level of goal achievement are control capital of the firm, most of the variables that indicates the firm's innovative effort and orientation, type of project, and the accumulative budget of the projects.

As already mentioned the above mentioned differences could be biased by the interaction between the different explanatory variables. For example the high level of goal achievement of the producers of the traditional intermediate goods could be explained due to the high number of small and medium sized firms (till 250 employees) in those sectors. To solve this methodological problem I have estimated a logistic regression whose results can be observed in Table 9 and will be explained in the following sub paragraphs.

### **Size of the firm**

The logistic regression does not confirm exactly the association between size and level of goal achievement in an asymmetric inverse U-form. On one side, the small differences between different groups of small and medium sized firms are not confirmed. On the other side the logistic regression model confirms the beneath average level of goal achievement of the largest firms. Not only in the model of all 545 CDTI firms but also in the model of the firms with co-operative projects being projects of basic R&D financed by the national R&D plan. So the below average performance of the large firm can not be explained by the interaction of the size with other explanatory variables. Except in the model of firms with only technology projects.

### **Sector**

The association tests did found several differences in the level of goal achievement of firms belonging to different sectors. Firms belonging to the R&D based sector and the service sector showed a low level of goal achievement while the firms of the traditional

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<sup>42</sup> For the logistic regression model I used this combined variable. On one side because on this way I can use the whole sample of 545 firms, increase on this way the reliability of the statistical methods. On the other side the use of sub samples –including the firms that considers the results as very important, could exclude firms with certain given characteristics which would have a negative impact on the representiveness of the sample.

sectors and the mass production assemblers did have high level of goal achievement. The logistic regression models do distinguish those results, on one side confirms the low degree of goal achievement of the firms of the R&D based sector and the service sector. On the other side the models do not confirm the high above average results of the traditional sectors and the mass production sectors. The apparently positive results of those sectors should be explained by the interaction with other explanatory variables included in the model like size or innovative efforts and orientation. The relatively weak performance of the R&D based firms could be related by the fact that the firms of this sector possibly carry out more complex and risky projects. The low performance of the firms of the service sector is more difficult to explain.

**Table 9: Simultaneous achievement of each of the technical objectives: a logistic regression model**

	Sample	Concertated	Only technological projects
<b>FIRM'S CHARACTERISTICS</b>			
Small (up to 50 employees) versus medium sized and large firms (over 50 employees)			
SME's (up to 500 employees) versus large firms (over 500 employees)	-0,46*** (0,09)	-0,82*** (0,19)	
<b>Competitive position</b>	+0,28** (0,06)		+0,36*** (0,07)
<b>Control capital</b>			
<b>Sector</b>			
Producers of traditional consumer goods			
Suppliers of traditional intermediate goods			
Specialised suppliers of intermediate goods and equipment			
Mass production assemblers			
R&D based sectors	-0,22*** (0,13)	-0,22** (0,11)	-0,23*** (0,11)
Services	-0,14*** (0,15)	-0,11* (0,06)	-0,18*** (0,17)
<b>TECHNOLOGICAL ORIENTATION AND EFFORT LEVEL</b>			
Co-operative attitude (Co-operation with clients)	+0,23*** (0,11)		+0,32*** (0,15)
R&D expenditures by sales			
Regularity of innovative activities		-1,5** (0,13)	+0,32* (0,04)
Importance of basic R&D carried out by the firm (OT1)	-0,14* (0,04)	-0,26* (0,07)	
Importance of applied R&D carried out by the firm (OT2))			-0,18* (0,04)
Importance of the technological development carried out by the firm (OT3)			
Importance of the own R&D in general (OT4)		-0,49* (0,09)	+0,35*** (0,12)
Technological autonomy	+0,01** (0,05)	+0,02*** (0,13)	
% of sales corresponding to the introduction of new products in the last 5 years		-0,45** (0,13)	
% of sales corresponding to the introduction of new processes in the last 5 years		+0,56* (0,17)	
<b>CHARACTERISTICS</b>			
Type of project			
Number of projects financed by the CDTI	+1,12*** (0,17)	+1,11** (0,12)	+1,28** (0,17)
Total budget of the financed projects			
Novelty of the project	-1,09*** (0,17)	-1,47** (0,20)	-0,98*** (0,13)
<b>Constant</b>	-0,6 <sup>NS</sup>	+4,39 <sup>NS</sup>	-2,37 <sup>NS</sup>
<b>Correctly classified</b>	75%	80%	79%
<b>Chi square of the model</b>	81***	46**	60***

Source; own elaboration based on the IAIF/CDTI questionnaire. Level of significance (\* 10%; \*\* 5% and \*\*\* 1%). The estimated models did contain several variables not reflected in this table because they were rejected. For the ERDs are used three dummy variables (up to 1%; between 1% and 5%; more than 5%), for the social capital were used four dummies (individual national firms, firms belonging to a national group, firms with foreign capital and public enterprises) for the personnel in R&D were used three dummies (up to 10 employees, from 11 to 25, over 25 employees). Most of them were rejected by the model because they were not statistically significant. It is worth mentioning that the variables of technological orientation and efforts can be substituted by each other. Excluding OT1 from the model implies the entrance of other variables like OT2, OT3 or OT4. But this substitution implies a lower level of statistical significance, a lower number of correctly classified firms or a lower Chi-Square for the model. This could imply that the model has some problems of co-linearity due to the variables of technological efforts and orientation (the same could be said for the variable personnel in R&D in relation with the variable employment) but during the construction of the model, and earlier estimations, I did not find any evidence or indications that

this is a real problem The dependent variable have two values, ONE which means that the firms do accomplish all five technological objectives or ZERO which means that the firms do not accomplish at least one of the five technological objectives

### **Competitive level of the firm**

The association test pointed out that the more competitive firms are more successful in carrying out innovation projects. Also the logistic regression models make clear that the leaders in the market (firms that are occupying a position within the first five on the principal market where they are acting) are more successful in their innovative activities than the firms with less market power. This tendency is been confirmed for the firms with only technology projects but not for the sub sample of firms with co-operative projects.

As has been pointed out several times the technology projects are in general smaller projects with a lower technical complexity than the co-operative projects. Besides that the group of firms with only technology projects is somewhat less innovative than the group of firms with co-operative projects. These facts could explain the different conclusion of both logistic regression models for each of the sub samples by type of project. Within the group of –less innovative- with smaller and less complex projects the more competitive firms are more efficient. Within the group of –more innovative- firms with co-operative projects mostly aimed on basic R&D the competitive position of the firm is excluded as an explanatory variable of the firm’s efficiency.

### **Innovative efforts and orientation of the firm**

It could be expected that the more innovative firms are more able to lead their projects to a technical success. Surprisingly the association tests didn’t find a intensive correlation between the level of goal achievement or -efficiency- and the innovative level of the firm. Only the firms that consider their own developed technologies as less important did show a high level of failure of their projects (45%). The logistic regression model includes two variables that reflect some aspects of the innovative efforts and orientation of the firm. On one side the firms with a higher level of technological autonomy<sup>43</sup> do have a higher degree of goal achievement than firms who are depending more on technologies available in the market. On the other side, the more important the firms consider the basic R&D the lesser the change that the firms achieves their pursued objectives. This apparent contradiction should not be that surprising and has to be interpreted on the following way. The more innovative firms (high level of technological autonomy) do shows higher level of technical efficiency. But those very innovative firms that at the same time considers basic R&D as very important, do carry out more complex and risky projects. So for this group it is more difficult to reach the pursued objectives. Although it wasn’t possible to control this interpretation due to the limits of the available data<sup>44</sup>.

Looking to the two models of the sub samples by type of projects the confusion about the variables, that indicates the innovative effort and orientation of the firms, do

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<sup>43</sup> Measured by the following question: The technology used in the firm proceeds or was developed: totally inside the firm; the own developments are quantitative more important than outside ones; are of equal importance or are less important, or the technology used is developed totally outside the firm.

<sup>44</sup> Although the firms that consider the basic R&D as important do have projects with higher budgets and do indicate more frequently that the project implies relatively new innovative activity.

increase. The model of firms with co-operative projects includes six variables that are reflecting the innovative level of the firm. Four of them have a negative sign and two of them have a positive sign. Again this apparent contradiction has to be interpreted that more innovative firms are more efficient and at the same time the most innovative firms do more complex and risky projects.

#### **Co-operative attitude of the firm**

A clearly positive influence on the technical goal achievement is the co-operation with users and suppliers. Those firms that consider such co-operation as important did have a higher level of goal achievement than firms that have a clear co-operate attitude. The co-operation with other firms or public research centres seems not related with the firm's efficiency. The logistic regression model confirms this relationship.

#### **Characteristics of the financed projects**

Two of the variables that reflect characteristics of the supported projects seems to be associated with the level of goal achievement. The more projects of the firm are financed by the CDTI the higher the possibility that the projects were successful. Moreover the firms with projects that imply relatively new technological activities do have a lower level of goal achievement. The type of projects, the accumulative budget of the projects are not related with the goal achievement. The logistic regression do confirm those results.

### **3.3 The technical results of the firms characterised as free riders**

In chapter two I made an analysis of the firms that could do their innovative activities also without CDTI support. In these firms the support measurement did not generate additional effects on their technological development and innovative activities. As mentioned 34% of the CDTI firms did reflect a freerider attitude.

It can be pointed out that the freerider firms do show a beneath average level of accomplishment of each of the five technical objectives. Although the differences were not very high and this relatively bad level of goal achievement was only statistically confirmed for the development of new products.

### **3.4 Commercial objectives and results of the CDTI projects**

#### **3.4.1 Introduction**

As can be observed in

Table 10, the IAIF/CDTI-survey analysed the importance of three commercial objectives and their goal achievement. Additionality offers the self-evaluation of three ways of commercial impact of which two are directly related with one of the analysed objectives. The analysed objectives of the projects related *with the impact of the firm's development on the market* are the opening of new markets and the improvement of the

competitive position of the firm. Also analysed is the importance of the results of those objectives. Moreover the improvement of the competitive position of the firm as a result for the firm is specified by the improvement in relation to national and international competitors. *The impact of the CDTI projects on the firms internal development* is analysed by the cost reduction (like an objective and result) and the improvement of the firms profitability (only as a result). This means that for five of the six forms of commercial impact the importance can be analysed taking in account importance of the objectives as a reference point. As mentioned the need of such a reference point is an important methodology problem. A first way to solve this problem is the analysis of each modality of the commercial results using three groups of firms, maintaining the importance of the corresponding objective as a constant factor<sup>45</sup>.

The most pursued commercial objective was the improvement of the competitive position of the firm, followed by the opening of new markets. The cost reduction was not one of the main objectives of the supported projects. Analysing the level of goal achievement (see Table 11) it can be pointed out that the firms were more successful in the improvement of their competitive position and the cost reduction than in the opening of new markets

**Table 10: Evaluation of the commercial objectives and results of the CDTI projects**

Objectives and results	Average importance as objective	Average importance as result
<b>Impact of the CDTI projects the firm's development on the market</b>		
Opening of new markets	3,16	2,83
Improvement of the competitive position of the firm	3,58	3,23
Improvement of the competitive position of the firm in relation with national firms		2,67
Improvement of the competitive position of the firm in relation with international firms		2,55
<b>The impact of the CDTI projects on the firm's internal development</b>		
Cost reduction	2,69	2,39

<sup>45</sup> Equally like by the analysis of the technological results three groups were isolated. First those firms that did indicate that the corresponding commercial objective wasn't important (0 or 1 point). The second group includes the firms that indicate that the corresponding objective had some importance (2 or 3 points) and the third group includes the firms that consider the corresponding objective as very important (4 or 5 points). The results presented are in general reflecting the statistical data of the third group although when necessary or desirable the results of the first two groups will be mentioned. I used this third group because of the methodological problems. Some of the sub groups of firms that indicate that certain objectives were not that important or not important are very small. Due to this fact it wasn't always possible to obtain reliable statistical test.

Improvement of the profitability of the firm		2,39
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Source; own elaboration based on the IAIF/CDTI questionnaire. The importance of the results and objectives were measured from 0 or 1 points (Irrelevant or not important) to 5 points very important.

**Table 11: Goal achievement of the commercial objectives<sup>46</sup>**

Commercial objectives	Number of firms that pursues each objective	Percentage of firms that fulfil their objectives	Percentage of firms that do not fulfil their objectives
Opening new markets	248	76%	24%
Maintaining or improving the competitive position	328	83%	17%
Cost reduction in the production	164	80%	20%
Firms that are fulfil simultaneously all three 3 objectives	545	75%	25%

Source: Own elaboration based on the IAIF/CDTI-survey The average level of goal achievement is calculated taking in account only the firms that considers the objective like important (3 or more points on a likert scale of 5 points).

A second way to resolve the methodological problem is to calculate the number of firms for which the importance of each of the pursued objectives was clearly higher than the importance of the obtained results. In this way a reference point will be created by the construction of a new variable indicating the level of goal achievement for each of the commercial objectives (See also footnote 46) and in which way the firms do fulfil simultaneously all the three commercial objectives. This combined variable indicates that 75% of all the firms included in the IAIF/CDTI-survey did achieve simultaneously all three commercial objectives. The results presented in the following paragraph are basically based on this combined variable.

### 3.4.2 Characteristics of the firms with a low level of goal achievement

#### Introduction

The association tests, as a first way to characterise the firms with a below or above level of goal achievement, are pointing out that the level of the following type of firms is differing, statically significant, from the average level of 25% of firms that do not fulfil their commercial objectives are: firms with commercial position inferior to their national competitors (40%), Firms of the service sector (34%), public enterprises (32%), firms with a low percentage of exports over sales (32%), firms with CDTI projects that implies relatively new kind of innovative activity for the firm (32%); firms with a low

<sup>46</sup> The level of goal achievement is calculated subtracting, for each of the firms, the value of the objective from the value of the results. If the result of this calculation is negative the firm did not achieve his initially pursued goal. If this calculation is zero or positive than the firms reached their aims or inclusive the results are more important than initially expected. Although it could be argued that a negative result of -1 also implies that the objectives weren't totally fulfilled I decided to consider only the firms with a negative value of at least two points as firms who's project did not achieved the initially pursued goals.

accumulative budget for the projects (29%), or with only one CDTI project (29%), Suppliers specialised in intermediate goods and equipment (18%), firms belonging to a holding or a group of firms (17%). Moreover the firms that are considering the co-operation with the users or clients of their products as important shows also a higher level of goal achievement. Analysing the goal achievement of each of the three commercial objectives individually it can be pointed out that the large firms had a lower level of goal achievement than the small and medium sized firms did. The combined variable that analyses if the firms do the fulfil simultaneously all the three commercial objectives do not confirm this results statically.

In the next sub paragraphs the result of the explorative analyses will be contrasted with the results of the logistic regression model.

**Table 12: Full accomplishment of the three commercial objectivesan confirmative model.**

	Sample	Concerted	Only technological projects
<b>FIRM'S CHARACTERISTICS</b>			
Small (up to 50 employees) versus medium sized and large firms (over 50 employees)			
SME's (up to 500 employees) versus large firms (over 500 employees)	-0,34** (0,07)	-0,47*** (0,10)	-0,85** (0,14)
<b>Competitive position</b>			
Control capital	+0,28*** (0,11)		+0,31*** (0,11)
<b>Sector</b>			
Producers of traditional consumer goods			
Suppliers of traditional intermediate goods			-0,51** (0,07)
Specialised suppliers of intermediate goods and equipment			
Mass production assemblers	-0,18* (0,08)		-0,29*** (0,14)
R&D based sectors			
Services	-0,06** (0,04)	-0,10* (0,08)	
<b>TECHNOLOGICAL ORIENTATION AND EFFORT LEVEL</b>			
Co-operative attitude (Co-operation with clients)	+0,15* (0,05)	+0,23* (0,08)	+0,19* (0,06)
R&D expenditures by sales			
Size of the research unit (number of employees dedicated to innovation)			0,63** (0,08)
Regularity of innovative activities			
Importance of basic R&D carried out by the firm (OT1)		-0,31** (0,12)	
Importance of applied R&D carried out by the firm (OT2))	-0,16* (0,07)	-0,35** (0,10)	-0,17** (0,07)
Importance of the technological development carried out by the firm (OT3)			
Importance of the own R&D in general (OT4)			
Technological autonomy			
% of sales corresponding to the introduction of new products in the last 5 years	+0,13* (0,05)	+0,45** (0,15)	
% of sales corresponding to the introduction of new processes in the last 5 years			
<b>CHARACTERISTICS</b>			
Type of project			

Number of projects financed by the CDTI	+0,65*** (0,10)		+0,75** (0,10)
Total budget of the financed projects		0,64** (0,15)	
Novelty of the project	-0,60** (0,08)		-0,82** (0,11)
<b>Constant</b>	+0,61 <sup>NS</sup>	1,53*	+0,67 <sup>NS</sup>
<b>Correctly classified</b>	72%	75%	68%
<b>Chi square of the model</b>	41***	24***	38***

Source; own elaboration based on the IAIF/CDTI questionnaire. Level of significance (\* 10%; \*\* 5% and \*\*\* 1%). The estimated models did contain several variables not reflected in this table because they were rejected. For the ERDs are used three dummy variables (up to 1%; between 1% and 5%; more than 5%), for the social capital were used four dummies (individual national firms, firms belonging to a national group, firms with foreign capital and public enterprises) for the personnel in R&D were used three dummies put o 10 employees, from 11 to 25, over 25 employees). Most of them were rejected by the model because they were no statistically significant Its worth to mention that the variables of technologicalorientation and efforts can be substituted by each other. Excluding OT1 from the model implies the entrance of other variables like OT2, OT3 o OT4. But this substitution implies a lower level of statistical significance, a lower number of correctly classified firms or a lower Chi-Square for the model. This could imply that the model have some problems of co-linearity due to the variables of technological efforts and orientation (the same could be said for the variable personnel in R&D in relation with he variable employment) but during the construction of the model, and earlier estimations, I did not find any evidence or indications that this is a real problem The dependent variable have two values, ONE which means that the firms do accomplish all five technological objectives or ZERO which means that the firms do not accomplish at least one of the five technological objectives

### Size of the firm

The analysis of the association between the size and the commercial results did not offer a clear panorama. Most of the analyses<sup>47</sup> of the results found for the three sub samples -maintaining as a constant factor the importance of the objectives related with each of the results- showed the same inverted asymmetric U-form found for the technological results. Medium sized firm are more efficient followed by the smaller firms while the large firms had the worst results. Analysing only the group of firms with co-operative projects this tendency is also found but in this case the results were not that pronounced and statistically insignificant. As already mentioned the other form of analysing the results -studying the level of goal achievement- also didn't offer a clear conclusion.

The logistic regression model clear the confusion generated by the explorative analyses. The model points out that the small firms have a similar level of goal achievement as the medium sized firms -taking in account the interaction between the dependent variables-. While the large firms have a lower level of goal achievement than the SME's<sup>48</sup>.

### Sectoral analysis

The explorative analysis indicated a statistically significant association between the variable 'sector' and the combined variable that indicates the level of goal achievement. Less efficient were the firms belonging to the service sector and an above average of goal achievement was found for the suppliers specialised in intermediate goods and equipment. The sectoral differences in size, innovative efforts and orientation or other firm's characteristics are well known. The advantage of the logistic models is that they analyse the specific sectoral level of goal achievement taking in account the interaction with other sector-specific characteristics just mentioned.

<sup>47</sup> This relationship was confirmed for the improvement of the competitive position en general, in relation with national competitors and in relation with international competitors and the improvement of the profitability of the firm. The impact on the cost reduction did show a similar tendency but the statistical significance was somewhat below the level of 90%. The success in opening new markets did not show any correlation with the size of the firm.

<sup>48</sup> Although in this logistic regression model the medium sized firms as a dummy variable is not included it has to be pointed out that in earlier logistic regression models this variable was included in the estimation of the model but expelled as an explanatory variable.

The logistic regression didn't confirm the above average level of goal achievement of the sector of suppliers specialised in intermediate goods and equipment. Their relatively high efficiency should be explained by its interaction with other explanatory variables. The beneath average level of goal achievement of the service sector is confirmed by the logistic regression model. Moreover, this model indicates that the mass production assemblers were also less efficient than could be expected taking in account simultaneously other aspects of this sector like the firms size, R&D efforts etc.

### **The control capital of the firm**

The explorative analysis –based on the association test- indicates that the public firms were less successful in achieving their commercial objectives while the firms belonging to a group of firms or a holding have an above average level of goal achievement. The logistic regression did only confirm the last result. The lower level of efficiency of the public firms has to be explained by the interaction of other explanatory variables. Those firms are in general large firms and frequently less innovative which could explain their low efficiency level.

### **The competitive position of the firms**

The explorative analysis indicated that more competitive firms were more efficient. The logistic regression model does not confirm the explanatory power of the variables that are indicating the competitive level of the firm.

### **Innovative efforts and orientation of the firm**

The analysis of the commercial results, taking in account the importance of the importance of each of the objectives, showed an intensive positive correlation between the importance of the results and the innovative level and orientation of the firm. The more innovative firms seemed to obtain better results. Moreover the relations found by the commercial results were even more pronounced than in the case of the technical results (see section 4). Especially the variables that indicate the innovative culture or orientation show a high correlation with the importance of the results. The variables that are reflecting in some way the innovative efforts (R&D expenditures, innovative regularity and sales of innovative product in relation to the total amount of sales etc.) are not that correlated with the importance of the results. The more innovative firms did especially well with the improvement of the commercial position in relation with the international competitors and the improvement of the profitability of the firm

Surprisingly the association tests didn't find an intensive correlation between in the level of goal achievement or -efficiency- and the innovative level and orientation of the firm. Several variables<sup>49</sup> did reflect that the more innovative firms did fulfil more frequently their commercial objectives. The differences are small, but statistically significant, and the relations found were more pronounced than in the case of the achievement of the technical goals (see section 4).

The logistic regression model that analyses the achievement of the commercial goals includes only two variables of the innovative efforts and orientation of the firm. On one

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<sup>49</sup> Four variables do confirm that the more innovative firms are more efficient than the less innovative ones: technological autonomy of the firm, importance of the applied R&D, importance of own developed R&D and the percentage of sales related with innovative products indicates

side the firms with a higher percentage of sales related with innovative products do have a higher degree of goal achievement than firms with a lower percentage do. On the other side the model indicates that; the more important the firm considers the applied R&D the lesser is the change that the firms achieve towards their pursued objectives. This apparent contradiction should not be that surprising and has to be interpreted in the following way. The more innovative firms (high percentage of sales related with innovative product) do show a higher level of commercial efficiency. But at the same time the model indicates that the most innovative firms (considering the applied R&D as very important) do carry out more complex and risky projects and have more problems to reach the pursued objectives<sup>50</sup>.

#### **Co-operative attitude of the firm**

The firms with a positive co-operative attitude indicate better commercial results than the firms that considers the co-operation as less important. Especially the co-operation with users and suppliers have a positive effect on the commercial results. The combined variable that indicates that the firm fulfil all its commercial objectives did reflect the same tendency although only statistically significant for the co-operation with users or clients. Also the logistic regression model confirms that the more co-operative firms have a higher level of goal achievement<sup>51</sup>.

#### **The characteristics of the CDTI projects carried out by the firm**

The explorative tests reflected the following results in relation to the characteristics of the project financed by the CDTI

- As well as the association test the logistic regression model indicates that the type of project (co-operative projects versus technology projects) is not related with the level of goal achievement.
- The firms with more than one CDTI project do consider the pursued objectives as more important and reflect a higher level of goal achievement.
- Another characteristic of the CDTI projects is the novelty of the type of activity for the firm. As could be expected firms that are carrying out relatively new activities do have a lower level of goal achievement too

All these tendencies are confirmed in the logistic regression model.

### **4.3 The commercial results of the firms characterised as free riders**

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<sup>50</sup> Those firms with a high percentage of sales are more successful in the commercialisation of the project does not seem so surprising because this high percentage could reflect its success in their CDTI projects. But as in all the logistic regression models presented in this PhD I did some control analyses based on the inclusion and exclusion of different variables that indicate the innovative effort and orientation of the firm. In these earlier models I found similar results. This earlier models did include several variables of the innovative level of the firms and some of them had with opposite signs.

<sup>51</sup> The model only includes the co-operative attitude in relation with the users or clients but excluding this variable of the initial model the co-operation with suppliers will be selected as an explanatory variable.

It can be pointed out that the freerider firms do show a below average level of accomplishment of the three commercial objectives. The differences were in general not very high but more pronounced than in the case of the technological results. The relatively bad level of goal achievement was statistically confirmed by the improvement of the profitability, the reduction of production costs and the improvement of the competitive position in relation with national competitors. The combined variable that indicates that the firm reached all its commercial objectives is not related with the variable 'freerider'.

### **3.5 Conclusions**

Section 3 and 4 analysed the technological and commercial impact of the firms. Although the success of the projects can not be seen as a direct impact of the public policy their evaluation is important to analyse the role and importance of the CDTI. As mentioned before the CDTI support programmes can only be justified if they generate a growth of the social welfare. Such growth can only be generated if a large number of those projects are successful.

There is no doubt about the fact that the results of the projects are very good. This could be surprising taking in account the supposed or expected complexity of the innovation projects. On one side this high level of access can be considered as positive because on this way the projects can generate growth of the social welfare. On the other side it could imply that the CDTI did support incremental R&D projects. This last interpretation seems to be reasonable because the CDTI has to select the projects from the group of applications presented by the Spanish firms. And most of them are doing incremental R&D. Most of the Spanish firms do consider incremental innovation or imitation as more important than radical technical changes. Moreover they do consider the technical development as much more important than the R&D<sup>52</sup>.

Although this interpretation can be put aside partially. It has to be pointed out that, on one hand, the CDTI has reserved a part of its budget for more complex and high-risk projects and, moreover, the development of new products was the most valued objective while at the same time the adaptation of acquired technologies was not an important objective for the CDTI projects. On the other hand, the study of the IESE (1995) pointed out that the technical complexity of the co-operative projects was relatively high<sup>53</sup>.

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<sup>52</sup> The studies about innovative behaviour of the Spanish firms point out that the most of them do incremental R&D and the introduction of important or radical technological changes is considered as less important (see among others the studies of: Circulo de Empresarios, 1995; Buesa/Molero, 1998, COTEC, 1998).

<sup>53</sup> For 50% of the co-operative projects the used knowledge existed only on a theoretical level and only 30% of the projects used knowledge that was already used in industrial applications. 31% of the projects developed a technology that was new on world level, 58% was new at national level and 60% was new on firm level.

The evaluation studies of technology policy should generate useful data for policymakers so that they can adjust the instrument, develop additional measurement to accompany the existing instruments or to improve their internal selection procedure of the presented applications. The objective of the characterisation of the firms with worse technical or commercial results and with a low level of goal achievement was the generation of such useful data. In spite of the rich information offered by the IAIF/CDTI survey it is difficult to characterise the firms with a low level of goal achievement using such practical and useful indicators

In an unexpected way it seems that the large firms have more problems to carry out successfully their R&D projects. It could be expected that those firms, with more market power, could convert more easily their technical results into commercial products than the smaller ones. It could be argued that this result is related with the kind of projects of the large firms that the CDTI finance. The CDTI has a closed budget and can not accept all the presented projects. In its aim to finance as many as firms as possible it could be that they select, in the case of the large firms small projects –or a project that is just a part of a big one- with low direct importance for the commercial situation of the firms. It is impossible to confirm this interpretation. Moreover this argument can only be used for explaining the low level of commercial results but not to explain the relatively bad technical results.

A group of firms that needs special attention from the CDTI are the firms of the service sector. The complexity of their projects or the low innovative level of those firms can not explain their low level of goal achievement as well as in relation to their technical objectives as in relation with their commercial objectives. The CDTI should handle more carefully the application forms of the firms of this sector during the selection procedure, improve the control of the development of those projects or offer additional support (like innovation or commercial consultancy or formation of researchers). The R&D based firms, that also show a low level of goal achievement, possibly do not need such extra attentions. Their relatively bad results are not based on a lack of technical capabilities but the result of more complex and risky projects.

Other type of firms that show a below average level of goal achievement –especially in relation with their commercial objectives- are the firms with a less competitive position in the market. The association tests make clear that those firms need extra attention especially to convert their technical result into products ready for the market.

The analyses do not doubt about the fact that a positive co-operative attitude has a positive influence on the efficiency of the firms. Especially firms that considers the co-operations with clients and suppliers like very important shows a high level of goal achievement. Although on the same time its important to stress that the co-operation with Public Research Centres is not that highly associated with the success of the projects. Although it could be explained by the possible high difficulty of the projects carried out in co-operation with such institutes.

To explain the apparently contradictory results that were found in the logistic regression models in relation with the indicators of the innovative efforts and orientation of the firms I used the following interpretation. The most innovative firms do have a relatively low level of goal achievement because they are carrying out more complex and difficult projects. Simultaneously -taking in account the complexity of the projects- the more

innovative firms show a higher level of goal achievement, in relation with their technological and commercial objectives, than the less innovative firms.

The second part of the interpretation can be explained by the fact that the more innovative firms possibly have better technological capabilities and experience in R&D. This interpretation can only be proved in an indirect way. The supposition that the most innovative firms do more complex projects is supported by the fact that those firms do carry out more frequently co-operative projects -normally including basic R&D-, their projects are in general characterised by higher costs or budgets and the technical objectives of their projects do diverge more frequently from their normal innovative activities. Moreover this interpretation could be more plausible taking in account the type of indicators that have negative or positive signs. The variable that indicates that the more innovative firms have a higher possibility to achieve their technical goals than the less innovative is the technological autonomy of the firms, an indicator that could be associated with the technological capability of the firm. The variable that indicates that the most innovative firms have a lower possibility to achieve their technical goals than the less innovative ones is the importance of basic R&D. If a firm considers the basic R&D as an important element of its innovative activities it could be supposed that they carry out more complex and difficult projects than the firms that deny the importance of basic R&D and are only doing applied R&D or technical engineering.

A last indirect fact that could corroborate this interpretation of the apparent contradiction was found in the explorative analysis using only the sub sample of co-operative projects. These analyses reflect a relation between the goal achievement and the innovative efforts and orientation of the firm in the form of an inverted U. Firms with a medium level of innovative efforts<sup>54</sup> have the highest level of goal achievement (87%) followed by the most innovative firms (75%). The less innovative firms did have a clearly lower level of goal achievement (60%). This could indicate that the firms do need a critical mass of R&D activities to assure a certain level of goal achievement. Once passed that critical mass the the higher the R&D efforts the worse the level of goal achievement. Again, this should be explained by the more complex activities of the projects carried out.

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<sup>54</sup> Measured by the expenditures in R&D by sales using three intervals (up to 1%; from 1 till 3% over 3%). Further on can be remembered that the average level of goal achievement of the technological objectives is 25%.



## CHAPTER 4

### THE LEARNING PROCESS GENERATED BY PUBLICLY FINANCED R&D PROJECTS

#### 4.1 Introduction

There is no doubt about the fact that innovation is a key aspect for economic growth (Griliches, 1986; Lichtenberg/Siegel, 1991; Fagerberg, 1988, 1994; Freeman, 1994) and that the development of new advanced technologies is an important factor of the competitive advantages of a country or a region and their enterprises (Freeman, 1987; Porter, 1990). Also on a micro level the innovation is an important factor. The competitive strength of a firms depend partially on its innovative level. As can be derived from the modern theories of technological change (the interactive model : see Box 1) the technological capacity of a firm is a fundamental factor to develop, successfully, R&D projects. The technological capability of a firm can be described as its potential to understand, manage, and adapt the purchased technologies or future innovations, the capacity to develop or generate technological innovations and is the result of an accumulative learning process and experience (Freeman, 1974, 1987; Dosi et al., 1988; Cohen/Levinthal, 1989 ; Meyer-Krahmer, 1989; Roussel et al., 1991; Dankbaar et al., 1993; Rothwell, 1994; Malerba/Orsenigo, 1995; Pavón/Hidalgo, 1996). The firm not only needs the potential to manage new technologies, but the enterprises have to be aware of the future technological developments which made them able to value, detect, select and absorb the relevant technologies for the firms (Cohen/Levinthal, 1989, P.569). Innovation management, as underpinned in box 1, should be part of the firm's corporate strategy.

In this paper I will analyse the learning effects of R&D using the concept of “generic impact” defined by the impact on the technological capabilities of a firm, generated by the development of R&D projects. A firm's technological capability consists of its know-how with a tacit, accumulative dimension determined by a broad number of factors like the influence of the human resources, the entrepreneurial attitude of the boarding director, the innovative culture, the potential to learn, the organisational structure and management of the innovation and the embeddedness of the firm in the national and regional system of innovation.

To put the conclusions of the study in a broader context and to overcome ad-hoc interpretations the results will be contrasted with several evaluation studies that analysed the learning effects of publicly financed R&D projects. Such a “case-study” includes an analysis of 4 studies that evaluated the actuation of the CDTI (Busom, 1991; Fontela et al, 1992; IESE, 1995 y Acosta, 1996) and also reflects the results of other evaluation studies, that analysed similar programmes, carried out in Spain or other countries.

### **BOX 1: Theory of technological change: the linear and interactive model<sup>55</sup>**

The modern theories of technological change upgraded the interest of policy makers in the concept of technological capabilities of a country and their firms. The Technology policy in most developed countries until the early 1980s was based on the *linear model* ( Behrend, 1995; Dankbaar, 1993 ; Nauweleers/Reid 1995) This model views R&D as an isolated activity performed in research centres without the direct influence of market considerations. Innovation is considered a linear, sequential process occurring in isolated stages, beginning with basic research and extending through to the introduction of an innovation-based product onto the market. Under this model, technology transfer – the dissemination of new technology – is supposed to take place automatically and without significant costs or delay through the mechanism of the “invisible hand”: technology is seen as information easy to transfer and copy. The linear model virtually neglects factors such as the influence of institutions, strategic and competitive behaviour of other firms or countries, or factors related to demand and education. Policies based on the linear model are aimed at the generation of innovation, for example through the establishment of research centres and support for basic research on key new technologies. A alternative model gained ground in recent years and fuelling radical changes in the design of technology policies is the *interactive model*, based on the notion of continuous interaction between different actors and elements throughout the innovation process – from basic research to industrial development, commercialisation, and introduction onto the market. While the linear model highlights only the activities of a firm’s R&D department, **the interactive model stresses the firm’s technological capabilities and entrepreneurial attitude, and sees innovation management as an integrated, strategic corporate activity in which the entire firm is involved. A firm’s technological capability consists of its know-how with a tacit, accumulative dimension.** Technology transfer is viewed as expensive and difficult, while understanding new technologies is seen as time-consuming. The interactive model considers innovation to be a dynamic process occurring in stages, with continuous feedback at each stage – moreover, the entire process is viewed as taking place within a changing environment. The model implies that support for basic research and the generation of new technologies is not enough, and that more political attention should be given to technology transfer and the improvement of innovation capabilities within enterprises. The design and implementation of technology policy is seen as a process of learning-by-doing within a changing context, demanding continuous adaptation to circumstances and competitive pressures.

## **4.2 Analysis of the generic impact of R&D projects in evaluation studies**

The learning process related to the innovation projects are analysed in most studies that evaluates the public finance of R&D projects and such learning process is often used as a argument to justify such policies (See also chapter 1 and 2). Table 13 reflects a broad

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<sup>55</sup> This box offers a short introduction about this subject for a broader discussion see Rothwell, 1983; Pavitt, 1984; Kline and Rosenberg, 1986; Dosi/Freeman/Nelson/Silverberg, 1988; Molero, 1994; Malerba/Orsenigo, 1995.

number of indicators used to measure the impact on technological capabilities. The aspects frequently analysed can be classified in three groups<sup>56</sup>.

Learning process in a strict sense

(improvement of the knowledge base, HH.RR. and innovation management of the firm).

Improvement of the innovative culture.

Intensification the collaboration and the improvement of the integration in the innovation system as a whole.

#### 4.2.1 *The learning effect of R&D activities in a strict sense*

The first group includes indicators that analyse the learning process in a strict sense. The technological capability of the firms is difficult to conceptualise and to measure. Most studies use qualitative indicators to measure the improvement of the technological capabilities based on the personal opinion of the managers. In other word the evaluation is based on the subjective perception of one of the managers responsible for the R&D activities of the supported firms.

As can be observed in Table 13, four indicators are used frequently to analyse the learning effects of the supported projects: improvement of the capabilities of the R&D personel, improvement of the knowledge base of the firm, improvement of the organisation or management of the innovation and improvement of the integration of R&D with other parts of the firm. Further on the study of Kulicke et all analysis the improvement of the conversion of innovations in products and the better integration of external ideas (from clients providers etc.). Both aspects are considered as very important and received increasing attention due to the modern theories on technological change (interactive model).

Not only the project can generate learning effects but also the administrative process -like the process of application for the support or the control mechanism during the time the project is carried out- can generate improvements of the technological capabilities. For example the support programme for the costs of R&D personel in Germany required a strict control of the time that the personel of R&D was really involved in innovative activities. For most of the supported firms it was the first time that they implemented such time control and a lot of them indicates that this control mechanism, obligated by the public administration, was converted in an important internal control mechanism. Another example could be the application process of the CDTI, in which a number of firms, especially smaller ones, had to improve their internal control mechanism of the their R&D activities and financial control to obtain public support.<sup>57</sup>

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<sup>56</sup> Although some of the indicators of each group seem similar it has to be pointed out that it was not always possible to detect how each of the indicators were conceptualised by each of the studies. The distinction and interpretation of each of the indicators is based on the questionnaires of each of the evaluation studies and, if not available, on the interpretation of the authors.

<sup>57</sup> Although there is no empirical evidence about the importance of those changes for these firms there isn't any doubt that it could be an important organisational innovation of the technology management of some of those small firms.

**Table 13: Indicators to analyse the generic impact used in 8 evaluation studies**

	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8
<b>IMPROVEMENT OF THE INNOVATIVE CULTURE</b>								
Improvement of the interest for R&D in the firm		*		*		*	*	*
Upgrading of the R&D department			*					
More continuity of the innovative activities						*	*	
Intensification of the innovative activities					*			
Increase of the personnel in R&D			*					
Increase of the R&D expenditures	*	*				*		
<b>LEARNING EFFECT</b>								
Improvement of the preparation of the R&D employees	*	*	*		*	*		
Improvement of the knowledge base of the firm	*	*	*					
Improvement of the R&D management	*	*	*		*			
Improvement of the conversion of innovations in products					*			
<b>IMPROVEMENT OF THE CO-OPERATIVE ATTITUDE</b>								
In general					*			*
With public R&D institutions		*	*					
With other firms		*						
With firms of the same group		*						
Better integration of external ideas of clients, providers etc.					*			
Broader number of external relations of resources of information			*					
Studies that analysed the general co-operative attitude of the firm		yes	yes		yes	yes	yes	yes

Source: Own based on Fontela et al, 1992 (Case 1), Bues a/Molero, 1995 (Case 2); IESE, 1995 (Case 3);, Buesa/Molero, 1994 (Case 4); Kulicke et al, 1997 (Case 5); Meyer-Krahmer, 1989 (Case 6), Becher et al, 1990 (Case 7); Siegert et al, 1985 (Case 8).

Most studies points out that the supported projects did generate important improvements of the technological capabilities. But only a few studies offer an analyses of the characteristics of the firms which could explain lower or higher impact level. Except the size of the firm which is studied in several occasions only the study of Molero y Buesa (1995) analyses some firms characteristics in correlation with the level of impact on the technological capabilities (like the sector, control capital<sup>58</sup>, number of public funded projects and size). Moreover the studies of Meyer-Krahmer (1989), Becher et al,(1989) and Kulicke et all (1997) did analyse the impact in relation with some aspects of the innovative efforts and orientation of the firms.

Only two conclusions can be mentioned. The first one is that all studies that analyse the size of the firm as an explanatory variable -independently of the type of instrument or type of indicator- indicate that the smaller firms had a higher impact on their technological capabilities than the large firms<sup>59</sup>. Although it can be pointed out that also for a huge number of large firms the impact has been very important (Kulicke et all. 1997).

A second conclusion, somewhat surprising, is the fact that the firms with the highest innovative level consider the impact on their technological capabilities as more important

<sup>58</sup> National individual firms, firms belonging to a national holding, public firms and Foreign firms

<sup>59</sup> The studies of Meyer-Krahmer (1989) and Becher et al. (1989) indicate that this modality of impact was the highest in medium sized firms, a little bit lower in the smaller ones and clearly less in the largest ones.

than the less innovative firms do<sup>60</sup> (Meyer-Krahmer, 1989; Becher et al., 1989; Kulicke et al., 1997).

#### 4.2.2 *The improvement of the innovative culture*

The second and the third group includes indicators that analyse the learning process in a more broader sense, taking in account the improvement of the innovative culture and the collaborative attitude. Maybe one of the most important aspects of technology policies could be the positive impact on the innovative culture of the firm (Rothwell, 1983, P. III). Some public support programmes are designed especially to generate such an impact trying to initiate a process of awareness about the strategic importance of innovation. The German evaluation studies stressed the importance of such effects (see Bräunling/Harmsen, 1975; Biekert, 1976; Röthlingshöfer/Sprenger, 1976; Meyer-Krahmer, 1989; Becher et al., 1989, 1992) while studies carried out in the USA almost didn't take in account this aspect. Biekert (1976) indicates that the improvement of the innovative culture could generate, on long term, a substantial increase of the R&D activities. Firms, including the small ones, have to distribute their limited financial resources between several possible ways of investment and the public support could be an argument to increase the investments in R&D (Meyer-Krahmer, 1989, P.179).

Also recent studies in Germany and Spain did analyse the influence on the innovative culture but there don't exist a common way in the construction of indicators to measure such impact (See Table 13). The concept of innovative culture is "intangible", very difficult to define and almost impossible to translate in a quantitative indicators. Most of the variables used to study this phenomena are based on a questionnaire asking for a "self-evaluation" about the impact on the innovative culture. In other words, the measurement of the impact is based on qualitative indicators expressed by a subjective perception or personal opinion of the one of the managers of the firm.

Most of the studies used the following kind of question: "The public support has increased or stimulated the interest of the firm for R&D ?". An other way to analyse this matter is to study the rise of the R&D expenditures or employees in R&D. It could be argued that such increase indicates that the firm upgrades the importance of R&D activities. From one side a study of Becher (1989) indicates a high correlation -statistical significant- between the rise of R&D expenditures and the improvement of the innovative culture which could confirm the validity of the change in R&D expenditures as an indirect indicator. On the other side, and in spite of the correlation between both phenomena's, the rise of R&D expenditures does not always have to imply an improvement of the innovative culture. For example, it can be a consequence of the rising prices and costs of R&D or a re-allocation of the R&D activities within a group of firms. Moreover it has to be pointed out that such an increase, decided by the top management of the firm does not mean that the importance and the need to innovate has been accepted by the firm as a whole. The resistance by a part of the personnel could seriously impede the implementation of apparently needed technological changes (Kulicke et al., 1997).

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<sup>60</sup> The study of the IESE (1995) did found an opposing conclusion but the learning effects in this study was measured by the entrance in new technological fields that will be more difficult to small firms than for larger firms. It should not be right to compare the results of two indicators that are so different in its concepts

Due to the use of several different indicators and the methodological problems of their measurement the comparison of the results of the case studies has to be done carefully and man should be cautious with the interpretation of the conclusions. Besides those methodological problems that impede a correct interpretation of the results, the kind of policy instrument analysed in each of the studies should be taken in account.

In spite of these methodological problems and the fact that it is not possible to generalise the results of each of the case studies I will highlight some of the tendencies found. In general the impact on the innovative culture seems to be higher in:

- smaller firms in comparison to bigger ones (Meyer-Krahmer, 1989; Molero/Buesa, 1995; IESE, 1996; Kulicke et al., 1997)<sup>61</sup>.
- private firms than in public ones (Molero/Buesa, 1995).
- firms of national capital than in foreign firms (Molero/Buesa, 1995).
- firms with a few public funded projects (1 to 3) than in firms with more projects (over 3) (Molero/Buesa, 1995).
- firms with a higher grade of organisation of their innovative activities (Becher, 1989; Meyer-Krahmer, 1989).

The studies of Becher et al. (1989) y de Meyer-Krahmer (1989) didn't find differences for a higher level of impact on the innovative culture related with the following variables: sector, R&D efforts and the size of the project carried out by the firms.

#### 4.2.3 *Augmentation of the technological co-operation*

In recent times the co-operation in the field of technology and innovation has been a subject of numerous studies (like Sharp/Shearman, 1987; Mytelka, 1991; Herden/Heydenbreck, 1991; Dodgson, 1992, 1994; Haagendoorn, 1995). In the last two decades the collaboration between firms on innovation has increased clearly and nowadays is being considered as an important aspect of the innovations system (Mytelka, 1991; Sharp/Shearman, 1987).

As can be observed in Table 13 almost all studies did analyse the co-operative attitude of the firms although only half of the studies analysed the impact on the collaborative attitude of the firms. Most of the studies did analyse this subject partially or in a very brief way. This can be seen as a logical consequence that most of the support programmes are not focussed on the improvement of the co-operation between firms.

In general the impact was measured by the question if the public funded project did augmentation the co-operation with other firms or research centres. It is impossible to

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<sup>61</sup> The evaluation study of Buesa/Molero (1995) did not find such a relationship what could be explained by the fact that this publicly support programme, to promote industrial design, has been used almost only by small firms from traditional sectors.

generalise the conclusions and results found in each of the studies. Maybe the most important point to highlight is that none of the studies analyses if the increase of the co-operation should be generated also without the public support. Moreover it should be important to analyse if the co-operation is an imposition of the public aid measurements or if it is a consequence of the needs or deficiencies of the technological capabilities or of cost saving reasons. To find out the real impact of the public support three questions should be answered in a simultaneous way.

- 1.- The project should not be initiated without public support ?
- 2.- The co-operation should not be initiated without public support ?
- 3.- The project should not be feasible without the co-operation ?

Only if all three answers are positive it can be stated that the public support had a positive effect on the national or regional innovation system by raising the integration and collaboration between its members.

### **4.3 Generic impact of the CDTI projects on the supported firms**

#### *4.3.1 Introduction*

Six indicators will be used to evaluate the improvement of the technological capability as a result of the R&D project financed by CDTI's low interest credits. The first two indicate the learning effects analysing the improvement of the knowledge base of the firms and of the formation of their personnel. A third indicator reflects the improvement of the innovation management (better integration between the R&D department and other areas of the enterprise) and a fourth indicates the improvement of the innovative culture of the firm. Moreover the augmentation of the co-operation will be analysed distinguishing between the rise of co-operation with public research centres or with firms. It has to be pointed out that the "co-operative" projects, financed by the national plan of R&D, are aimed at the promotion of the co-operation with public research centres and firms to carry out basic research projects. Although co-operation is a clear aim from the point of view of the public administration this does not imply automatically that such co-operation is an aim for the firms. For this reason this modality of impact is considered as a generic one. For example, it can be possible that they just co-operate to get the government loans or that they already considered the co-operation as an important factor of their innovative strategy.

In general the firms did consider the generic impact as important or very important. Over 83% did consider the improvement of the formation of their personnel as very important, 79% indicated an important rise of the knowledge base of the firm, 64% of the firms considers that the R&D department improved its integration with other areas of the company and 83% of the firms said that the innovative culture improved clearly. Moreover, almost 59% did rise their collaboration with public research centres and 42% their co-operation with other firms. Studying the six modalities of generic impact in a simultaneous way it can be pointed out that only 40 firms did indicate that there was no

impact at all.<sup>62</sup> So only seven percent of all firms indicate that the projects didn't have any impact on their technological capabilities.

**The IAIF/CDTI-survey did measure the generic impact of the CDTI projects by the following question :** Evaluate each of the following aspects of the impact arising from the CDTI project, according to their level of importance (From 0 not relevant to 5 very important)

**Impact on the innovative culture**

The financial support has stimulated the firms interest in R&D

**Impact on the technological capabilities**

Improvement of training of employees

Improvement of the information base of the firm

Improvement of the integration of the R&D department with other units of the firm

**Impact on the co-operation attitude**

Improvement of technological co-operation with public research centres

Improvement of technological co-operation with other enterprise

As mentioned before most of the studies did not offer an analysis about the type of firms with a lower level of generic impact. Only the size and, in a lesser extent, the innovative level of the firm was studied with some frequency in relation with the level of generic impact. In this article I will make a broad analysis of the firms characteristics in relation with the level of generic impact. Therefore I used two statistical methods. First, (see Table 14) I present briefly the results of the association test ( $X^2$  of Pearson) to analyse the correlation between the dependent variables (the modalities of generic impact) and the independent variables. Afterwards I will study the interaction between the explanatory variables using a multivariate model (Logistic regression, see Table 15 till Table 17).

### 4.3.2 Size of the firms

The CDTI/IAIF survey indicates that the relationship between the size of the firm and each of the six modalities of generic impact is, in general, weak, although statistically significant, and not always linear. Generally the large firms (over 500 employees) do consider the impact on their technological capabilities and innovative culture as less important. Except the rise of the co-operation with public research centres where the large firms reflects an above average impact level. In relation to each of the variables that reflect the generic impact the explorative analyses, based on a test of association, did reflect the following results:

The large firms showed a below average impact of learning in a strict sense, reflected by a relatively low improvement and formation of the R&D personnel. This tendency, also

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<sup>62</sup> Appraising each of the six modalities of generic impact with zero points on a scale from 0 till 5.

found in other studies (Meyer-Krahmer, 1989, Becher et al, 1989; Molero/Buesa, 1995; Kulicke et al 1997), could be explained due to the fact that those large firms have a relatively high number of employees dedicated on R&D and a large stock of information and knowledge in relation to the smaller firms. Which could imply a lower learning potential.

The exploratory analyses showed a clearly higher improvement of the innovative culture in the smaller firms in comparison with the larger ones. A tendency also found in the studies of Meyer-Krahmer, 1989; Molero/Buesa, 1995; Kulicke et al., 1997. The medium size firms appraised the improvement of the innovation management (improvement of the integration of R&D activities with other areas of the firm). The lower impact of such changes in smaller firms seems logically due to the fact that their small size facilitates almost automatically the integration. Those firms show short lines and direct contact between the different areas of the firm -often managed by the same persons- and a central role of a few managers in the whole development of the firms. The very low level of impact in the large firms can be explained for two reasons, on one side, most of those firms have an established formal structure difficult to change. On the other side, in relation to the large firms, it has to be pointed out that the CDTI supports relatively smaller projects<sup>63</sup>, which could be a second reason for a lower impact level.

The rise of the co-operation with public research centres, as an effect of the publicly financed projects, was higher for large firms. While the rise of co-operation with other firms was lower for the largest companies.

Analysing the logistic regression the role of the size as an explanatory variable should be revised. The discriminatory role of the variable size fade away in the multivariate models related to the improvement of the formation of R&D personnel, of the innovation management and of the innovative culture. It seems that the detected associations have to be explained by the interaction with other explanatory variables of the model as could be the innovative level and orientation of the firm<sup>64</sup>. Ostentatious is the relationship between size and the augmentation of the stock of knowledge. The test of association did not find a relationship between both variables but the univariate model indicates that larger firms (over 500 employees) have a lower impact level than the smaller firms.

**Table 14: Principal results of the explorative analyses of the generic impact**

(Each cell contains the percentage of firms that considered the impact as very important ( 4 or 5 point on a scale from 0 till 5) except for the variables with a (\*) these cells reflecting the firms that considers the impact as important (2 till 5 points).

	Improvement of the formation of the RR.HH	Improvement of the knowledge base	Improvement of the innovation management	Improvement of the innovative culture	Rise of the co-operation with public research centres	Rise of the co-operation with other firms
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<sup>63</sup> It should be pointed out that the CDTI has a limited budget and in their aim to finance the largest number of firms as possible they could decide to select, in relation to the large firms relatively small projects

<sup>64</sup> The inclusion or the number of employees in R&D in the model can not be the reason of the expulsion of the variable size. Although there is a highly positive correlation between both variables their correlation with the level of impact showed an opposite sign. The smaller the firm the higher the impact. The higher the number of employees in R&D the higher the impact.

Percentage of firms that considered the impact as very important (4 or 5 point on a scale from 0 till 5)	40	48	29	42	33	13
Small firms (till 50 employees)	43		29	52	30	12
Medium size firms (50-500 employees)	40		32	40	33	16
Large firms (over 500 employees)	28		16	31	40	6
Firms with foreign participation			30	24	31	
Public enterprises			19	13	45	
National private firms			30	50	32	
Producers of traditional consumer goods	29	43	32	42	28	9
Suppliers of traditional intermediate goods	49	56	44	54	46	16
Specialised suppliers of intermediate goods and equipment	29	35	29	41	26	7
Mass production assemblers	33	46	26	46	25	19
R&D based sectors	53	58	26	49	42	8
Services	53	59	25	50	39	21
R&D expenditures/sales (till 1%)	27	46		36	24	9
R&D expenditures/sales (1% - 5%)	38	48		48	36	12
R&D expenditures/sales (over 5%)	54	58		52	41	19
Percentage of firms that considered the impact as important (2 till 5 point on a scale from 0 till 5)	89	83	64	82	59	41
R&D are considered like not important*	67	79	50	77	N.A.	N.A.
R&D are considered like important*	86	64	64	79	N.A.	N.A.
R&D are considered like very important*	90	87	72	85	N.A.	N.A.
Firms with co-operative projects *	94	89	72	89	62	17
Firms with only technological projects *	79	75	63	80	18	9

Source (Heijs, 2000). Cells without information implies the differences were not statistically significant N.A. indicates that the data was not available (N.A.) which means they were significant but not reflected or included in the PhD thesis of Heijs (2000).

Although the test of association indicates that the rise of the co-operation with public research centres or with other firms, as an effect of the publicly financed project, is related with the size of the firm. The model of logistic regression did not confirm such discriminative power of the variable size.

The models of logistic regression revealed that the interpretation of the size as an explanatory variable only based on the results of the association tests is not sufficient and has to be completed with an analysis taking in account the interaction between the size and other independent variables.

#### 4.3.3 *Innovative level and orientation*

Maybe the most ostentatious conclusion is that fact that the most innovative firms indicates, in general, a higher level of impact on their technological capabilities than the firms with less consolidated innovative attitudes. This result is surprising because it could be expected that the less innovative firms should have more margin to learn and to improve their innovative capabilities. But the results of the IAIF/CDTI questionnaire points out that those less innovative firms, which should have more necessity to improve their innovative capabilities, do not take that much advantage of their projects as the more innovative firms, a conclusion also confirmed in the estimation of the logistic regressions. Moreover it can be pointed out that the group of 40 firms that

indicates that the generic impact has been irrelevant is characterised by a very low innovative level. Those findings do have coincidence with the results of other studies like Meyer-Krahmer (1989), Becher et al. (1989) or Kulicke et al. (1997). Also the fact that the less innovative firms consider the impact on their innovative culture as less intensive than the more innovative firms has been confirmed by earlier studies (see Meyer-Krahmer, 1989). In other words, in spite of the fact that less innovative firms are doing R&D projects, their back laying position in relation with more innovative firms do not improve. It seems very difficult to close the technological gap without the more innovative firms and only a very intensive approach could improve their situation.

Furthermore it can be pointed out that the analysis based on the group of small firms (till 50 employees) offered the same tendency but much more pronounced. In this group was detected a group of small highly innovative firms that took broad advantage of their R&D activities in form of generic impact. While at the same time the small less innovative firms almost didn't improve their technological capabilities. It seems that within this group of small less innovative firms the generic impact isn't assured due to the lack of experience in a such very special and complex field of innovative activities.

Analysing the results of the logistic regression it can be pointed out that, on one side, there is no doubt about the fact that the less innovative firms can't take that much advantage of their projects as the more innovative firms. This relationship was confirmed as well as for the whole sample of CDTI firms as for the both sub samples by kind of projects (firms with co-operative projects and firms with only technological projects).

On the other side, the logistic regressions about the improvement of the innovative culture and the innovation management distinguish the relationship between the innovative level and the intensity of the generic impact. In those models the included variables that reflect the innovative efforts and orientation of the firm do reflect opposite tendencies<sup>65</sup>. Some of them confirm that the less innovative firms do have a less intense generic impact (importance of R&D or technological development carried out by the firm, percentage of sales corresponding to innovative products) while in the meantime other variables of the same model do reflect the opposite relation (number of employees in R&D and expenditures in R&D over sales), and indicates that the more

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<sup>65</sup> Two aspects have to be kept in mind for the interpretation of the results. First, all the variables that indicate the innovative level and orientation of the firm did show, in the association test, that the more innovative firms did have a higher level of impact, or at least did not contradict such relationships. The second one is related with probable methodological problems. The inclusion of a large number of indicators to measure the innovative level of the firm could generate a problem of co-linearity. The existence of co-linearity should have made invalid the whole model due to the fact that it not only effected the coefficients and their signs of the interrelated variables but also those from other explanatory variables included in the model. The analysis to control the problem of co-linearity showed that the correlation between the indicators for the innovative level of the firm is not extremely high. Moreover, the preliminary estimations of the models pointed out that the inclusion or exclusion of different variables of the innovative level, only implies some changes within that group of variables. Those experiments did not influence the inclusion and the sign of other variables of the model. This confirms that the models presented in this paper are stable and consistent and can be considered as valid.

innovative firms have a lower generic impact level. This apparent contradiction should not be that surprising and has to be interpreted on the following way. The more innovative firms do show a higher impact on their innovative culture and innovation management, but once reaching a certain innovative level, this impact is less pronounced. Those very innovative firms have assumed already and intense innovative culture and created a clear, well-defined innovation management system. So their innovative activities are well designed with less deficiencies and are less open for improvements.

The same kinds of results are found by the analysis of the impact on the co-operative attitude of the firms. The more innovative firms raised more often their co-operative attitude, but again, within the group of very innovative firms with a very high level of R&D efforts, are already convinced of the importance to co-operate and didn't show a high level of impact on that subject.

#### 4.3.4 *Sectoral differences*

The tests of association indicates that the variable sector is correlated with the level of generic impact although the analysis of control<sup>66</sup> and the model of logistic regression do distinguish those preliminary results

*Producers of traditional consumer goods* showed a somewhat lower impact of learning (improvement of formation of their personnel and their knowledge base) and also the improvement of the co-operation with public research centres is somewhat below the average level. The improvement of their innovative culture is above average. The logistic regression only confirms the low impact level related to the improvement of the knowledge base.

The association tests for the sector of *suppliers of traditional intermediate goods* showed a clear higher effect for each of the six modalities of generic impact. Although only one of the six models of logistic regression (the one that analyses the improvement of the technological management) did confirm such correlation.

*Specialised suppliers of intermediate goods and equipment* showed a lower impact on their technological capabilities (improvement of formation of their personnel, their knowledge base, their innovative culture, augmentation of the co-operation with public research centres or other firms). The improvement of their innovative management (improvement of the integration of R&D activities with other areas of the firm) is on the average level. The logistic regression confirms the low impact level related to the improvement of the formation of personnel, the improvement of the innovative culture and the below average level of the augmentation of co-operation with other firms.

The generic impact in the firms belonging to *the mass production assemblers* almost didn't differ from the average level. Although the explorative analysis did indicate that the impact on the innovative culture and on the augmentation of the co-operation with

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<sup>66</sup> The following results were not found in the group of firms with a very high level of R&D expenditures (above 5% of their sales). In this group was found high generic impact independent of the sectoral belonging.

public research centres was somewhat below average the logistic regression did not found any differences at all.

The firms of the *R&D based sectors* reflect a clear above average impact level of learning (improvement of formation of their personnel and their knowledge base) and also the improvement of the co-operation with public research centres is above the average level. The improvement of their innovative culture and innovation management does not diverge from the average and the augmentation of co-operation with other firms is below average. The models of logistic regression do not confirm those results based on the association tests. Which means that they have to be related with other explanatory variables especially the innovative level of the firms.

*The service sector* indicates an above average impact related to the learning effects (improvement of formation of their personnel and their knowledge base) and the augmentation of the co-operation. The improvement of their innovative culture is on average level and the improvement of their innovation management system is somewhat below average level. None of the logistic regression models did include the belonging to the service sector as an explanatory variable. Which means that the results of the association tests should be explained by the interaction between independent variables.

#### 4.3.5 *Control capital of the firm*

The analysis of the intensity of the generic impact, taking in account the control capital, distinguishes three types of firms. National private firms, public enterprises and firms with foreign financial participation. *The national private firms* show an impact level very close to the average one. The explorative analysis (association tests) pointed out that, for this firm, only the improvement of the innovative culture was above average. The logistic regressions did not indicate any difference at all for any of the six modalities of generic impact.

The test of association indicates that the *public enterprises* had average learning effects (improvement of the formation R&D personnel and of the knowledge base), a below average impact on their innovative culture and innovation management and an above average augmentation of co-operation with public research centres. The logistic regression models, that analysed simultaneously all independent variables, pointed out that the improvement of the formation of R&D personnel was below average and the augmentation of co-operation with public research centres was above average. While the below average impact on innovative culture and innovation management wasn't confirmed by the logistic regression models.

*The firms with a presence of foreign capital* almost didn't differ in their generic impact level. Only the impact on their innovative culture seems somewhat below average. An aspect only confirmed in the logistic regression for firms with only technological projects. Further on these models show a somewhat below impact on their innovation management system (improvement of the integration of R&D activities with other areas of the firm).

#### 4.3.6 *Competitive strength of the firms*

The level of generic impact seems not to be correlated with the competitive strength of the firms. Of all modalities of generic impact only the improvement of the integration of R&D activities with other areas of the firm seems to be somewhat higher in the more competitive enterprises. But this weak relationship wasn't confirmed in the logistic regression model.

#### 4.3.7 *The type of project*

Together with the innovative level of the firm, the type of project seems an important explanatory variable. The association tests for the type of project showed that the firms with "co-operative" projects showed a higher level of impact for each of the six modalities of generic impact. The logistic regression models did confirm those tendencies found in the contingency tables (except for the improvement of the innovation management). So it can be concluded that the firms with "co-operative" projects do have a clearly higher generic impact level than the firms with only "technological" projects. This result is not surprising because the "co-operative" projects are normally larger, basic R&D orientated ones, while the "technological" projects used to be innovative activities close to the market, less complex and less pretentious.

#### 4.3.8 *Other characteristics of the projects*

Besides the type of the project also other characteristics were taken in account in the analyses, like the number of projects financed by the CDTI, the total budget of the projects financed by the CDTI and the novelty of the innovative activity. The main results are that the firms with more projects or with a higher total budget indicates, in general, a higher generic impact and that those ones with a higher degree of novelty do not seem to be correlated with a higher impact level and a higher budget. The last conclusion can be considered as surprising but the atypical concept used to measure the degree of novelty could be one of the reasons of this result.

## 4.4 **Conclusions**

In general the generic impact reached a high level. Approximately 80% of the firms indicates that the learning effects and the improvement of the innovative culture have been important or very important. For the improvement of the integration of R&D with other areas of the firm and the augmentation of co-operation with public research centres this percentage has been roundabout 60%. Moreover 42% of the firms considered the augmentation of co-operation with other firms as important or very important. Only 7% of the firms did consider simultaneously the generic impact of each of the six analysed modalities as unimportant.

The most important explanatory variable for the generic impact is, without any doubt, the innovative level and orientation of the firm. The firms with a low innovative level and orientation consider the generic impact as less important than the more innovative

firms. This fact could lead to two conclusions: first, the less innovative firms do carry out less innovative projects, embedded in their normal everyday innovative activities and second, those firms do not need only financial support but they need additional support measurement like technical constancy and so on. The need of such support measurements has been reflected in a study about the innovative enterprises in Madrid (IMADE, 1992). Analysing the opinion of the innovative firms about the support that they esteem as necessary this study pointed out that they not only demand financial help (70% of the firms demanded financial support to buy new modern equipment and over 50% demanded financial support to carry out R&D projects), but also technical advice to initiate their project (42%), supervision and orientation during the development of the projects (17%) and formation and training for their managers (36%) and their personnel (56%).

The results that are presented in this paper underpin again the importance of the technological capabilities of a firm and the fact that those capabilities are the results of an accumulative process. The most innovative enterprises show a higher learning capacity than the less innovative ones. This means that the less innovative firms can only close the technological gap with an extraordinary effort. So the improvement of such capabilities should be an important goal of the public intervention in the field of technological change and R&D. This fact should be kept in mind especially in the selection of the firm that should be supported. On one side it can be pointed out that the less innovative firms, which should improve more their technological capabilities, participate less frequently in the state programmes in support of R&D. On the other side it was stated that this is not the result of the selection procedure of the CDTI<sup>67</sup> but a consequence of the type of innovation activities supported (Heijs, 1998, 1999)

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<sup>67</sup> In fact the study of Heijs (1998, 1999) indicates that the less innovative firms, that applies for financial support of the CDTI, has a higher change to become such support than the more innovative ones.

**Table 15:** Generic impact: a logistic regression model (a)

	IMPROVEMENT OF THE FORMATION OF HH.RR.			IMPROVEMENT OF THE KNOWLEDGE BASE		
	Sample	Co-operative projects	Technological projects	Sample	Co-operative projects	Technological projects
<b>FIRM'S CHARACTERISTICS</b>						
Small (up to 50 employees) versus medium sized and large firms (over 50 employees)						
SME's (up to 500 employees) versus large firms (over 500 employees)				-0,20 <sup>*</sup> (0,06)		
Year of creation of the firm						
Competitive position in its main market						
National individual firm						
Firm belonging to a national group/holding						
Firm with foreign capital		-0,36 <sup>***</sup> (0,19)				
Public enterprise	-0,44 <sup>***</sup> (0,05)	-0,79 <sup>**</sup> (0,14)				
Producers of traditional consumer goods		-1,19 <sup>**</sup> (0,12)				
Suppliers of traditional intermediate goods		-0,65 <sup>***</sup> (0,11)			-1,04 <sup>***</sup> (0,25)	
Specialised suppliers of intermediate goods and equipment	-0,21 <sup>**</sup> (0,08)		-0,27 <sup>***</sup> (0,12)			-0,17 <sup>*</sup> (0,05)
Mass production assemblers						
R&D based sectors						
Services						
<b>TECHNOLOGICAL ORIENTATION AND EFFORT LEVEL</b>						
Expenditures in R&D on sales (ERDs) (Up to 1% versus 1% or more)						-0,63 <sup>*</sup> (0,04)
Expenditures in R&D on sales (up to 5% versus 5% or more)						
Personal in R&D (up to 25 versus 25 or more)				+0,37 <sup>*</sup> (0,04)		
Regularity of the innovative activities		+1,11 <sup>**</sup> (0,11)				
Importance of basic R&D carried out by the firm (OT1)						
Importance of applied R&D carried out by the firm (OT2)				+0,18 <sup>***</sup> (0,10)	+0,56 <sup>***</sup> (0,28)	+0,14 <sup>*</sup> (0,04)
Importance of the technological development carried out by the firm (OT3)						+0,22 <sup>**</sup> (0,07)
Importance of the own R&D in general (OT4)	+0,23 <sup>***</sup> (0,09)	+0,44 <sup>**</sup> (0,11)	+0,27 <sup>***</sup> (0,11)			
Technical Autonomy					+0,02 <sup>**</sup> (0,14)	
% of sales corresponding to the introduction of new products or new processes in the last five years	+0,24 <sup>**</sup> (0,09)		+0,20 <sup>***</sup> (0,06)			
<b>CHARACTERISTICS</b>						
Type of project	-0,83 <sup>***</sup> (0,13)			-1,25 <sup>***</sup> (0,17)		
Number of projects financed by the CDTI						
Total budget of the financed projects						
Novelty of the project						
Constant	+0,97 <sup>***</sup>	+0,45 <sup>NS</sup>	-0,71 <sup>**</sup>	+2,49 <sup>***</sup>	-0,04 <sup>NS</sup>	+0,97 <sup>NS</sup>
Correctly classified	71%	83%	67%	78%	91%	71%
Chi square of the model	40 <sup>***</sup>	29 <sup>***</sup>	21 <sup>***</sup>	39 <sup>***</sup>	22 <sup>***</sup>	12 <sup>*</sup>

Source; own elaboration based on the IAIF/CDTI questionnaire. To make possible the use of a logistic regression model I dicotomized the dependent variables joining on one side the values 0-2 (irrelevant-or less important) and on the other side the values 3 -5 (important to very important). Level of significance (\* 10%; \*\* 5% and \*\*\* 1%). The estimated models did contain several variables not reflected in this table because they were rejected. For the ERDs are used three dummy variables (up to 1%; between 1% and 5%; more than 5%), for the social capital were used four dummies (individual national firms, firms belonging to a national group, firms with foreign capital and public enterprise) for the personnel in R&D were used three dummies put o 10 employees, from 11 to 25, over 25 employees). It's worth to mention that each other can substitute the variables of technological orientation and efforts. Excluding OT1 from the model implies the entrance of other variables like OT2, OT3 o OT4. But this substitution implies a lower level of statistical significance, a lower number of correctly classified firms or a lower ChiSquare for the model. This could imply that the model have some problems of co-linearity due to the variables of technological efforts and orientation (the same could be said for the variable personnel in R&D in relation with he variable employment) but during the construction of the model, and earlier estimations, I did not find any evidence or indications that this is a real problem

**Table 16:** Generic impact: a logistic regression model (b)

	IMPROVEMENT OF THE INNOVATION MANAGEMENT			IMPROVEMENT OF THE OF THE INNOVATIVE CULTURE		
	Sample	Co-operative projects	Technologica l projects	Sample	Co-operative projects	Technological projects
<b>FIRM'S CHARACTERISTICS</b>						
Small (up to 50 employees) versus medium sized and large firms (over 50 employees)						
SME's (up to 500 employees) versus large firms (over 500 employees)						
Year of creation of the firm					-0,43** (0,13)	
Competitive position in its main market						
National individual firm						
Firm belonging to a national group/holding						
Firm with foreign capital	-0,13** (0,05)	-0,25*** (0,03)				-0,19** (0,08)
Public enterprise					-0,68** (0,14)	
Producers of traditional consumer goods						
Suppliers of traditional intermediate goods	+0,31** (0,03)					
Specialised suppliers of intermediate goods and equipment			+0,23* (0,09)	-0,23*** (0,09)		-0,40*** (0,18)
Mass production assemblers						
R&D based sectors						
Services						
<b>TECHNOLOGICAL ORIENTATION AND EFFORT LEVEL</b>						
Expenditures in R&D on sales (ERDs) (Up to 1% versus 1% or more)		-0,22* (0,07)			-0,34*** (0,17)	
Expenditures in R&D on sales (up to 5% versus 5% or more)				+0,63* (0,07)		+0,61** (0,04)
Personal in R&D (up to 25 versus 25 or more)	-0,59*** (0,12)	-0,46*** (0,11)	-0,78*** (0,19)	-0,81*** (0,19)	-0,78*** (0,18)	-0,84*** (0,15)
Regularity of the innovative activities						
Importance of basic R&D carried out by the firm (OT1)	+0,11*** (0,03)		+0,17* (0,06)	+0,29*** (0,13)	+0,59** (0,18)	+0,28** (0,11)
Importance of applied R&D carried out by the firm (OT2))	+0,17*** (0,10)		+0,23*** (0,12)			
Importance of the technological development carried out by the firm (OT3)						
Importance of the own R&D in general (OT4)						+0,20* (0,05)
% of sales corresponding to the introduction of new products or new processes in the last five years	+0,17* (0,06)	+0,51*** (0,19)			-0,37** (0,09)	-0,20* (0,07)
<b>CHARACTERÍSTICS</b>						
Type of project				-0,62** (0,07)		
Number of projects financed by the CDTI	+0,23** (0,05)		+0,26* (0,05)	+0,31* (0,09)		+0,52*** (0,13)
Total budget of the financed projects	+0,43*** (0,09)	+0,55** (0,11)	+0,33** (0,05)			
Novelty of the project			0,54* (0,05)			-0,34** (0,04)
<b>Constant</b>	-1,34***	-1,01***	-0,60***	1,48***	3,50***	0,55 <sup>NS</sup>
<b>Correctly classified</b>	64%	65%	67%	77%	86%	76%
<b>Chi square of the model</b>	49***	23***	37***	53***	36**	55***

Source; own elaboration based on the IAIF/CDTI questionnaire. To make possible the use of a logistic regression model I dicotomized the dependent variables joining on one side the values 0-2 (irrelevant-or less important) and on the other side the values 3-5 (important to very important). Level of significance (\* 10%; \*\* 5% and \*\*\* 1%). The estimated models did contain several variables not reflected in this table because they were rejected. For the ERDs are used three dummy variables (up to 1%; between 1% and 5%; more than 5%), for the social capital were used four dummies (individual national firms, firms belonging to a national group, firms with foreign capital and public enterprises) for the personnel in R&D were used three dummies put o 10 employees, from 11 to 25, over 25 employees). Most of them were rejected by the model because they were no statistically significant. Its worth to mention that the variables of technological orientation and efforts can be substituted by each other. Excluding OT1 from the model implies the entrance of other variables like OT2, OT3 o OT4. But this substitution implies a lower level of statistical significance, a lower number of correctly classified firms or a lower Chi-Square for the model. This could imply that the model have some problems of co-linearity due to the variables of technological efforts and orientation (the same could be said for the variable personnel in R&D in relation with he variable employment) but during the construction of the model and earlier estimations, I did not find any evidence or indications that this is a real problem

**Table 17:** Generic impact: a logistic regression model (c)

	INCREASE OF CO-OPERATION WITH PUBLIC RESEARCH CENTRES			INCREASE OF CO-OPERATION WITH OTHER FIRMS		
	Sample	Co-operative projects	Technological projects	Sample	Co-operative projects	Technological projects
<b>FIRM'S CHARACTERISTICS</b>						
Small (up to 50 employees) versus medium sized and large firms (over 50 employees)						
SME's (up to 500 employees) versus large firms (over 500 employees)						
Year of creation of the firm	+0,18** (0,07)	+0,35* (0,12)				
<b>Competitive position in its main market</b>						
National individual firm						
Firm belonging to a national group/holding						
Public enterprise	+0,64** (0,06)		+0,79** (0,07)			
Firm with foreign capital					-0,28** (0,11)	
<b>Sectors</b>						
Producers of traditional consumer goods			-0,07* (0,06)			
Suppliers of traditional intermediate goods		+0,97* (0,07)				
Specialised suppliers of intermediate goods and equipment		+0,72** (0,04)	-0,40*** (0,15)	-0,21** (0,07)	-0,38** (0,08)	
Mass production assemblers			-0,25** (0,11)			
R&D based sectors						
Services						
<b>TECHNOLOGICAL ORIENTATION AND EFFORT LEVEL</b>						
Expenditures on R&D by sales			+1,0*** (0,10)	+0,67** (0,06)		+0,72* (0,05)
Personal in R&D (up to 25 versus 25 or more)						
Importance of basic R&D carried out by the firm (OT1)	+0,19** (0,07)	+0,40** (0,15)	+0,20** (0,10)	+0,19*** (0,10)	+0,20** (0,06)	+0,17** (0,07)
Importance of applied R&D carried out by the firm (OT2)	+0,20*** (0,08)					
Importance of the technological development carried out by the firm (OT3)				+0,23*** (0,09)	+0,69*** (0,20)	
Importance of the own R&D in general (OT4)						
Regularity of the innovative activities				-0,71*** (0,07)		-0,72** (0,06)
Technological autonomy				-0,95*** (0,09)	-0,97** (0,08)	-1,07** (0,12)
% of sales corresponding to the introduction of new products or new processes in the last five years	-0,21** (0,08)	-0,39** (0,15)				+0,13* (0,05)
<b>CHARACTERISTICS</b>						
Type of project	-2,00*** (0,30)					
Number of projects financed by the CDTI	+0,37*** (0,12)		+0,51*** (0,17)			
New activities					-1,02*** (0,17)	
Total budget of the financed projects		+0,47*** (0,09)		+0,39*** (0,11)	+0,68*** (0,16)	+0,35*** (0,07)
<b>Constant</b>	+1,7***	+0,15 <sup>NS</sup>	-3,12	-2,73***	-3,69**	-2,5***
<b>Correctly classified</b>	74%	82%	72%	72%	72%	71%
<b>Chi square of the model</b>	154***	24***	45***	39***	41***	17**

Source: own elaboration based on the IAIF/CDTI questionnaire. To make possible the use of a logistic regression model I dicotomized the dependent variables joining on one side the values 0-2 (irrelevant-or less important) and on the other side the values 3-5 (important to very important). Level of significance (\* 10%; \*\* 5% and \*\*\* 1%). The estimated models did contain several variables not reflected in this table because they were rejected. For the ERDs are used three dummy variables (up to 1%; between 1% and 5%; more than 5%), for the social capital were used four dummies (individual national firms, firms belonging to a national group, firms with foreign capital and public enterprises) for the personnel in R&D were used three dummies put o 10 employees, from 11 to 25, over 25 employees). It's worth to mention that each other can substitute the variables of technological orientation and efforts. Excluding OT1 from the model implies the entrance of other variables like OT2, OT3 o OT4. But this substitution implies a lower level of statistical significance, a lower number of correctly classified firms or a lower Chi Square for the model. This could imply that the model have some problems of colinearity due to the variables of technological efforts and orientation (the same could be said for the variable personnel in R&D in relation with he variable employment) but during the construction of the model, and earlier estimations, I did not find any evidence or indications that this is a real problem



## CHAPTER 5

### THE DIFFUSION OF THE LOW INTEREST CREDITS FOR R&D PROJECTS WITHIN THE SPANISH PRODUCTION STRUCTURE

#### 5.1 Introduction

The identification of the firms supported by public policies is in most evaluation studies only done in a partially way. Most of the evaluation studies<sup>68</sup> analysed offer a description of the firms assisted by the public institutions. The majority of them only presents the main characteristics of the supported firms (size, sector region o technological fields; see for example Siegert, 1985; Becher, 1990; Fontela et all 1992). Information that is relatively easy to obtain and in most occasions available from the public institutions which administer the policies according to the written forms. Other studies offer broader information about the characteristics of the firms including their competitive position, innovative orientation and resources in R&D or aspects of their internationalisation (See for example Becher, 1989; Buesa/Molero, 1994; Molero/Buesa, 1995; Kulicke, 1997)

The comparison of the supported firms with control groups or reference groups<sup>69</sup> is less common. The typical exception is the comparison with a reference group for some basic features (size, sector or regional distribution), based on existing and available public statistics. In most cases the researchers compare if the distribution of the supported firms is equal to those of the reference groups and find out if one kind of firms receive more assistance than other kinds of firms (For example Meyer-Krahmer, 1989; Becher, 1989; 1990; Molero/Buesa, 1995).

Most of the developed countries offer information about the basic characteristics of its firms and also of the innovative firms<sup>70</sup>, which has been used frequently to compare the supported firms. The problem is that –in spite of the fact the Statistical Agencies have collected a broad range of data and indicators of characteristics of the firms- they only offer the basic ones like size, sector, region and social capital and often use different criterias of classification.

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<sup>68</sup> It has to be clear that here we only analysed some studies of Spain and Germany. I do not conclude that these are representative of all the studies done but it gives a broader idea about what is happening in this field.

<sup>69</sup> The concept of a reference group is used for the comparison of the supported firms with public information not especially elaborated for the evaluation and the concept of a control group refers to a group of firms determinated by the evaluator and included in the survey.

<sup>70</sup> Especially the European Innovation Survey started up in 1992 has improved the availability of such data although some countries have offered this kind of information before that period.

In general most of the evaluation studies can be characterised by the lack of a comparison group or the presence of a problematic one. These problems, which are sometimes explicitly mentioned and other times not mentioned or not even detected at all, are an important and recognised weakness of technology policy evaluation studies (Meyer-Krahmer, 1991; Feller, 1991; Roessner, 1992; Brown et al, 1996). Feller suggests that the lack of basic information and the viability of the data was inconclusive that it is only possible to offer qualitative conclusions. I think that the situation is not that extreme but it has to be clear that the interpretation and comparison of the specific characteristics of the control group and the group of reference has to be taken into account and has to be explicitly mentioned.

In my opinion the use of comparison group is necessary to assure a good contrast of the behaviour and characteristics of the supported firms with other comparable firms. The validity of the evaluation is threatened when the conclusions about the supported firms do not reflect an effect of the support scheme but reflects a general situation of the kind of firms which are supported, in our case the innovative firms, which are products of overall changes in the economical and technological system.

For example, the conclusion that firms supported by their technological activities have higher export rates in relation with their sales and are growing faster than the non supported firms could be a mis-interpretation. Such behaviour of the supported firms is not that suprising taking into account that all innovative firms, the potential users of R&D promotion, have such higher export and grow rates. Also the conclusion that the technology policy has brought the R&D expenditures on a higher rate could be wrong if this responds to a normal development which can be tracked by all firms of the production structure and not only by the supported ones.

## **5.2 The use of comparison groups**

In this study I distinguish two kind of comparison groups. The first one, the reference group is used as a comparison group for the supported firms based on public information, in most of the occasions not especially elaborated by the evaluation study, only available on a aggregated level. This means that the scientist can not discriminate - using the firm level- and have no influence on exact determination of the comparison group. The second kind of comparison group is the control group. Its concepts are a group of firms determined by the evaluator and included in the survey. The advantage is that the researcher knows exactly how the group is constituted and can make analysis on firm level.

The following two sections will make clear the exact differences and the advantages of both kinds of comparison groups.

### *5.2.1 Selection of reference groups*

The use of reference groups can be problematic because you can never be sure if some sub groups of supported firms with similar characteristics are excluded from this reference group. Table 2.1 reflects four kinds of reference groups that can be used to compare the

firms supported by the Spanish government. The first group (A) includes all the firms of the industrial sector the second group refers to all the firms of the industrial sector which can be categorised as innovative firms in a broad sense (B) and the third reference group (C) includes all the industrial firms which carry out, on a occasional, irregular or regular form, formalised R&D activities being the innovative firms in a strict sense. While the firms reflected in Table 18 reflect the all the innovative firms of the Spanish production structure regularly implementing R&D activities. This table shows in a clear and simple way that the choice of a reference group implies problems of interpretation and is not free of methodological discussion. Conclusions based on one group or another can be totally different.

Table 18 reflects that the CDTI has supported in a period of 11 years less than one percent of the Spanish industrial firms almost 6% of the innovative firms in a broader sense and 23% of the innovative firms in a stricter sense. Although the general tendency is the same for each reference group the largest firms were supported more intensively than the SME's.

The second part of the table, reflecting a reference group of the whole Spanish productive structure, indicates a contradictory tendency. Using this reference group it should be possible to conclude that the CDTI has benefited relatively more the SME's than the larger firms. Using a different type of classification of size, this table shows that 52% of the CDTI firms have less than 50 employees while only 39% of the firms identified by the INE as innovative firms in the strict sense have that size. Taking as a reference the number of projects supported by the CDTI this positive discrimination fades away

So what has to be clear is that the use of public statistics as a reference group is not free of methodological problems and can only be justified if it is done with a critical view for the interpretations of the results. The election of the group of references depends on the type of instrument and the objective of the evaluation study In his article of 1987 Meyer-Krahmer analyses the characteristics of the firms that who where reached by three forms of financial support of individual firms: direct project support, indirect specific promotion and general non selective promotion.

The first form is the direct project support meant to develop special technological fields that are considered very important. The selection of projects and firms are based on the content of the project, the expected results and the time planning. The objective of this kind of promotion is to accelerate the technological development of several high tech fields like nuclear power, bio-technology or microelectronics which are often concentrated in large firms with large high-risk projects. This kind of policies are normally justified due to the lack of venture capital and investments of the private sector. Investments in the new emerging technology fields implies high risks leading to underinvestment of the private sector but at the same time generates externalities which could justify public investments. The second form of public finance of R&D of individual enterprises is the indirect specific promotion. Indirect because each firm can initiate a project within the support scheme and selective because the support is limited to several technological fields of applications (CAD/CAM, Biotechnology, CIM etc.). These types of instruments are used in the case that general non selective promotion does not accelerate the transfer enough and the development of new high-tech or key technologies, due to the high risks or costs and the complexity of the projects (Meyer-Krahmer, 1989)

When comparing the supported firms of these two types of instruments with a reference group the fact that only the firms with large R&D capabilities can apply for such projects should be taken in mind. So it seems not to be logical to take as a reference group all the enterprises of the productive structure but it seems to be more reasonable to use the innovative firms in a stricter sense as a comparison group.

General non selective promotion is a third kind of instrument by the financing of firms R&D activities. This promotion scheme is based on private initiatives leaving the direction of the technological change to the private sector. These instruments are open for all the firms which like to incorporate new and existing technologies, and do not select certain activities by criteria like technology fields, risks, quality etc. but try to promote the general innovative attitude of the firm and to raise the R&D expenditures of the production system. The activities promoted by such support schemes are in general based on incremental changes (Kuntze/Hornschild, 1995; Becher, 1989) and are not only focused on high tech but also supporting medium and low tech activities (Meyer-Krahmer, 1989).

**Table 18: The differences between the possible groups of reference in the Spanish case**

<b>Table 2.1a Innovative firms of the industrial sectors</b>										
Size in number of employees	Industrial firms (A)	Innovative firms in a broad sense (B)		Innovative firms in a strict sense (C)		CDTI-firms 1984 – 1994 (D)				
		N	A/B (%)	N	A/C (%)	N	D (%)	A/D (%)	B/D (%)	C/D (%)
Less than 5	83.400	3.712	4,5	328	0,4	177	18	0,1	1,4	10
From 5 a 19	61.700	8.422	13,7	1.511	2,45					
From 20 a 49	12.600	2.863	22,6	945	7,46	268	27	2,1	9,3	28,4
From 50 a 199	4.300	1.688	39,2	962	22,3	267	27	6,2	15,8	27,8
More than 200	1.100	799	69,6	614	53,5	281	28	24,5	35,2	45,7
Total	163.200	17.483	10,7	4.360	2,67	993	100	0,6	5,7	22,8

<b>Table 2.1b Innovative firms of all the productive sectors</b>			
Size in number of employees	CDTI-firms and projects during the period 1984 – 1994		Innovative firms in a strict sense
	2268 projects	1354 firms	
Less than 50	42%	52%	39%
from 51 a 250	32%	30%	34%
from 251 a 500	12%	9%	13%
More than 501	14%	8%	14%
Total	100%	100%	100%

Source: Own elaborated with the Survey on innovation technology in firms 1994 (INE, 1996, P. 50)

(N-Number of firms; Di-Distribution)

It is possible to distinguish two types of instruments of direct non-selective promotion. The first kind of instruments gives financial support in an automatic way, provided that a firm fulfils some prerequisites. Examples of such instruments are the German grants given towards the costs of R&D personnel or tax measurements. The problem of these instruments is that the government can not control the costs of such policies. The budget is not closed and in the case that they are very successful can be very problematic. For this kind of promotion instrument it seems to be reasonable to use the total number of productive enterprises as a reference group or the innovative firms in a broader sense because in theory all the innovative firms will be favoured by those instruments<sup>71</sup>. Using the whole group of productive enterprises as a reference group probably will generate a good estimate of the number of innovative firms in the productive structure. Using the innovative firms in a broad sense as reference group you will find out the pick-up rate by the potential users. The study of the firms that could have benefited from the scheme and did not apply<sup>72</sup> could offer information of what went wrong and why these firms were not reached.

A second form of direct non-selective support is the support of formalised R&D projects with a mechanism of selection and with a closed budget. Selection will not be based on quality of the project, technological fields and so on but the projects have to fulfil some basic prerequisites and the government will finance projects until all the budget is spent. This instrument of general non-selective promotion implies that the firm's innovative activities have to be converted into formalised projects with clear objectives, and timetables, which means that other innovative activities will not be supported. The election of the reference group depends on the objective of the study. What seems to be clear is the whole number of productive firms will not be a representative reference group. Both the firms defined as innovative in a stricter sense and those defined as innovative in a broader sense can be a useful group of reference.

The firms in a strict sense represent the firms that should be able to apply for support without any real change in its R&D activities. Taking as a comparison group the innovative firms in a broader sense implies that the comparison takes into account all the firms that could be potential users of the support scheme, intensifying or reorganising their existing innovative activities. The support scheme of low interest credits of the CDTI, which will be analysed in the empirical part of this paper, is such an instrument.

Meyer-Krahmer made an extensive study concerning the firms reached by each kind of instrument and he indicates that the three types are supplemental and it is not possible to substitute the direct support by indirect measurements. Not only are the objectives of the instruments clearly different but also the clients actually reached, their innovative

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<sup>71</sup> The German evaluation studies to the grants towards the costs of R&D personnel used the total number of industrial firms like a reference group (Meyer-Krahmer, 1989; Becher, 1989, 1990) analysing a general non-selective promotion instrument that reached about 20% of all German firms.

<sup>72</sup> Remember that each firm that fulfils the prerequisites get automatically the financial assistance

behaviour, and the relative importance of new technologies and the in house effects. Direct project support and indirect specific promotion of R&D are normally limited to some sectors and regions where high-tech firms are over presented and are used by a small number of firms. (For a broader discussion about this subject see Meyer-Krahmer, 1987). The choice of the instruments depends on the policy objectives. If the government wants to move the level of the technological development, grants for specific R&D projects are needed, and if the government wants to broaden the use of new technologies, indirect specific measurements would be more effective. While if they just want to promote the innovative attitude, a general non-selective promotion of R&D will be the most appropriate instrument.

An other way of studying the supported firms with a “group of reference” is the use of general information about normal (innovative) patterns of firms comparing them with the particular patterns of the supported firms. This is not a comparison of two groups but rather a contrast between the general features reflected in the literature and empirical studies with the particular orientation of the supported firms.

### 5.2.2 *Selection of a control group*

The presence of a control group in evaluation studies is very rare. Due to the high costs and the problems of defining and selecting a representative group of control most studies lack such analysis. Although there are several ways to build a control group it is possible to distinguish between two basic forms. The first way is to create a representative group of potential users which makes it possible to analyse the take up rate within the group and study the differences between the supported and not supported firms (See for example Buesa/Navarro, 1997). The second way is a matched group comparison. This implies the selection of some basic criteria and for each supported firm there will be one added, comparable firm which did not make use of the support scheme (See for example Kulicke, 1997)

Buesa and Navarro (1997) has created in the first step of their research a database of 766 innovative firms of the Basque Country and Navarro to study the innovative attitude of those firms and the impact and the role of the technology centres. As a second step they sent to all the firms a survey with the objective to study the differences between firms that made use of the technology centres and those that did not co-operate with those centres.

Kulicke (1997) analysed the public support –based on low interest credits and subsidies– offered to 1180 firms by the national German government. As a first step she constructed a control group selecting a group of 1800 firms with a structure that was equal in size, R&D expenditures and sector in comparison to the supported firms. In a second step she matched each supported firm with an equal firm that did not receive support, matching their size and R&D expenditures (Due to the disperse sectoral distribution it was not possible to match them also on that variable).

As forementioned there are more forms to create a group of control. An interesting example offers the study made by Lay (1993), who evaluated the public support of the diffusion of CIM technology. He created a control group of firms which could have

participated in the support scheme but that have not been supported<sup>73</sup>. Another example is the study of Brown et al (1991) analysing the supported firms<sup>74</sup> within certain groups of firms clearly characterised (Association of inventors, Patent holders, firms which are located in innovation and incubator centres, etc.).

### **5.3 Diffusion of the CDTI's low interest credits within the group of Spanish innovative firms**

#### *5.3.1 Introduction*

In this section of the paper, I will present an analysis of the diffusion and take-up rate, within the Spanish production structure, of the low interest credits for R&D projects offered by the Centre for the development of Industrial Technology (CDTI). The public finance of the firm's R&D activity in Spain carried out by the CDTI is meant as a general non selective instrument of the promotion of technological development which should make able that all firms that are carrying out innovative activities could make use of it.

As argued in section 2, the evaluation of the characteristics of firms which received public funding has to be completed with a contrast of those firms which were not supported, to find out the indirect influence that could have been generated due to the public support scheme on technological development. In this part of the paper I compare the firms subsidised by the Spanish government (with low interest credits) and the innovative firms in a broad way, defined as those firms which carry out any kind of innovative activity and with innovative firms in a strict sense, those firms who do carry out formalised R&D activities with clear objectives, well planned and with a time schedule.

The decision to compare the CDTI-firms with other innovative firms is based on the empirical findings of earlier studies (Meyer-Krahmer 1989; Becher, 1989; Molero/Buesa, 1995, 1996; Kulicke et al, 1997) which made clear that even in the case of general non-selective instruments almost only the innovative firms will apply for support. Only a very small number of the supported firms did R&D in an irregular way and almost none of them started for the first time with R&D activities due to the public aid. The CDTI firms confirm this hypothesis because only 4% of the supported firms indicate that they normally did not have formal R&D activities and only four firms (0,8%) indicates that they carry out any R&D activities at all. So the diffusion and use

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<sup>73</sup> Both Kulicke and Lay, working in the ISI Fraunhofer institute, have made use of the broad source of information on firm level that this institute has generated for more than 25 years. They selected their control groups using data from their institute. For most countries such information is not available or researchers have no access to the data due to the legal protection or because the information is private property of the research centres like in the case of ISI-Fraunhofer.

<sup>74</sup> Brown et al evaluated a support scheme that was focused on the aid of inventors and small companies to help them to develop their Energy-Related inventions.

of the programmes amongst the population of potential users (pick-up rate) and amongst different classes of potential users has to be calculated with the innovative firms as a comparison group.

Therefore I will make, basically, use of two sources of empirical dates. The first source -or reference group- are the public statistics<sup>75</sup> dealing with 17.483 industrial firms which carry out any kind of R&D activities (INE, 1997)<sup>76</sup>. The problem of this report is that it only offers some basic characteristics of the firms (size, sector, and social capital) and present a classification in size, that is not the same as used in the survey of our evaluation study. Also I will include the main conclusions of a study of Heijs (1999) who did an analysis of the CDTI's presence in a group of 218 innovative firms in the Bask Country and Navarra<sup>77</sup>. The study was based on a control group which makes it possible to work on firm level.

### 5.3.2 *Size of the supported firms*<sup>78</sup>

The first characteristic of the firms analysed here is the size of the supported firms. The comparison of the CDTI firms with other innovative firms in the broad sense (Table 18)

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<sup>75</sup> With 1804 firms which carry out formalised R&D activities (INE, 1994) and

<sup>76</sup> Also a public report that describes the R&D activities of 1804 firms which carrying out formalised R&D activities (INE, 1994) will be used. Although this study is used only as an additional source of information due to a uneven representation. Especially for the smallest innovative firms that are not represented.

<sup>77</sup> The empirical dates, on firm level, used by Heijs (1999) are based on a study on Mikel Buesa, Mikel Navarra and Arantxa Zubiaurre of 219 innovative firms in the Spanish "Comunidades Autonomas" Basque Country and Navarra. Buesa et all selected 766 firms that carried out all kind of innovative activities and the survey (Survey-ESTE-Eusko Ikaskuntza) sent to these firms was answered "correctly" by 219 of them of which 55 were supported by the CDTI. This database was completed with information of 50 CDTI -firms obtained by a survey (Survey-IAIF-CDTI), as a result of an evaluation study by José Molero and Mikel Buesa concerning the CDTI firms.

In this way I have obtained the information of 269 innovative firms of these two autonomous communities covering 70% of the CDTI firms. Aware of the methodological problems derived by the over representation of the CDTI firms I will use the Survey-ESTE-Eusko askuntza with 218 firms, the limited data base. Only in a few cases will I use the whole group 269 firms. The comparison of the information of the CDTI firms generated by both surveys did not show differences in size, sector or level of R&D expenditures that could limit the methodological and statistical problems.

<sup>78</sup> The reader of this part of the paper has to take into account two important methodological remarks. First all the relations and empirical results mentioned in this section are statistically significant except if it is denied explicitly. The second remark is that all the relations and results of the analysis of the pick up rates, presented in the following sections were controlled on the possible influences by three variables (size, expenditures on R&D as a percentage of the sales (ERDs) and type of project. Repeating the analysis by each of the following sub-groups (Size: up to 50 employees, from 51 to 250, from 250 till 500 and more than 500 employees; ERDs: up to 1%, more than 1% and less than 3% and more than 3%; type of firm concerted projects versus technology development projects

shows us how the smaller the firm the lesser the possibility that it would belong to the CDTI firms. In general 28% of the innovative firms in the Basque region and Navarro. are supported by the CDTI but for the smaller ones this rate is only 10% (Heijs, 1999, see also Table 19). These percentages are very similar to those we saw in Table 18, which shows the take up rate for the industrial firms of the whole of Spain. So we could suspect that the conclusions based on the survey ESTE/Eusko Ikaskuntza reflects more or less the Spanish situation.

The differences in the pick-up rate for firms of different sizes are confirmed independently by the type of project<sup>79</sup> supported by the CDTI. Maintaining as a constant factor the firms expenditures in R&D in relation to their sales (ERDs) it was discovered that the firms which are spending less than 1% of their sales in R&D have generally a low pick-up rate (22%) which does not differs to firms of different sizes while the firms with a higher ERDs level shows clear differences between the pick-up rates of SME's and the large firms.

Further on the Table 18 reflects that the CDTI has supported in a period of 11 years less than one percent of the Spanish industrial firms almost 6% of the innovative firms in a broader sense and 23% of the innovative firms in a stricter sense. Although the general tendency is the same for each reference group the largest firms were supported more intensively than the SME's.

**Table 19: Take up rate of the CDTI in the Basque Country and Navarro by size**

Size by number of employees	National projects *	Technology development projects		Co-operative projects	
		218 firms <sup>NS1</sup>	269 firms <sup>**</sup>	218 firms <sup>NS2</sup>	269 firms <sup>**</sup>
<b>1-9</b>	10%	14%	23%	9%	10%
<b>10-19</b>	11%				
<b>20-49</b>	34%				
<b>50-99</b>	27%	21%	35%	10%	12%
<b>100-249</b>	29%				
<b>250-499</b>	33%	24%	48%	12%	22%
<b>More than 500</b>	47%	35%	46%	24%	30%
<b>Total</b>	28%	19%	34%	11%	15%

Source: The survey ESTE/Eusko Ikaskuntza and the survey IAIF/CDTI.

\*  $\chi^2$  of Pearson with a level of significance of 90%.

\*\*  $\chi^2$  of Pearson with a level of significance of 95%

<sup>79</sup> Although the CDTI distinguish between 4 types of projects in this paper I divided them in two groups. The first group are the so called "concerted projects" which are of precompetitive nature and are developed jointly by companies and Universities or other Public Research Centres (PRC) and are financed by means of interest free credit charged to the annual endowments from the national R&D fund. The second group is the projects of technological development, technology transfer or technological innovation. Those projects that are developed wholly by companies are of an applied nature and are more market-oriented. They are financed by means of low-interest credits from the CDTI own resources (For more details see also the annual reports of the CDTI, 1997).

- NS1  $\chi^2$  de Pearson not significant, level of significance 89%
- NS2  $\chi^2$  de Pearson not significant, level of significance 61%

The comparison of the CDTI firms with the innovative firms in a strict sense the conclusion about the negative discrimination of small firms has to be revised. The second part of Table 18, reflecting a reference group of the whole Spanish productive structure, indicates a contradictory tendency. Using this reference group it should be possible to conclude that the CDTI has benefited the SME's relatively more than the larger firms. Using a different type of classification on size, this table shows that 52% of the CDTI firms have less than 50 employees while only 39% of the firms identified by the INE as innovative firms in the strict sense have that size. Taking as a reference the number of projects supported by the CDTI this positive discrimination fades away. This conclusion is confirmed by the analysis of the firms which applied for support and whose projects were not submitted by the CDTI (Heijs, 1999). This analysis shows that the projects of small firms have a bigger chance to be financed.

This makes it clear that it is not the CDTI who overlooks the SME's but probably the problem is related with the exclusion or self-exclusion of these small firms.

### 5.3.3 Sectoral distribution

The analysis of the sectoral distribution of the support firms indicates a broad dispersion. Logically 75% of the firms are industrial enterprises but 16% belong to the service sector and about 6% to the primary sector. Due to the limited number of firms I reduced the number of sectors based on the taxonomy of the innovative behaviour of the firms<sup>80</sup>

**Table 20: Approximated pick-up rate of supported firms by sector.**

Sectors	Industrial firms (A)	Innovative firms in a broad sense (B)		Innovative firms in a strict sense (C)		Industrials CDTI firms (D)			
		N	B/A	N	C/A	Approximated pick-up rate of supported firms			
	N				N	D/A	D/B	D/C	
<b>Producers of traditional consumer goods</b>	107968	10217	9%	1483	1%	256	0,2%	3%	17%
<b>Suppliers of traditional intermediate goods</b>	26777	2352	9%	346	1%	71	0,2%	3%	21%
<b>Specialised suppliers of intermediate goods and equipment</b>	16293	2461	15%	1150	7%	293	2%	12%	25%
<b>Mass production assemblers</b>	5980	1148	19%	692	12%	208	3%	18%	30%
<b>R&amp;D based sectors</b>	3540	1062	30%	623	17%	165	5%	16%	26%
<b>Total</b>	160558	17240	11%	4294	3%	993	0,6%	6%	23%

Source: own elaboration based on "la Encuesta sobre Innovación Tecnológica en las empresas 1994 (INE, 1997) and the IAIF/CDTI-survey. All differences found for the pick-up rate are confirmed statistically with a  $\chi^2$  de Pearson on a 99% of significance.

<sup>80</sup> Such taxonomy was presented for the first time by Pavitt (1984) who studied the innovative attitudes of English firms. In 1991 Archibugi et al (1991) presented such taxonomy based on the innovative activities of the Italian firms. I will use the five types of industrial sectors proposed by Archibugi et al (See table 3.3.a) appending the sector of services. This implies that some sectors supported by the CDTI are not included in this analysis due to the limited number of firms (which are construction, agriculture, fishery, mining and energy).

**Table 21: Pick-up rate of the CDTI support scheme between the innovative firms of the Basque Country and Navarra by aggregated sectors based on their technological behaviour**

Sector	National projects **	Technological development projects **	Co-operative projects <sup>NS</sup>
Producers of traditional consumer goods	9%	3%	3% <sup>D*</sup>
Suppliers of traditional intermediate goods	16%	13%	3% <sup>D*</sup>
Specialised suppliers of intermediate goods and equipment	28%	26%	14%
Mass production assemblers	44%	33%	15%
R&D based sectors	45%	36%	18%
Business services	29%	26%	6%
<b>Total</b>	<b>26%</b>	<b>21%</b>	<b>9%</b>

Source: The survey ESTE/Eusko Ikaskuntza and the survey IAIF/CDTI.

\*\*  $\chi^2$  of Pearson with a level of significance of 95%

NS  $\chi^2$  de Pearson no significant

D\* Dichotomising the variable sector in six dummies only these two sector have a pick -up rate statistically different from the average firm with a level of significance of 90%.

Looking at the results in table 3.3 two sectors are highlighted due to their low pick-up rate between the innovative firms in a broad sense. Being the sector of the producers of traditional consumers goods (with a pick-up rate of 9%) and the suppliers of traditional intermediate goods (16%) while the pick-up rate of all the firms of these sectoral analysis is 26%. The pick-up rate of the specialised suppliers of intermediate goods and equipment and the sector of services are about average, while the sector based on R&D and the sector of mass-production assemblers have very high pick-up rates of 45%.

For the technological development projects the intersectoral differences are very similar to the global panorama while for the co-operative projects the inter-sectoral differences are much more moderated. More Suprisingly the sector of traditional consumer goods with a low pick-up rate has a relatively high number of co-operative projects that could be related with the high number of public research centres in these sectors.

Due to the limited number of firms the control of the sectoral analysis by the possible influence of the size of the firms and the level of ERDs is not possible

#### 5.3.4 Social capital

Due to the limited number of firms with public capital in survey ESTE/Eusko Ikaskuntza it is not possible to analyse if those were favoured in relation to other firms. The only conclusion that seems clear is that the public firms supported by the CDTI have a higher possibility of having co-operative projects (66%) in relation to the rest of the CDTI firms of which only 33% have such projects.

The CDTI firms belonging to a holding or a group of firms show a relatively high pick-up rate (45%) within the group of innovative firms “in a broad sense” from the Basque Country and Navarro, while the individual firms are less presented (21%). This effect can not be explained due to the relatively small size of the individual firms because the additional analysis of the sub groups based on size reflect that also within the group of small firms and within the group of medium sized firms the same relationships were discovered. For the group of large firms a generally high pick-up rate was found independent of the type of social capital. Also each of the additional analyses for sub groups based on the level of ERDs or types of projects confirms the low participation rate of the individual firms.

**Table 3.4 Pick-up rate by social capital**

Social capital	National projects ***	Technological development projects ***	Co-operative projects **
Individual firms	21%	13%	6%
Firms of a group or a holding	45%	36%	19%
Firms with foreign capital	33%	17%	17%
Total	28%	18%	10%

Source: The survey ESTE/Eusko Ikaskuntza and the survey IAIF/CDTI.

\*\*\*  $\chi^2$  of Pearson with a level of significance of 99%

\*\*  $\chi^2$  of Pearson with a level of significance of 95%

In general firms with foreign capital were not negatively discriminated or excluded from the public support schemes. Within the sub group of small firms (Up to 50 employees) a relatively high number of CDTI firms with foreign capital were found.

This could be explained, on one hand, due to the higher innovation capabilities of the firms with foreign capital. Most of the foreign investors are interested in modernising the production structure of their firms, which means a growing attention for new technologies. This improvement of the innovative culture implies that the firms are better prepared to formalise their R&D activities in projects that could obtain public support.

On the other hand the relatively high presence of foreign firms within the group of small firms could be explained due to the fact that they normally belong to a holding or a group of firms. If this should be the case the foreign firms are discriminated in comparison with the national firms that belong to a holding or a group of firms. But the data of the survey do not allow the control of this hypothesis although the comparison of the CDTI firms with innovative firms in a strict sense may not support this hypothesis.

The comparison of the CDTI firms with innovative firms in the strict sense shows some results that are in contradiction to the earlier conclusions. Almost 12% of the CDTI firms are enterprises with foreign capital while for the group of innovative firms “in a strict sense” identified by the INE (1997) this percentage is 25%. So it seems that, using this reference group, there is some evidence of a negative discrimination of the firms with foreign capital.

As already said most of the public statistics do only offer information about some basic characteristics of the firms. Therefore this chapter includes some findings taken from the article of Heijs (1999), who's results are based on the ESTE/Eusko Ikaskuntza-survey.

The competitive position as a character of the supported firms will be analysed to find out if the public support schemes are picking up the winners of the production structure or if they also support the less competitive firms.

The survey ESTE/Eusko Ikaskuntza offers three kinds of indicators for the competitive position. The first one, that shows the position of the firm in its main market<sup>81</sup>, almost doesn't correlate with the fact that a firm belongs to the supported ones. But, studying the sub groups based on the size of the firms, it was discovered that, on one side, within the group of small firms (up to 50 employees) the pick-up rate of the leaders in the market (46%) is much higher than for the rest of the firms (27%). The small firms with a relatively low position in their main market do not apply or were no supported by the CDTI. On the other hand within the group of large firms (over 250 employees) the leaders of the market have a relatively low presence within the group of CDTI firms (pick-up rate of 45%) in comparison with the non-leaders (a pick-up rate of respectively 45% and 69%).

The second type of indicator is a self-evaluation of five characteristics of the competitive position of the firms; the quality and the price of their products, technological level and commercial position of the firm and services to clients. The analysis of these variables reflect that the most competitive firms, -those who consider their competitive position very high in relation to their national competitors- have a pick-up rate somewhat higher than the less competitive firms. But this relation is only confirmed in a statistically significant way for the firms with technology development projects, not for those firms with co-operative projects. Controlling these relations for each sub group based on the size it can be pointed out that this positive discrimination of the most competitive firms is confirmed for the sub groups of SME's. The sub groups of large firms, with a high pick-up rate, don't reflect such discrimination.

The third indicator of the competitive position of the firm, the percentage of exports over the whole sales of the company, also indicates that the most competitive firms are somewhat over represented within the group of CDTI firms. But this relation fades away when studying the sub groups of control (Size and ERDs).

Studying the results of the three indicators it seems that the CDTI have not really got a policy of picking-up the winners because they supported also the less competitive firms. Although some of the indicators showed some positive discrimination of the more competitive firms the differences, although statistically significant, were not that big. And in the case of the firms position on its main market the conclusions were contradictory and biased by the size of the firm (Heijs, 1999).

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<sup>81</sup> In the survey the firms had to indicate their position on the market. First position or leader, position 2 till 5, position 6 till 15 or beneath the 15<sup>th</sup> position

As forementioned the support scheme for technological development normally reached only firms already carrying out R&D activities. In this part of the paper I try to demonstrate that mainly the firms with higher innovative culture and R&D effort make use of the CDTI's support scheme. The survey ESTE/Eusko Ikaskuntza provides over sixty variables<sup>82</sup> that reflect all kinds of characteristics of the innovation process. Here I would like to present only the most important conclusions illustrated by only some of the indicators found in the study of Heijs (1999).

**Table 22: Pick-up rate by level of Expenditures in R&D by sales**

Expenditures en R&D by sales	Pick-up rate by type of projects			Distribution of firms with* :	
	National projects ***	Technological development projects *	Co-operative projects ***	Rejected projects	Submitted projects
less than 1%	13%	9%	2%	15%	26%
From 1 to 3%	27%	19%	8%	37%	48%
From 3 to 5%	44%	30%	20%	22%	15%
Over 5%	52%	35%	30%	26%	11%
<b>Total</b>	<b>28%</b>	<b>20%</b>	<b>11%</b>	<b>100%</b>	<b>100%</b>

Source: The survey ESTE/Eusko Ikaskuntza and the survey IAIF/CDTI the database of the CDTI

\*\*\*  $\chi^2$  of Pearson with a level of significance of 99%

\*  $\chi^2$  of Pearson with a level of significance of 90%

The traditional indicator for the input of the innovative activities is the ERDs. Which can be seen in Table 22 this variable discriminates clearly between CDTI firms and not supported firms. The higher the level of ERDs the bigger the chance that a firm is supported by the CDTI. This relation is confirmed independently of the variable size<sup>83</sup> or type of project.

To find out if this is a deliberate policy of the CDTI or if its a consequence of the design of the instrument the study of Heijs (1999) compared the firms whose projects were rejected by the CDTI with those with projects which were accepted. Table 22 shows that it is not the CDTI which selects firms with a high level of ERDs but the firms with a low level simply do not apply that much for public support. Firms with a low level of ERDs have,

<sup>82</sup> Most of these variables confirm the tendency that more innovative firms have higher changes to form part of the CDTI firms and a lot of them show statistically significant relations. Moreover the most important conclusion of the more than 60 variables analysed is that none of them show a contrary tendency

<sup>83</sup> These relationships were confirmed in the two sub groups of size, which contains the SME's. The subgroup of firms with more than 250 employees, with a high general pickup rate, firms with higher ERDs do not have a higher pickup rate than the firms with a low level of ERDs.

assuming that they should apply for support, a higher possibility that their project will be approved than the firms with a higher ERDs level.

A second variable that represents the R&D efforts of the firm is regularity of its R&D activities. 88% of the CDTI firms carry out R&D activities on a regular basis while for the non CDTI firms of the survey ESTE/Eusko Ikaskuntza this percentage is about 65%. Calculating the pick-up rates it was discovered that 34% of the firms who are doing R&D on regular basis are supported by the CDTI while for the rest of the innovative firms of the Basque Country and Navarra this percentage is 14%. These relations have been confirmed independently by the size of the firm, the type of project and the ERDs<sup>84</sup>.

Most of the analysed variables<sup>85</sup>, that reflect the process of innovation, indicate the same relationship. Even within the group of innovative firms, in a broad sense, from the Basque Country and Navarra it is possible to detect that the most innovative firms have been benefited more by the public support scheme than the less innovative firms

So the general conclusion, based on the analysis of the innovative orientation and R&D efforts by the firms makes clear that the more innovative firms, within the group of innovative firms in a broader sense, are supported more by the CDTI than the less innovative firms.

#### **5.4 The diffusion of the CDTI support schemes: a logistic regression model**

Taking in account the explorative analysis of the diffusion of the CDTI within the Spanish productive structure it seems that the level of participation depends on the firm's size, sector, control capital, innovative efforts and orientation and although less pronounced on its competitive position. This analysis based on an association test of each of the explanatory variables with the dependent variable (level of diffusion) does not take in account the possible interaction between explanatory variables. Therefore I present here a logistic regression model (Taken from Heijs, 1999) that analyses the diffusion of the CDTI in the Autonomous Communities the Basque Country and Navarra. As already said it isn't possible to generalise the conclusions of this model for

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<sup>84</sup> Except for the sub group with an ERDs lower than 1% who in general has a low pick up rate and for the sub group of very large firms (more than 250 employees) which have in general a high pick-up rate. In these two sub groups there was no difference in the possibility of firms belonging to the CDTI firms due to more or less regularity of their R&D activities.

<sup>85</sup> Other variables analysed are the technological autonomy of the firm, the importance of several kinds of R&D, the importance of own R&D activities, the importance of technical objectives, quality of the products and technological level of the firm in comparison with national and with international competitors, Patents, percentage of innovative products in sales and in exports. For a more detailed analysis of these aspects see Heijs 1999.

the whole Spanish production structure but will give some hints of possible bias of the conclusions based on the association tests<sup>86</sup>.

The first model presented in the study of Heijs (1999) analyses the diffusion of the CDTI within the group of innovative firms –in a broad sense- of the Bask Country and Navarro. The explanatory variables that, in a simultaneous way, are summarised as follows:

- A higher level of diffusion has the firms with a high level of R&D expenditures by sales, the firm's which technological level is higher in relation of such level of other firms, with a high level of export by sales, and those belonging to a Spanish group of firms or holding.
- A low degree of participation do have the firms belonging to the sector of traditional consumer goods traditional intermediate products or firms specialised in intermediate goods and equipment.

Ostentatious is the fact that the association between the size and the diffusion rate seems to be apparent but is non-existent when the other explanatory variables are taken into account. This could be explained by the possible presence of a high number of low innovative small firms that do not participate in the CDTI projects. It seems that the reason of their non participation depends more on their innovative level than their size.

**Table 23:** The diffusion of the CDTI in Bask Country and Navarro: a logistic regression model

Firms characteristics	Innovative firms in a broad sense	Innovative firms in a more strict sense	A sample of matched firms
<b>Size</b>			
Small (up to 50 employees) versus medium sized and large firms (over 50 employees)		+0,25* (0,07)	
SME's (up to 500 employees) versus large firms (over 500 employees)			
<b>Position Competitive</b>			
Percentage of exports over sales	+0,32* (0,08)		
Competitive position in the main market of the firm			
<b>Control Capital</b>			
Firm belonging to a national group/holding	+0,45*** (0,21)	+0,41*** (0,22)	+0,42*** (0,21)
Firm with foreign capital			
<b>Sector</b>			

<sup>86</sup> For example, the sectoral differences in size, innovative efforts and orientation or other firm's characteristics is well known. The advantage of the logistic models is that they analyse the specific sectoral level of diffusion taking in account the interaction with other sectoral specific characteristics just mentioned.

Producers of traditional consumer goods	-1,57*** (0,13)		
Suppliers of traditional intermediate goods	-0,79*** (0,16)		
Specialised suppliers of intermediate goods and equipment	-0,34*** (0,12)		
Mass production assemblers			
R&D based sectors			
Services			
<b>TECHNOLOGICAL ORIENTATION AND EFFORT LEVEL</b>			
Expenditures on R&D by sales	+0,52*** (0,14)	+0,69*** (0,17)	
Personal in R&D (up to 25 versus 25 or more)			
Regularity of the R&D activities			+1,12*** (0,13)
Importance of own R&D activities			
Technological level in relation with competitors	+0,85*** (0,13)		
Constant	-4,24***	-2,72**	-2,39***
Correctly classified	75%	71%	65%
Chi square of the model	57***	20***	16***
Number of firms in the model	206	128	116

Source; own elaboration based on the IAIF/CDTI questionnaire. Level of significance (\* 10%; \*\* 5% and \*\*\* 1%). The estimated models did contain several variables not reflected in this table because they were rejected. The shadows of the cells in first column indicate that those explorative analysis found a association between these variables and the dependent variables. The shadows in the last two columns indicates that those variables were excluded of the estimation. Because they in the second column they had the same value for all the firms and in the third column refers to the variables on which the firms are matched. The innovative firms in a strict sense are, in this case, conceptualised as firms that do R&D on a regular way, who's R&D expenditures are over 1% of their sales and that are considering their R&D activities as important or very important. Of course this is only an approximation of the innovative firms in a strict sense

The second model only includes the innovative firms in a strict sense<sup>87</sup>. In this case the model indicates that the more innovative firms and the firms belonging to a national group of firms or a holding are participating more frequently in the CDTI support programmes than the individual firms<sup>88</sup>. Moreover this model indicates that –within this group of very innovative firms- the small firms (less than 50 employees) do participate less in the CDTI programmes than the medium sized and large firms. So excluding the group of small low innovative firms the size recovers its explanatory power.

The third model estimated by Heijs (1999) is based on a sample of firms in which each CDTI firms is coupled to a similar non-CDTI firm; taking in account the firms sector, its R&D efforts and its size. In this way I constructed a control group of firms very similar to ones supported by the CDTI. This control group of firms contains the firms that possibly could have participated in the CDTI programmes but that had not applied for support or whose applications were refused. This “MATCHED” model points out

<sup>87</sup> In this case conceptualised as firms that do R&D in a regular way, whose R&D expenditures are over 1% of their sales and that are considering their R&D activities as important or very important. Of course this is only an approximation of the innovative firms in a strict sense.

<sup>88</sup> The different type of control capital is included in the model as dummy variables. In the case of excluding the dummy for the firms belonging to a group of firms the dummy individual firms are included as explanatory variable in the model. This change does not have a real influence on the composition of the set of explanatory variables of the model (except very small changes in the values of the coefficients).

that two variables can explain the diffusion level of the CDTI. The first one is the innovative efforts and orientation of the firms. This variable, like in the other two models, plays a central role in the explanation of the participation. Especially ostentatious in this case, were the control group of firms do have a similar level of R&D efforts. The second explanatory variable is the belonging to a group of firms or a holding. The individual firms do participate less in the CDTI programmes than the firms belonging to a group of firms.

## 5.5 Conclusions

In the first part of the paper I have discussed briefly the methodological problems of the use of reference groups and control groups. It has been pointed out that the choice of one of the possible comparison groups can lead to different conclusions. This has not only been demonstrated by a simple example presented in the second section but also in the empirical part we have seen that the use of different comparison groups has led to different conclusions. So the selection of the reference groups and the methodological consequences has to be explained clearly. And if it is possible the researchers should use more than one reference group and try to explain eventual contradiction in the results. Due to the uncertainty of the viability of the different reference groups I think the best, but more expensive solution, would be the use of a control group.

The next summary of the rate of supported firms proves that those methodological problems are no that easy to solve. Using different reference groups I have illustrated that the CDTI supports only 0.6% of all the industrial firms during a period of 11 years, only 5,7% of all the industrial firms with innovative activities in a very broad sense and almost 23% of the industrial firms which carry out formalised R&D activities.

Using a control group of innovative firms, in a broad sense, in Basque Country and Navarro the pick-up rate of CDTI was 27% calculated for only the industrial firms. Remarkable is the difference between those 27% and the 5.7% aforementioned. Although both are defined as innovative firms in a broad sense the 5.7% is based on the European Innovation Survey:. That survey was sent to a large number of industrial firms to find out if they are doing R&D and uses a very broad definition of R&D activities. The survey ESTE/Eusko Ikaskuntza started to select a group of innovative firm's (766) based on demonstrated results and clearly revealed activities. Using a definition much more broader than formalised R&D activities but clearly more restrictive than the European Innovation Survey<sup>89</sup>.

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<sup>89</sup> The survey ESTE/Eusko Ikaskuntza is based on a database of 766 innovative firms selected due to the fact that they: have registered patents, models, applied for public support by several administrations, firms of the database of EUSTAT that did formalised R&D activities in 1993, firms who had given technical assistance in foreign countries, firms with investment in foreign countries related with patents, design, landmarks or models etc.)

So it is not that easy to explain the differences between several reference and control groups. But it has to be clear that the CDTI reached only a very small number of firms of the Spanish productive structure and a relatively high number of innovative firms.

The evaluation studies did frequently analyse the size of the firms to characterise the diffusion of the policy programmes but comparing the studies I did not obtain conclusive results. The idea that most support programmes do benefit more frequently the smaller firms is not been confirmed. Several studies do point out a positive discrimination of the small and medium sized firms (Becher et al, 1990; Molero/Buesa, 1995). The study of Becher et al (1989) points out that within the group of SME's the larger ones has been more benefited than the smaller firms. A study of Heijs (1998, 1999) points out that the below or above average participation of the smaller firms could be related with other explanatory variables, especially the innovative level of the firms. Using different kind of reference groups Heijs did find different conclusions in relation with the level of participation of the smaller firms.

Based on an association test between size and the level of diffusion it can be stated that the **size** is a clear discriminatory variable. It seems that small innovative firms are not able to make use of the CDTI support scheme due to the lack of time and information but also due to the implicit requirements in obtaining low interest credits. The CDTI support scheme, theoretically accessible to all firms, is focused on clearly designed R&D projects that hinder the entrance of small firms with other types of innovative activities. Although it seems that the CDTI has not favoured that much the small innovative firms the study of Heijs (1999) indicates that the small firms that apply for support have a bigger chance that their project will be financed than the larger firms. This makes it clear that it is not the CDTI who overlooks the SME's but probably the problem is related with the exclusion or self-exclusion of these small firms.

There are two fundamental reasons that the smaller firms are not participating in the support scheme of the CDTI The first reason is the limitation of human resources and time that they can dedicate for gathering information about all kinds of financial aids from the public administration and to prepare the written forms. In fact almost all the large firms who applied for help did sent three or more projects while the small ones sent only one.

The second reason, and maybe the most important one is the auto-exclusion of the smaller firms related with the strict concept of R&D managed by the CDTI. This concept limits the support to formalised R&D projects excluding other kinds of R&D activities. Due to the limited capacity of innovation management of those firms they have difficulties to translate their innovation activities in well-organised projects with clear objectives. Spain almost doesn't have additional support scheme that supports the other forms of R&D activities<sup>90</sup>. The analysis of the firms in Navarro and Basque Country reflect that especially the smaller firms, that indicate that their R&D activities are normally incremental and not formalised, never applied for help by the central government (Heijs, 1999).

The logistic regression model does distinguish the role of the size as an explanatory variable Studying the innovative firms in a broad sense the size did not have any

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<sup>90</sup> Except the promotion scheme of the industrial design but this instrument has very limited budgets

explanatory power. It seems that in this sub sample exists a large number of small firms with a very low innovative level that do not participate. In the logistic regression model estimated for the innovative firms in a stricter sense the size recovers its explanatory power.

So there still exist confusion about the role of the size as an explanatory variable for the diffusion of public support measurements. Although it seems clear that the idea of a positive discrimination of smaller firms has to be revised. It is true that smaller firms are discriminated positively in the case that they are applying for support. But the problem is that most of those firms do not apply for help.

The **sectoral analysis (association tests and the logistic regression model)** indicates that the traditional sectors have lower pick-up rates than the modern ones, a fact that can't be explained only by sector specific characteristics<sup>91</sup>. The higher level of participation of the R&D based sector and the mass production assemblers was only found in the association tests. The logistic regression model did point out that their high participation level has to be explained due to the interaction with other sector specific variables like size of innovative effort and orientation.

The low level of participation of the traditional sectors is not a typical Spanish circumstance but occurs in the majority of European countries (Dankbaar et al., 1994 Pyke/Becattini/Sengenberger, 1992). Although these sectors are still very important in some of those countries. Dankbaar et al. argues for a more active public support for those sectors. The problem is if it is possible to obtain long range sustainable advantages in such low-tech sectors. It seems that only in high tech sectors is it possible to create high-valuable externalities and to build up competitive advantages with a high added value on a long term.

The analysis of the pick-up rate by **social capital** pointed out that foreign firms are not excluded from financial support by the CDTI. But the analysis of the CDTI firms with the innovative firms in a strict sense does not offer a clear conclusion. The results depend on the kind of comparison group and for a better understanding additional information is required. The logistic regression model offers a clear conclusion that tinges the aforementioned analyses. First the foreign firms do not diverge from the average level of participation. Further on this model point out that the firms belonging to a group of firms or a holding do participate more frequently in the CDTI support programme than the individual firms do. Both tendencies were confirmed in all three models.

In relationship with the **competitive position** of the support firms, it can be said that the CDTI doesn't have a clear policy of picking up the winners. It seems that within the group of innovative firms, in general, the leaders of the market have the same possibility of belonging to the CDTI firms as the non-leaders.

As forementioned the evaluation studies indicate that the firms reached by the instruments of the technology policy are firms who already do carry out innovative activities (Becher, 1989, 1990 Meyer-Krahmer, 1989, 1995; Buesa/Molero, 1995;

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<sup>91</sup> Within the group of innovative firms in a strict sense the low participation level of traditional sectors fades away

Molero/Buesa, 1996). The analyses of this chapter points out that even within the group of innovative firms it is possible to detect “more” innovative firms with a clearly greater possibility belonging to the CDTI firms. The results of the survey ESTE/Eusko Ikaskuntza made it clear that the firms with a low **level of ERDs**, low **regularity of innovation activities**, low importance of their own R&D etc. have less chance of belonging to the group of CDTI firms. Even in the case of a control group were the R&D expenditures of the non CDTI firms are similar as for the CDTI firms evidence was found that the most innovative firms are participating more frequently.

The fact that only the more innovative firms do participate in public support schemes is one of the main problems for the traditional technology policy model. This model based on the supply of financial sources, information and technological knowledge does not reach the firms that are not doing any innovative activity at all. This is not a typical Spanish problem but in all developed countries you can find the same tendency. The technology policy favours a part of the most dynamic and fast growing innovative firms accelerating their innovative activities.

The modern technology policy should not only force the R&D activities of the already innovative firms, but also raise the number of innovative firms. The problem is how to push the small individual firms, often owned by a sole family or a few partners, to modernise their production structure and to integrate the innovation as a central aspect of their strategic behaviour.

## CHAPTER 6

### THE IMPACT AND ROLE OF THE CDTI's AID PROGRAMMES: A GLOBAL REVIEW

#### 6.1 Introduction

Although almost all evaluation studies did analyse the role and impact of the public support in the benefited firms most of them offered the results in general terms without the identification of firms that could not take that much advantage of their publicly supported innovative activities. This could be the consequence of the fact that most studies are carried out to justify the support programmes. The use of such studies to adjust the policy instruments or to develop additional support schemes to improve the innovation process of the firms seems to be less important. The case studies pointed out that large parts of most of the innovation studies are descriptive.

In each of the chapters of this doctoral thesis I made a broad analysis of the characteristics of the CDTI-firms that do consider the support as not important, that has a low level of goal achievement or didn't take advantage of the project by initiating a learning process. The main conclusions were explained in each of the chapters, in this part I like to point out some type of firms that showed a clearly diverging behaviour in relation with almost all of the evaluated items. Like for example the less innovative firms, the large firms, the small less innovative firms, the firms belonging to the service sector and those belonging to the R&D based sectors

#### 6.2 The small less innovative firms

Some of the analysed evaluation studies did offer data about the impact of the firms taking in account simultaneously the size and innovative level of the firm (See among others IESE, 1995 and Kulicke et al, 1997). In this PhD thesis I did not use such sub samples in a direct way but the additional analyses in sub samples by size, level of R&D expenditures and type of project offered in an indirect way such analyses. Table 24 reflects the results of those control analyses and will be used to support the results presented in the following paragraphs.

**Table 24: Role and importance of the CDTI support schemes for the firms (classified simultaneously by size and R&D expenditures as an percentage of sales (ERDs))**

	Small firms			Medium sized firms		Medium size and large firms with a high level of ERDs	Large firms		Total	X <sup>2</sup> de Pearson
	Low ERDs	Medium ERDs	High ERDs	Low ERDs	Medium ERDs		Low ERDs	Medium ERDs		
Percentage of firms with a freerider attitude	36	28	30	37	28	31	64	44	34	**

Level of diffusion <sup>92</sup>	11	11	25	23	31	47	33	60	28	**
Simultaneous achievement of all 5 technological goals	68	72	76	78	79	74	64	71	75	NS
Simultaneous achievement of all 3 commercial goals	65	74	76	82	76	82	60	68	75	NS
No improvement of the formation of R&D personnel	26	20	18	26	20	13	12	22	21	*
No increase of the knowledge level of the firm	29	17	14	18	15	5	8	17	17	NS
No improvement of the innovation management	54	38	38	25	30	21	44	36	36	**
No improvement of the cooperative attitude with public R&D centres	55	36	42	59	40	28	28	24	41	**
No improvement of the cooperative attitude with other firms	84	55	55	69	60	44	60	44	59	***
No improvement of the innovative culture	39	14	16	14	12	18	12	29	18	***

Source: The IAIF/CDTI-survey. Each cell contains the percentage of firms that reflect each of the characteristics mentioned in the first column.

\*  $\chi^2$  of Pearson with a level of significance of 90%.

\*\*  $\chi^2$  of Pearson with a level of significance of 95%

\*\*\*  $\chi^2$  of Pearson with a level of significance of 99%

NS  $\chi^2$  of Pearson not significant

Political responsables are paying a lot of attention to the small and medium sized firms. Several support measurements are designed especially for this group of firms. The high cost related to the critical mass of R&D investment implies, especially for the SME's, a relatively higher level of risk in the case of failure of the projects. In this case such firms can get into a difficult financial problems<sup>93</sup>. This last aspect is confirmed by the results of the chapter about freeriders. Small and medium sized firms indicate more frequently that their technological development depends of the public support than the large companies. A tendency especially pronounced in the existence of financial alternatives to finance the projects. At the same time the less innovative firms do reflect a higher level of freeriding. A tendency especially pronounced in the group of small less innovative firms. These groups of firms should worry about the policy agencies because they show a high level of freeriding, do participate less in the CDTI support programmes and generic impact (see Table 24).

Moreover their goal achievement is also below average. This last conclusion could not be statically proved but is surprising. It could be expected that the less innovative firms carry out less complex innovative activities close to the market. This supposition could explain on one side the low level of generic impact but should go accompanied with a higher level of goal achievement.

<sup>92</sup> Based on the ESTE/Eusko Ikaskuntza-survey

<sup>93</sup> Some studies do indicate that such problem is not that important as it seems. Small firms do initiate projects according to their size, financial possibilities or technological capabilities (Levin et al., 1987, P.544). As well as large firms like the SME's can take advantage of their comparative advantages by type of market, technological characteristics, appropriability and technological opportunities (Levin et al., 1985; Rothwell/Dodgson, 1994)

### 6.3 Large enterprises

Other group of firms that showed a diverging behaviour for almost all the aspect analysed in this PhD thesis are the large enterprises. Over 53% of those firms –that are participating relatively more in the CDTI support programmes than the smaller firms– do show a freerider attitude. Taking in account the R&D efforts of the large firms it can be pointed out that 64% of the large less innovative firms are freeriders and the more innovative large firms while for the large more innovative enterprises this percentage was 45% (see Table 24). Moreover these firms show a lower level of technical and commercial results including a low level of learning or generic impact. Taking in account those findings it should be positive to adjust the selection criteria for large firms. Without excluding them totally from the support programmes it could be possible to require a higher interest level, close to the market prices.

### 6.4 Sectoral differences

The sectoral analyses did find some differences that could not only be explained by sectoral differences of size or innovative effort and orientation or other sector<sup>94</sup>.

A first sector that can be highlighted is the R&D based firms. The association tests indicate that those firms are participating more in the CDTI programmes than the firms of other sectors. But the logistic regression models pointed out that this above average participation level is apparent. Taking in account other explanatory variables – especially the innovative level of the firm– the participation level of the firms of this sector is on average level. The R&D firms do have a relatively low level of goal achievement whereas the generic impact is clearly above average. These two apparently contradictive tendencies could confirm the hypothesis that those firms are carrying out complex and riskful projects. Such projects do generate a high level of learning but at the same time their goals are difficult to achieve. In relation to the freerider attitude those firms do not diverge from the average firm.

A group of firms that show relatively bad results are the firms of the service sector. Those firms show a level of goal achievement clearly below average. The logistic regression model point out that such can not be attributed to the size, innovative level or other specific sectoral differences. The low level of goal achievement of the R&D based sector was accompanied by a high level of learning, which could be an indirect indicator of the complexity of the projects. For the firms of the service sector a relative large percentage indicates that the generic impact was almost non existent<sup>95</sup>. So it seems that those firms did carry out R&D activities that are lying within their technical frontier

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<sup>94</sup> Here is only highlighted the sector who's behaviour did diverge in more than one chapter. Other conclusions in relation to the sectoral analyses can be found in each of the chapters. It should not be correct to conclude that those conclusions should be less important but they are excluded from this section for not repeating the conclusions of each of the chapters.

<sup>95</sup> Although the average valuation of the generic impact of the service sector was, in general, similar to the average level of the whole sample it is remarkable that a relatively large number of firms of the service sector indicate that the generic impact was almost non existent.

projects. This means that the firms of the service sectors do not need only financial support but also should receive a more persistent control of the project development and additional support like technical consultancy or commercial advise.

## 6.5 Final conclusions

In the last part of this chapter (section 5) I will present some of the most important findings of my work. The role of the CDTI in the Spanish production structure can be considered as important. In the period 1984-96 the CDTI did finance almost 3.7% of the Spanish expenditures in R&D and 7% of the industrial expenditures in R&D. Roundabout 0.6% of the Spanish firms did get financial support. But taking into account the innovative level of the firms it can be pointed out that 6% of the innovative firms in a broad sense were supported and over 23% of the innovative firms in a strict sense were supported by the CDTI.

The discussion about the main conclusion of my PhD thesis has to take into account the five questions included in the conceptual framework about technology policy evaluation developed in chapter one<sup>96</sup>. It has to be pointed out that my analyses do answer only the first three questions of that framework. The answers obtained by my analyses do not permit to disqualification of the actuation of the CDTI. On one hand, I found that most of the firms used the public support to raise and intensify their innovative activities and most of the firms would have serious problems to finance their activities without the public support. On the other hand the technological and commercial results were satisfying. Moreover, the high level of generic impact and learning could imply a displacement or improvement of the technological frontier of the firms or even of the industrial system as a whole.

It has to be underpinned that the PhD thesis only analysed the first three questions of the conceptual framework. The results of my study do not offer any evidence that indicates which we should reject the hypothesis that the public support did raise the social welfare. So I do not reject this hypothesis but to confirm it the last two questions of the conceptual model should be analysed. Therefore the study should not only analyse the role and impact for the supported firms but also the impact on the whole production system.

This does not mean that the actuation of the CDTI could not be improved, but such improvements will be, on one hand, incremental, and on the other hand should take into account the global Spanish system of technology policy. The conclusions about the characteristics of the firms with a below level goal achievement and generic impact –not only the before mentioned ones but also the conclusions mentioned in each of the

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<sup>96</sup> As mentioned in chapter one, to justify the public support of R&D five questions should be answered positively in a simultaneous way 1) Does the public intervention generates additional private investments? 2) Does the project generates new technologies, an improvement of its application or an acceleration of their diffusion? 3) Are these converted into new products introduced on the market? 4) This introduction does not mean the substitution of existing similar technologies? and 5) The costs of the policy (including the opportunity costs) and its implementation are lesser than the social benefits?

chapters- do suggest the existence of a group of firms for which the financial support as an isolated instrument is not enough. The supply of financial funds, on its own, is an instrument related with the linear model of innovation. In this model the input of the innovation process is converted automatically into technical results whose introduction in the market is easy and costless. But the interactive model revealed that the financial funds are a necessary but not sufficient factor to generate new technologies and convert them into useful products for the market. The study of the IMADE (1992), about the innovative firms in the region Madrid do confirm this hypothesis<sup>97</sup>. The CDTI, as a policy agency, should explain the political responsables of the need of a more adequate policy and convince the government to make such additional measurement possible and finance them.

Almost all studies indicate that the firms reached by most technology policy instruments are firms who already do carry out innovative activities (Becher, 1989, 1990 Meyer-Krahmer, 1989, 1995; Buesa/Molero, 1995; Molero/Buesa, 1996). Even within the group of innovative firms it was detected that the most innovative firms have a clearly greater possibility of belonging to the CDTI firms. These results were also found in other studies (Siegert et al., 1985; Meyer-Krahmer, 1989; Becher et al., 1989, 1990; Molero/Buesa, 1995; Kulicke, et al., 1997; Heijs, 1999).

The fact that only the more innovative firms do participate in public support schemes is one of the main problems for the traditional technology policy model. The policies related to this model -based on the supply of financial sources, information and technological knowledge- do not reach the firms that are not doing any innovative activity at all. This is not a typical Spanish problem but in all developed countries you will find that the technology policy favours a part of the most dynamic and fast growing firms, accelerating their innovative activities.

Like the study about the goal achievement and the generic impact, the study about the diffusion of the public support also points out that the less innovative or not innovative firms need special attention. The modern technology policy should not only force the R&D activities of the already innovative firms, but also raise the number of innovative firms. The problem is how to push the small individual firms, often owned by a sole family or a few partners, to modernise their production structure and to integrate the innovation as a central aspect of their strategic behaviour.

Although it seems that the smaller firms and less innovative ones do not have a high participation grade their exclusion of the CDTI from support programmes can not be found in the decision making process of the CDTI. On the contrary smaller and less innovative firms are discriminated positively in the case that they are applying for support. The problem is that most of those firms do not apply for help. Maybe the most important reason for the auto-exclusion of the smaller firms –or the less innovative firms- is the

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<sup>97</sup> As mentioned before, this study -analysing the opinion of the innovative firms about the support that they esteem as necessary- pointed out that they not only demand financial help (70% of the firms demanded financial support to buy new modern equipment and over 50% demanded financial support to carry out R&D projects), but also technical advice to initiate their project (42%), supervision and orientation during the development of the projects (17%) and formation and training for their managers (36%) and personnel (56%).

strict concept of R&D managed by the CDTI. This concept limits the support to formalised R&D projects excluding other kinds of R&D activities. Due to the limited capacity of innovation management of those firms they have difficulties to translate their innovation activities in well-organised projects with clear objectives<sup>98</sup>.

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<sup>98</sup> The analysis pick-up rate of the CDTI within the innovative firms in Navarro and the Basque Country did confirm this conclusión. This study indicates that the R&D activities of the small and less innovative firms are normally incremental and not formalised, and that most of those firms did never apply for help from the central government (Heijs, 1999).



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## Resumen

El tema central de este artículo es la evaluación global de la financiación pública de la I+D empresarial, analizando los créditos blandos para proyectos de innovación gestionados por el Centro para el Desarrollo Tecnológico Industrial –el CDTI-. El objetivo de este estudio es analizar el papel e impacto de los proyectos financiados por el CDTI en las empresas. Se analizarán la importancia de las ayudas para las empresas (comportamiento utilitario), los objetivos tecnológicos y comerciales y su nivel de cumplimiento y el impacto de los proyectos sobre la capacidad tecnológica y la actitud cooperativa de las empresas.

Para el estudio de **la trascendencia del CDTI en el sistema productivo**, se analiza el volumen financiero de los créditos del CDTI respecto al total de los gastos empresariales en I+D, la difusión de las ayudas dentro de las empresas del sistema productivo; y se comparan las características de las empresas beneficiadas por el CDTI con las de las empresas no beneficiadas. Para analizar **el papel y el impacto** de los créditos del CDTI **en las empresas** se estudian, entre otros aspectos, si las empresas cumplen los objetivos tecnológicos y comerciales previamente estipulados, si los proyectos financiados generan una mejora de las capacidades tecnológicas y, por último, la importancia de las ayudas para el desarrollo tecnológico de la empresa, analizando si las ayudas fueron imprescindibles-o no- para llevar a cabo los proyectos financiados por el Estado.

**Palabras Claves: Política tecnológica, CDTI, evaluación de las políticas, innovación y cambio tecnológico**

## Summary

The **central subject** of of this paper is the evaluation of the low interest credits for R&D provided by the Centre for Industrial Technologic Development. The objectives are, on one side, a global evaluation of the role and impact of the projects, financed by the CDTI, within the firms, and, on the other side to measure the importance of the CDTI for the Spanish productive structure.

The study of **the importance of the CDTI within the production structure** will be analysed by the total volume of the CDTI funds in comparison with the R&D expenditures by the private enterprises and the diffusion of the CDTI within the productive structure. The characteristics of the CDTI firms will be compared with those of the innovative firms that didn't participate in the support programmes of the CDTI. The **impact and role** of the CDTI projects, **within the supported firms**, are analysed by several aspects like the financial importance of the support, the technical and commercial objectives and their accomplishments, the impact on the innovative culture and the improvement of the technological capabilities and co-operative attitude.

**Key words, Technology policy, CDTI, innovation and technological change, policy evaluation**

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