Treball de recerca

“Technological Transfer from universities: A theoretical review and an empirical analysis of Spin-offs in Spain”

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1. - Introduction:

The Bayh Dole Act (1980) and the 1986 Federal Technology Transfer Act (1986) moved the right to own and license inventions from federally funded research to the universities in the US. From then, the amount of innovation commercialized from the universities has increased dramatically (Nelson, 2001; Mowery et al., 2001), not only in the US, also in other countries where Universities have the same structure of ownership and decision rights about inventions, like Spain, Italy or UK (Geuna et al., 2003).

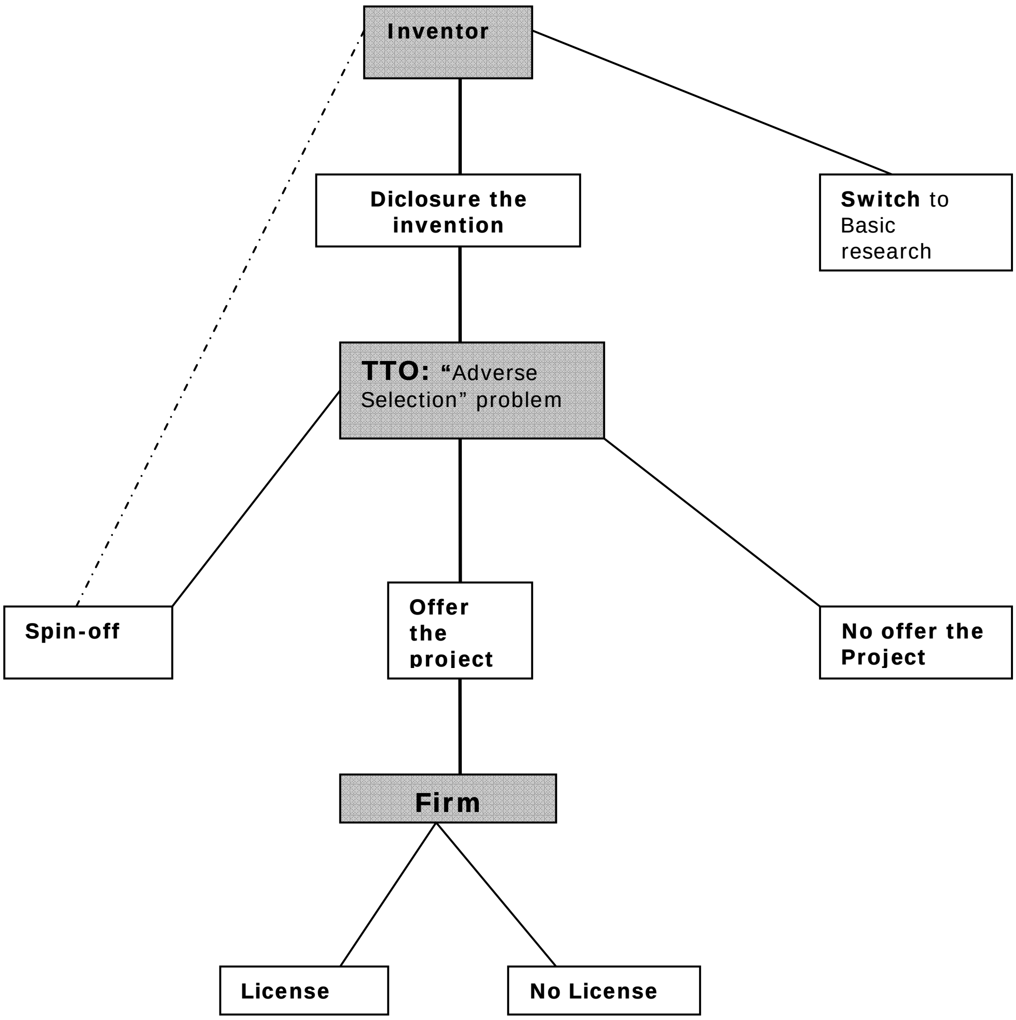
This commercial success and the commercialization of research as an important option to create wealth (Etzkowitz, 1998; Shane, 2002) also have gone with an increasing interest of academics about the role of University Transfer Technology Offices (TTO). This literature has analyzed the two ways of commercialize innovation from a university. Selling licenses and spinning out companies. The analysis mainly focuses on the organizational contexts that defines the actions, decisions and shapes the motivations of the main agents of these processes: the university scientist, the TTO and the firm in the case of licensing.

The University Scientist or inventor has an academic culture and it carries with an ambiguous relationship to commercial innovation and a preference for basic research (Ndonzuau, Pirnay and Surlemont, 2002). Most of his career recognition, and consequently compensation, comes from his success in the basic research, therefore it is a clear, and in some cases important, opportunity cost for the development of commercial innovation. Obviously, institutional arrangements can modify such interests. Besides the personnel policy of scientist and academic staff, the University also has other vias to stimulate the development of commercial innovation. More concretely, the University has the intellectual property of those developments made by their scientists, so the University decides the internal distribution of the income that comes from patentable and not patentable inventions, also called labor inventions, among general administration, TTO, and inventor or faculty.

University Transfer Technology Offices (TTO) is the name that usually receives all the persons in charge of the protection and commercialization of University's intellectual property and deals with the researchers, in order to receive commercial innovations, and the firms, in order to use this innovation in their production organization or development of new projects. Usually the TTO receive suggestions from scientists and they analyze if the project is commercializable and later decide how to commercialize it, by licensees or creates one Spin-off, ventures founded by employees (professors, researchers, students, etc.) of the university around a core technological innovation which had initially been developed at the university (Birley, in press). The TTO has a bureaucratic culture as a public institution, given that make administrative tasks inside the University. Although that, their budget comes in part from the income generated in these transactions.

Finally, the entrepreneur or firm is an agent interested in investing in new projects. These projects tend to be a proof of concept or a prototype and then they are in an embryonic stage, and thus need further development before commercialization, so it is needed the collaboration of the University scientists. In order to commercialize these projects firms usually pays to the University a fixed fee and sponsored research in a first stage and if success they also pay royalties or give equity. Figure 1 summarizes the timing of the different decisions taken by the cited agents.

Figure 1: Timing of decisions related with technological transferences



Next Section summarizes the relevant Spanish legislation around the transactions appearing in Figure 1. The Section 3 revises the literature focused on the decisions and role of University TTO on how and which innovations are going to be commercialized. In particular, we deal with questions as why TTO's exist (Macho, Veugelers and Perez, 2005), the mechanisms that universities have to stimulate researchers in order to develop commercial innovation (Jensen, Thursby and Thursby 2003), and finally under which circumstances TTO choose between license and Spin-off (Chukumba and Jensen, 2005) deriving the most important empirical implications of these models.

Section 4 summarizes the growing literature focused specifically on Spin-off companies and more specifically their development problems, Vohora et al. (2004). The most relevant questions in this area have been based on the study of information and financing problems (Macho, Veugelers and Perez, 2006) and skill limitations of the managers (Lazear, 2004, 2005). Section 5 presents empirical evidence on the development of Spin-offs in Spain, comparing their development problems with those of other technological firms. Conclusions close the work.

2. – The Spanish legal environment

The creation of TTO's in Spanish Universities (Oficina de Tranferencia de Resultados de Investigación, OTRI) was impelled by the Government in the First National Plan of R&D in 1988 developed by the Secretary General of R&D. The TTO assumes the role of dynamist that the National Plan needed in order to integrate the industry in an innovating dynamics. The main tasks of the TTO recognized in such plan, are listed below.

- Contact with experts that have the knowledge that the firms required in order to advice them.
- Establish contracts and ways of collaboration between university and firms.
- Look for public financial aid for the collaboration activities established.
- Diffuse the catalogue of knowledge and technologies available in order to transfer it to the firms.
- Manage the patents that belong to the university and control the exploitation from the interested firms.

Although it exists some degree of legal emptiness, three seems to be the most important laws that affect their activities, the Spanish Patent Law, the Universities Law (Ley Orgánica de Universidades, L.O.U.) and the Law of incompatibilities of the personnel of public administrations such as Universities.

The Spanish Patent Law establishes the property and the decision rights over inventions developed by employees. In general, the inventions made by the employee during the contract period, which are part of the implicit or explicit activity of research that is object of the contract, will belong to the employer. In addition, the employee author of the invention will not have the right to a supplementary remuneration unless the importance of the invention clearly exceeds the object of the contract (Article 15). In particular, the property and decision rights of the inventions made in Public institutions such as universities, the owner of the inventions made by university professors as a consequence of the standard functioning in the university is the university (Article 20). Moreover, all these inventions must be communicated by the professor to the university immediately through the Figure of the TTO (Article 20.3). In any case the professor has the right of participating in the profits that the university gets exploiting the rights of the inventions, this participation will be published in the statutes for each university (Article 20.6). For example, accordingly with the statute of the Autonomous University of Barcelona (2003), a 33% of the profits of transferring technology go to the professor, the TTO get 33% and the rest goes to university general expenses.

The transference of technology can be achieved by ways different to the licenses. One of the ways is through the creation of firms (Spin-off) which is explicitly recognized by the Spanish legislation (in the article 41.2.g of L.O.U.). Spin-off is understood as the creation of technological based companies linked to the university. The links with the University can be diverse; some examples are legal and financial advising, introduce academic entrepreneurs into the correct networks, offer work spaces to allocate the firm in its initial phases (normally in technological parks) and so on. It is important to notice that the universities do not have the obligation to help financially the creation of the Spin-off, even in some cases the university charges for the services to the new ventures.
In some cases the success of the Spin-off is linked with the participation in the project of the invention developer. Although in those activities, university employees (professors, researchers) can participate according to the statutes of the universities, the

"Law of incompatibilities of the personnel of the public administrations" difficult (article 12.1.b) their participation in the social capital and in the management of the Spin-offs, especially for those university employees that works at complete time. The unique option for the academic entrepreneur would be on leave faculty voluntarily. If the Spin-off wishes to participate with the public administrations, the employees of the university can have a maximum of the 10% of the social capital.

Furthermore, the collaboration among firms and universities is facilitated by the access to financial support and fiscal incentives. In particular some public institutions stimulate the creation and future growth of these firms through subventions and other financial aids. Finally, in concordance with the National Plan of R&D 2000-2003 there are fiscal incentives for R&D activities. In particular, the deduction of the complete quote is 30%, the deduction of the expenses in R&D that exceed the average of the expenses in R&D of the last 3 years is 50%, the deduction of the personnel of R&D is 10%, other concepts that can be deducted are the projects of R&D subcontracted at the universities or public institutions and the acquisition of advanced technology. In this sense, a Spin-off can avoid a maximum of 45% of the total taxes depending on the expenses in R&D.

3. – Theoretical framework of the process of technological transfer

In this Section are going to be discussed three of the most relevant questions referent to the decisions showed in Figure 1. In short, (1) Why TTO exists, (2) disclosure and commercialization decisions, and (3) the decision between licensing or Spin-off. For that purpose we develop a general benchmark, based on Jensen, Thursby and Thursby (2003); and Jensen and Thursby (2001), introducing some nomenclature in order to capture the main decisions and variables described in the introduction.

In a first stage the institutional context fixes how the University incomes, for simplicity we assume that are only royalties (R), are going to be distributed among the TTO (a α share) and the Scientist (a β share). The remaining ($1-\alpha-\beta \geq 0$) income is going to support general expenses of the University.

The scientist has to decide which kind of research is going to do, commercial innovations or basic research, obtaining in the last case a utility of V_I. If he decides for commercial innovations the scientist choose when the project can be commercialized, i.e. proof of concept stage or prototype, or in other words the level of effort (e) put into the project. For simplicity, let us to assume that the utility function of the Scientist is defined by U_I = w-C(e), where w is the income obtained by the Scientist, in our case w = βR and C(e) is the cost of effort, C(e) = c $e^2/2$ where e Є [0,1] and c is a constant (c = $\partial^2 C(e) / \partial e^2 > 0$) , so $U_I = \beta R - c^2 e^2/2$.

The TTO maximizes the differences between incomes (Y= α R) and the costs, basically those of searching a firm to license (V_T), which not depends on the success of the project. So the TTO objective function is: α R - V_T. The TTO is going to accept all of those projects that generate profits, $U_T = \alpha R - V_T > 0$.

Finally, the firm takes care of its profits. For each project the firm has a fixed cost of project commercialization (K) independent of the project success. The net income of one project is going to be Π if it is a success and 0 otherwise. The probability (P) of success increases with the quality of the idea of the scientist (Q Є [0,1]) and the stage of development of the project (e). Then, the probability is defined as follows:

$$P(Q,e) = e*Q \qquad (1)$$

So the expected profits of the firm are going to be, $U_F = \Pi P - E(R) - K$.

Take note that R are the royalties paid to the University, which are going to be a share *r* of the profits obtained, so the expected amount of royalties is $E(R) = Pr\Pi$, so $U_F = P [\Pi*(1-r)] - K$. We have not considered explicitly the possibility of fixed fees paid by the firm to the University. In fact, the consideration of these fees just implies a redefinition of the variables K, V_T ,V_I. The former, K, can be interpreted now, as the sum of fixed fees and commercialization costs of one project. V_T is the difference among the costs of looking for a firm to license and the part of fixed fees received by the TTO and V_I the difference among the opportunity cost of doing commercial innovations and the part of fixed fees received by the scientist. For large fixed fees, V_T and V_I could be negative. All the agents are risk neutral. Table 1 summarizes and relates the nomenclature defined with the actions and motivations identified in the introduction.

3.1. - Why TTO exists?

Although the TTO has some relevant occupations as specialized services or intellectual property management that can justify its presence, Macho, Veugelers and Perez (2005) argue that TTOs exist mainly because building a reputation allow parties to reduce asymmetry of information and therefore avoid adverse selection problems.

In order to consider the arguments of Macho, Veugelers and Perez (2005) in our benchmark, assume now that the effort of the inventor is given (for simplicity e = 1) but we have projects with different quality levels. In order to simplify, we define only two possible qualities, being λ the percentage of high quality (Q=1) projects and 1-λ the percentage of low quality (Q=0) projects that every year receives the TTO. Let's assume that there is asymmetry of information, and thus the quality of one project is just known by the faculty members and the TTO but not by the firms. Assume also that each scientist only can do one commercial innovation, the TTO and the firm are infinitely lived and all the inventions are licensed to the same firm[1]. The firm can license each period a new project knowing beforehand the results of the project of the year before. For sake of simplicity let us to assume also that α and β are equal 0 and consequently all the income received by the TTO and the inventor comes from the fixed fee (V_I and V_T < 0), so the TTO and Scientist incomes come from the number of projects licensed, independently of the quality of the project, $U_I - V_I = -c/2 - V_I > 0$ and $U_T = -V_T > 0$. The firms also pay a fixed fee included in K, R=0.

Table 1: Agents of Innovation transfer from universities

	Actions	Primary motives	Secondary motives	Organisational cultures
University Scientist	New Research projects or Commercialize the current project (e)	Recognition within scientific community (V_I) Financial gain: Max: $\beta R - c\,e^2/2$	Financial gain and a desire to secure additional funding	Scientific
TTO	Sell the technology to licensee, create a Spin-off, or even cancel it.	Protect and market the University's intellectual property $U_T = \alpha R - V_T > 0$	Facilitate technological diffusion and secure additional research funding	Bureaucratic
Firm/Entrepreneur	Commercializes new technology	Financial Gain $U_F = \Pi P - E(R) - K > 0$	Maintain Control of property technologies	Entrepreneurial

Readapted from Siegel, Waldman and Link (2003)

Previously to play this game infinitely periods, the University and the Firms negotiate the fixed fees and the University establishes the decision about the creation of the TTO,

[1] Take note that for simplicity we assume that there is only one firm. This assumption could be interpreted as we have many firms that have complete information about the behaviour of the TTO, therefore all the firms know if the TTO honors or betrays for each agreement.

or in other words two situations are analyzed, one just the scientist can sell the license and consequently does not exist a TTO, and another one where the University can license the inventions made by the researchers and consequently exists a TTO. Table 2 synthesizes the timing of the game.

Table 2: Timing of the game.

Periods	Events
(0)	Fixed fee (K) is defined.
(0.1)	The University decides whether to create a TTO or not.
(i.1)	Firm receives a project (by the TTO or randomly selected).
(i.2)	If the project is developed, the firm obtain profits π or not and consequently knows the quality of the projects (Q=1 or Q=0).
i= 1…∞	The game is repeated infinitely in the last two steps.

Situation 1: TTO does not exist. In that case, after the firm has developed the project and it is a failure, a low quality project, (P=Q=0), the firms can not impose any punishment to the scientist because they will never met again in the market. So for the firms a priori all the projects are equal and the expected profits are going to be: $E(U_F)= \lambda \Pi - K$. The firm will buy all the projects if the expected profits are positive, therefore if the percentage of good projects is high enough ($\lambda > K/\Pi$) all the projects will be commercialized. On the contrary, when $\lambda < K/\Pi$, no project will be negotiated. So the average income generated by the firm during each year in this situation is $\lambda \Pi$ or 0. So $\lambda \Pi$ is the maximum K, university fixed fees plus marketing expenses, which firms can support.

Situation 2: TTO exists. The TTO interacts continuously in the market with the firm. In that case, after the firm has developed the project and it is a failure, a low quality project, (P=Q=0), the firms can impose a punishment to the TTO not buying any project more (trigger strategies). Take note that this is a Subgame Perfect Nash Equilibrium. If one year the TTO sells a low quality project obtains a net income of $U_T > 0$, but the TTO is not going to sell any more projects in the future, so the TTO is going to loose infinite

future pay offs. Knowing that, the firm is going to accept all the projects due that they are going to be of good quality. So the income generated each year by the firm is Π, which is the maximum K that firms can support.
Consistently with the model of Macho, Veugelers and Perez (2005) the fact of joining the projects of a university in the same office of technology transfer allows the creation of a reputation that avoids the adverse selection problems. In our simple version of the model, this let to firms obtain greater incomes (Π versus λ Π) and consequently in a possible negotiation for the fixed fees between the Firm and the University, the University could capture part of these incomes through greater fixed fees.

Implication 1: Commercialization through TTOs generate greater incomes for the Firms and Universities.
Godfarb and Henrekson (2003) give partial evidence to this implication. They compare the case of Sweden where the right of selling the intellectual property belong to the inventor (Situation 1), with the case of US, where the right of commercialize the intellectual property belong to the university and exploit these resources through the figure of the TTO (Situation 2). They conclude that having Sweden a higher relative amount of researchers than US, the income generated by licenses is relatively larger in US, and therefore the ownership of the decision right for the University and the presence of the TTO bring to a more efficient technology transfer process.

If we relax the assumption of a TTO with an infinite life, future payoffs can be lower that U_T and the TTO have no incentives to maintain the reputation. As emphasized by Macho, Veugelers and Perez (2005), in that case the incentives increase with the life of the TTO, a variable that in our model is capturing the size of the TTO.

Implication 2: The TTO needs to achieve a critical size in order to be able to build a reputation.

3.2. – How to stimulate commercial innovation?
At the moment that a scientist realizes that he has done a potential innovation, the invention usually is a proof of concept and needs further development. In order to assure this development, institutional context, TTOs and firms must stimulate the scientist. This problem is contained in Jensen, Thursby and Thursby (2001 and 2003).

For summarizing Jensen, Thursby and Thursby (2001 and 2003) main results we assume that the quality of the project is given, for simplicity we assume Q=1, and consequently the effort is equal to the probability of having success with the project, P=e.

The socially optimal level of effort would be in this case $e_S = \text{argmax} \{U_I + U_T + U_F\} = \Pi/c$. We are going to assume that the effort is neither observable nor contractible; therefore the effort exerted depends on the scientist incentives. So the scientist, before to develop a commercial innovation, analyzes the effort he want to put on it. In our benchmark, the effort that maximizes his expected utility[2] is: $e^* = \arg\max \{ U_I \} = \beta R/c$ and consequently the expected utility in that case is $U_I(e^*) = (\beta R)^2/2c$. He is going to develop the project if all the next restrictions are fulfilled:

i) The expected utility is higher than the participation constraint ($U_I(e^*) = (\beta R)^2/2c = P\beta R/2 > V_I$).

ii) The TTO have interest to commercialize the innovation when the probability of success is higher than the ratio between the fixed cost of looking for a firm over the TTO income, $e^* > V_T/\alpha R < 1$.

iii) The firm have interest to acquire the license if the probability of success is higher than the ratio between the fixed cost over the net margin are positive, $e^* > K/(\Pi - R) < 1$.

The model above, have several implications assuming that the effort cost (c) is equally distributed among the scientists of different universities:

Implication 3: No development and thus no commercialisation will be done unless there are either royalties (R) or equity (β) in the compensation of the scientist.

Jensen, Thursby and Thursby (2001) provide survey evidence of the licensing practices of 62 U.S. universities. They found that only 12 percent of the projects were ready for commercial use at the time of license, and manufacturing feasibility was known only for 8 percent. Moreover, 75 percent were no more than proof of concept or lab scale prototype. So inventions tend to be in an embryonic stage at the moment the firm who

[2] Take note that the maximum effort that the agent can do is one, so if $e^* = \beta R/c > 1$, the restriction above applies and the solution to the scientist problem is to make an effort equal 1 and consequently the expected utility in that case is $U_I(e^*=1) = \beta R - c/2$.

license the technology wants to commercialize it, and even if the invention is already a prototype it needs further development in order to be commercialized.
According to Jensen and Thursby (2001) since the development of the product (once the firm has licensed the technology) is made by the inventor, it exists a moral hazard problem because the inventor usually prefers to work in new research projects than develop projects that are already licensed, mostly if they receive little incentives for development.

Implication 4: From the level of effort, $e^* = \beta R/c$, in those Universities where the share of royalties (β) that go to the scientist (or his department) are higher, increases the quality of the projects.
Jensen, Thursby and Thursby (2003) find that the universities with greater net income have less proportion of inventions in the initial phases, and therefore more prototypes. Moreover, from restrictions i to iii), these universities have a greater fraction of scientists dedicated to commercial innovations. Lach & Schankerman (2003) confirm the idea that higher royalties for the scientist increases the number of projects disclosed. They Analyse panel data on US universities and they find that universities with higher shares for the scientists have higher license incomes.

Implication 5: From the level of effort, $e^* = \beta R/c$, those scientist with greater effort costs (c) are going to disclose less developed projects.

Implication 6: From restriction i), when the share of royalties (β) that go to the scientist increase, some of the scientists with greater effort costs (c) that before would not have interest for commercial innovation, now, will be interested in those innovations.
Jensen, Thursby and Thursby (2003) for example argue that those scientists with best results on basic research have a greater preference for their time, and consequently a greater cost for developing commercial projects (c). In particular, they found that the quality of the faculty affects positively and significantly the amount of inventions disclosed in early stages and negatively the amount of prototypes. In other words, when the share of the scientist increases the projects are disclosed easier but in a more embryonic stage.

Implication 7: From restriction i), those scientists with a more promising career in the basic research arena, higher V_I, needs more incentives (βR) in order to develop commercial innovations.

Jensen, Thursby and Thursby (2003) find evidence that the TTO directors feel that the quality of the inventions that are disclosed is low, and therefore high quality faculties have more incentives to follow with their research in new projects than disclose the inventions.

Implication 8: From restriccion ii), more efficient TTO's (less costs of searching firms over royalties, $V_T/\alpha R$) help to increase the number of commercial innovations.

Take note that this restriction is applied only when firms are relatively more efficient ($K/(\Pi\text{-}R) < V_T/\alpha R$). The findings of Siegel, Waldman and Link (2003) support this result. The TTOs that bring the commercial innovation from the inventor to the market in a more competent way, obtain on average more income in licenses.

Implication 9: From restriction iii), more efficient firms (less marketing costs over profit margin, $K/(\Pi\text{-}R)$) help to increase the number of commercial innovations. Take note that this restriction is applied only when TTO are relatively more efficient ($K/(\Pi\text{-}R) > V_T/\alpha R$).

Notice that it is an issued unexplored since it is difficult to find evidence on the Marketing costs of the different projects.

3.3. - Licensing or Spin-off?

The transfer of technology from Universities to the commercial sector has historically been dominated by the practice of licensing (Siegel et al., 2003). But Locket et al (2003) indicate that more successful universities in UK have developed more explicit and proactive strategies towards the development of Spin-off companies. Therefore deciding whether to license or spinning off has become from few years ago a relevant question for both, academic research and advice to the government.

Chukumba and Jensen (2005) propose a model that is a reasonably straightforward compilation and extension of those in Jensen and Thursby (2001) and Jensen, Thursby and Thursby (2003). In order to adapt their model to our benchmark, we assume that Q is constant (Q=1) and let us to assume that some of the variables of the model have different values depending on the nature of the firm that commercializes the invention, an Spin-off (SO) or an existing firm.

Inventor implication: An inventor has a closer relationship with a Spin-off, and may provide greater implication, rejecting more easily basic research projects than if the invention is going to be commercialised by other firms ($V_I > V_I^{SO}$). In that case, accordingly with restriction i) in Section 3.2, the projects that are going to be commercialised as Spin-offs are those projects that $V_I > U_I(e^*) > V_I^{SO}$. What let to develop as Spin-offs, projects of low quality that otherwise will not be developed[3].

Implication 10: The decision (of the TTO) whether commercializes through a license or a Spin-off depends on the implication of the scientist. The fact that the scientist has less aversion to applied research when a Spin-off is created entails that low quality projects with small probability of success tend to be developed through Spin-off.

Cost of Searching: Chukumba and Jensen (2005) consider that TTOs tend to focus their limited time on finding established firms as licensees for their most promising inventions, while essentially ignoring the others, which then typically are commercialised only if the inventor makes the effort of finding investors for the Spin-off.

So in this case we can consider that the commercialisation cost of licensees are greater than the cost of commercialise through Spin-offs, ($V_T > V_T^{SO}$). Accordingly with restriction ii) in Section 3.2 are going to be commercialised as Spin-offs, those projects that $V_T/\alpha R > e^* > V_T^{SO}/\alpha R < 1$. What let to develop as Spin-offs projects of low quality that otherwise will not be developed.

Implication 11: The decision (of the TTO) whether commercializes through a license or a Spin-off depends on the cost of searching for an established firm. The fact that search for licensee is more costly entails that low quality projects will be commercialised through Spin-off.

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[3] In all of the argumentations of this Section we are assuming indifferent scientists and that TTOs prefer to license that create a Spin-off. This is similar to assume that creating a Spin-off has a very small cost.

Chukumba and Jensen (2005) found evidence that gross licensing royalties impacts positively and significantly to licenses to established firms but does not affect significantly the creation of Spin-off. In this sense, it looks that those universities that are able to generate many start-ups may not be the same universities that also have large royalty incomes, and therefore the majority of “royalty rich” TTOs obtain their revenue from established firms, and view Spin-off as a last resort.

Opportunity cost: expected profits depend on the firm’s cost of development effort and the cost of commercialisation. The opportunity cost of development and commercialisation can be greater for established firms ($K > K^{SO}$), which typically have alternatives that are more closely related to their current product line, and so more profitable. On the contrary, venture capitalists routinely deal with inventions that do not fit well in existing product lines, thus they may have cost advantage from better access to information about the technological expertise needed to develop and commercialise embryonic inventions. Moreover, the inventor’s superior knowledge of the technology can limit transactional and informational problems. Finally, when it exists the possibility of getting financial aid from public institutions (like CIDEM in Spain) for the creation of new firms the incentives of creating a Spin-off will be higher.

In that case we can find that restriction iii) in Section 3.2 is not fulfilled for existing firms but is fulfilled for Spin-offs, $K/(\Pi\text{-}R) > e^* > K^{SO}/(\Pi\text{-}R) < 1$. What let to develop projects of low quality that otherwise will not be developed.

Implication 12: The decision (of the TTO) whether commercializes through a license or a Spin-off depends on the cost of commercialisation and the cost of development. If these costs tend to be greater for licenses, low quality projects tend to be commercialised through Spin-offs

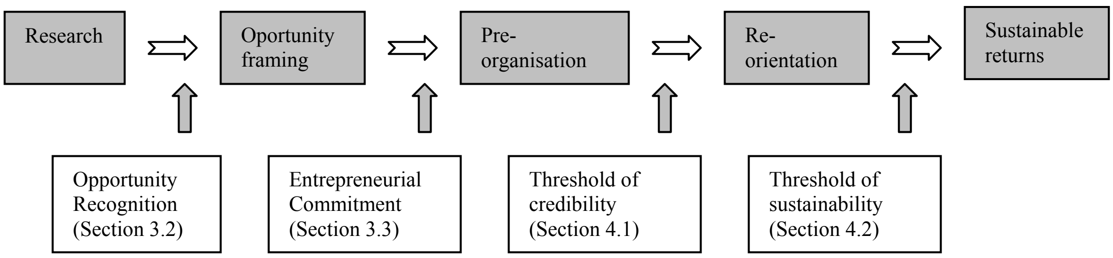
Chukumba and Jensen (2005) found evidence that opportunity cost is an important variable at the moment of choose for the optimal alternative, they focused on the opportunity cost of the venture capitalist, and found that the five year rolling average of returns to venture capital negatively and significantly impacts the creation of Spin-off. That means that when the rate to venture capital is high, venture capitalist have many opportunities that are more lucrative, and so they pursue these. Alternatively, stated, given the embryonic nature of university inventions, the evidence of Chukumba and Jensen (2005) suggests that venture capitalists turn to university start-ups as a last resort.

Arrow (1962), Shane and Stuart (2002) and Locket et al. (2003) offers another justification for the existence of Spin-offs in the case of projects that are protected with ineffective patents. In that case the profits of the firm are unobservable for the TTO and they can not contract on basis to these profits. So the royalties are going to be null R=0 and consequently from Implication 3 the inventors have no incentive to provide commercial innovation. For these authors the advantage of Spin-offs is that makes the profits observable for the TTO and the scientist and consequently incentives can be provided to the inventor.

4. Spin-off development.

According to Vohora et al. (2004), through the analysis of 9 case studies, a Spin-off may overcome 5 phases of development in order to be a successful venture (see Figure 2). In particular, (1) Research Phase, (2) Opportunity framing phase, (3) Pre-organization phase, (4) Re-orientation phase; and finally, (5) Sustainable returns phase.

Figure 2: The 5 phases of development and the 4 critical junctures (Vohora et al., 2004)



The authors define as critical junctures the processes and objectives that must be acquired in each phase in order to advance into the next one. In this sense, the authors define four critical junctures, (1) Opportunity recognition, (2) Entrepreneurial commitment, (3) Threshold of credibility, and (4) Threshold of Sustainability (see Figure 2).

Vohora et al. (2004) argue that (1) Opportunity recognition is the match between an unfulfilled market need and a solution that satisfies the need, to do so it is necessary an ability to synthesize scientific knowledge with an understanding of markets that is enhanced significantly by higher levels of social capital in the form of partnership, linkages and other network interactions.

The critical juncture of (2) Entrepreneurial Commitment arises due to the conflict between the need for a committed venture champion to develop the Spin-off and the inability to find an individual with the necessary entrepreneurial capabilities; these difficulties are caused by the academic culture of the inventor and his preference for basic research. Once these two critical junctures are achieved, finance is the key resource without which the entrepreneur was prevented from carrying out the transition to a fully operational business that is able to engage in productive activities. In addition, the finance issue entails a problem of information between the scientist and the external entrepreneur.

Therefore, the main problems that appear in the (3) Threshold of credibility are the financing necessity and the relation between the entrepreneur and the venture capitalist. Once the venture has received seed financing and embarks upon the process of commercially exploiting its technological assets, the entrepreneurial team must develop the ability to create value from the existing resources. Thus, the main issue for overcoming the (4) Threshold of sustainability is the necessity that the management team acquires the correct skills.

The first two phases, Research and Opportunity framing, are related with the researcher focus on commercial innovation and its decision of being an academic entrepreneur, which have been broadly analyzed in previous Section 3.2. In next Sections we are going to analyze more deeply the problems of finance, particularly to the informational problems with the venture capitalist (Section 4.1) and the problems linked to the skills of the management team of the Spin-off (Section 4.2).

4.1. – Threshold of Credibility: How are solved the problems of information?

Macho, Veugelers and Perez (2006) argue that part of the financing problem is due to moral hazard problems. Venture capitalists have difficulties to observe or evaluate the development level (or effort) of the invention. So the problem is similar to the analyzed in Section 3.2, instead of having an established firm we have a venture capitalist and the use of royalties is not common in Spin-off. More formally, the optimal effort derived in the cited Section is: $e^* = \beta R/c = \beta r\Pi/c$, where now βr play the same role that the capital shares of the entrepreneur in the Spin-off. From the result above, development will occur if and only if the inventor has a positive equity.

The socially optimal level of effort, $e_s = \Pi/c$ (see Section 3.2) can be obtained with the sufficient level of participation in the capital of the firm, $\beta r = 1$. Macho, Veugelers and Perez (2006) argue that given wealth limitations academic entrepreneurs could not obtain such participation and therefore in this case the moral hazard problem with the venture capitalist will not be solved completely.

Implication 13: In order to develop projects in Spin-offs, it is necessary that the inventor is a shareholder of the new venture, in addition the limited resources of the inventors could entail that the moral hazard with the venture capitalist is not solved completely, in particular when the moral hazard problem is acute.

Macho, Veugelers and Perez (2006) find evidence from a case study, in particular the K.U. Leuven Research & Development (A Belgium TTO). This TTO has generated 60 Spin-offs and one of the reasons for their success is their incentive system. For the case of Spin-off, individual researchers can receive up to 40% of the intellectual property shares, they can also invest financially in the Spin-off and will hence obtain a pro rata share in the common stock of the company.

Lockett, Wright and Franklin (2003) compare two groups of universities in U.K. In the first group they include the top ten universities in transferring technology and in the second group the rest of universities (47). Using surveys to all these TTOs they identify that more successful universities tend to create new ventures where the equity is divided more equally between parties; particularly, the TTO, the venture capitalist and the academic entrepreneur.

4.2. – Threshold of sustainability: Do the academic entrepreneurs have skill limitations?

Following Lazear (2004, 2005) entrepreneurs perform many tasks. The founder of a Spin-off needs to have many skills in order to be updated in scientific and technological advances, hire workers, chose firm location, obtain good materials from suppliers at a reasonable cost and so on. In this sense, Lazear (2004, 2005) argues that entrepreneurs must be generalist, and in the case they do not have all the necessary skills they must acquire them.

As Lazear (2004, 2005), let's assume that the effort is a function of the skills developed by the entrepreneur. To simplify we assume that the entrepreneur can develop two skills, technical (e_1) and management (e_2), and moreover his effort function is $e(e_1, e_2) = \text{Min}\{e_1, e_2\}$. The intuition of this effort function comes from the fact that in order to create a firm both, scientific and management skills are equally important.
As the entrepreneur comes from the university environment we assume that initially he is scarce in management skills, $e_1>e_2$. Consequently he may increase his skills in management (e_2) in order to acquire the optimal effort that maximizes his expected utility subject to his participation constraint ($e_2 = e^* = \beta R/c < e_1$).

Implication 14: The academic entrepreneur will invest in management skills in order to increase the probability of success of the firm created, or at least, he will joint the direction with a management expert. In other words, the director or direction team may have generalist skills.

Lazear (2005) find two kind of evidence. First, those who have more varied careers, as evidenced by having more roles as part of their work experience, are more likely to be entrepreneurs. Second, from Stanford MBA data, Lazear (2005) concludes that those students who study a more varied curriculum are more likely to be entrepreneurs and to start a larger number of businesses over their careers.

5. An Empirical Analysis of Spin-offs in Spanish Universities.

The number of Spin-offs created in Spain until 2004 is around 300 (see Table 3) according to a study of the association of Spanish TTO's[4]. The number of Spin-offs yearly created during the period 2001-2004 has been doubled and is quite similar to the number of licenses.

[4] RedOtri (2005) www.redotriuniversidades.net

Table 3: Number of Spin-off and licenses in Spain

	Number of Spin-off	Number of licenses
Before December 2000	18	__
2001	39	50
2002	65	53
2003	87	78
2004	90	143
Total	299	324

Source: Survey RedOtri Universidades 2005, and the data we received

In order to identify the Spin-offs generated in Spain, we contacted with the Offices of Technological Transfer (TTO) of the 58 different Spanish public universities. We received information from 37 universities, an answer rate of 67%, but seven of these Universities communicate us that they do not have yet Spin-offs but they are interested in their creation. The rest of the TTOs sent us a list with contact information of the Spin-offs. In this way we were able to list 201 Spanish Spin-offs. In the Appendix 1 are shown all the names of the Spin-offs classified by Universities.

Table 4: Spin-off by university

REGION/S	***UNIVERISITIES*** (NUMBER OF SPIN-OFFS FOUND)
ANDALUSIA, EXTREMADURA AND MURCIA	*U de Almeria* (1), *U de Cadiz* (2), *U de Cordoba* (1), *U de Extremadura* (2), *U de Granada* (10), *U de Murcia* (2), *U de Sevilla* (4)
ARAGON	*U de Zaragoza* (4)
BALEARICS	*U de les Illes Balears* (7)
CATALONIA*	*UAB* (18), *U de Barcelona* (23), *UdG* (10), *UPC* (?), *U Ramon LLull* (6), *U Rovira I Virgili* (1)
GALICIA AND CANTABRIA	*U de Cantabria* (5), *U de La Coruña* (7), *U de Vigo* (2), *U Santiago de Compostela* (11)
MADRID AND CASTILLA	*UAM* (3) , *U Carlos III* (18), *U Complutense de Madrid* (1), *U de Leon* (2), *UPM* (17), *U Pontificia Comillas de Madrid* (2)
BASK COUNTRY AND NAVARRA	*Universidad Publica de Navarra* (12), *U del País Vasco* (26)
VALENCIA*	*U Miguel Hernandez de Helche* (2), *U Jaume I* (1), *UPV* (?)
TOTAL	*30 Universities*

They lack Spin-off UPV and UPC by different problems with OTRI' s. In particular we have found 149 in UPC but we can not distinguished between Spin-off and start-ups.

Table 4 summarizes the number of Spin-offs by Universities. We identify that universities with a high degree of technological tradition such as polytechnics (UPM, UPC…) tend to create more Spin-off, or at least tend to have greater technological transfer. This is the case of UPC that gave us incomplete information about 149 firms where they do not differentiate the origin of the entrepreneur (Spin-off or start-up), but anyway the amount of firms created indicates the high degree of technological transfer that comes from UPC. From Table 4 we identify that Catalonia, even without taking into account a possible outlier as UPC, is the region with more Spin-offs (58) followed by Madrid (44) and Bask Country and Navarra (38).

In Table 5 we complement the information above with the sector of economic activity of the different Spin-offs. The sectors used are related to those used by Vohora et al (2004). They used the definition of BVCA (British Venture Capital Association; www.bvca.co.uk) and consider 9 sectors[5]. In order to simplify we generalize and took only 4 sectors (R&D, Chemical, Biotechnology and Computer Science), moreover those are consistent with the classification created for the Centro para el Desarrollo Tecnológico Industrial (CDTI) [6]. We can observe that the computer science field (hardware and software) is the most represented, consistently with Gompers (2005) who found that around 70% of the new technological firms in US between 1986 and 1999 belong to the sector of informatics, while the sector with the lowest amount of Spin-offs created is Biotechnology.

Table 5: Descriptive for Spin-off

	R & D	CHEMICAL	BIOTECHNO LOGY	COMPUTERS SCIENCE	TOTAL
ANDALUCIA, EXTREMADURA AND MURCIA	3	4	3	12	22
ARAGON	1	1	0	2	4
BALEARICS	2	1	1	3	7
CATALONIA	8	12	6	32	58
GALICIA AND CANTABRIA	6	5	3	11	25
MADRID AND CASTILLA	11	7	2	24	44
BASK COUNTRY AND NAVARRA	11	6	1	20	38
VALENCIA	1	0	1	1	3
TOTAL	43	36	16	105	201

As a simplification computer science is considered any company that dedicates to Software (Design, applications, Programming, etc.) or Hardware. In R&D we introduce all the firms that make research projects in a variety of sectors. Finally, chemical includes all the firms related to chemicals and pharmaceutics

[5] Communications, Computer Hardware, Computer Internet., Computer Semiconductors, Computer Software, Other Electronic related, Biotechnology, Medical, Instrumentation and Medical Pharmaceutical.
[6] It is an Enterprise, dependent Public Organization of the Spanish Ministry of Industry, Tourism and Commerce, that promotes the innovation and the technological development of the Spanish companies. It grants to the company own financial aids and facilitates the access to other sources of finance. For more information see www.cdti.es

5.1. – Sample construction and research purpose.

In order to have financial information about Spin-offs, we checked on SABI (a database with financial information of Spanish firms[7]) and we found information about 50 of the 201 companies identified by the Universities, which are listed in Appendix 2. SABI provides financial information over the period 1993-2004[8]. The oldest Spin-off was created in 1995 and the average number of years is practically three, so we have 149 observations related with the 50 companies identified.

In order to test for possible differences in the process of Spin-offs creation and development with other technological firms, we decided to use a catalogue of companies that the CDTI (Centro para el Desarrollo Tecnológico Industrial) offer. In this catalogue appear companies that have asked for aids or cooperation to the CDTI. The criteria selection was that firm appears in SABI, that has been founded in 1995 or after this year and we have tried to guarantee a similar representation to the sample of Spin-offs of the economic sectors, firm sizes and geographic areas. The average life of non university firms is around four years, so we have 205 observations related with these 50 firms.

Therefore, we use an unbalanced panel with 100 firms and 354 observations during the period 1995-2004, 149 observations corresponds to firms with university origin and 205 with non university origin. Table 6 presents a summary of these firms.

Furthermore to the fact if the firm is a University *Spin-off* (dummy variable with value 1) or not (value 0), the firms' geographic situation, *Region* (from now we distinguish only between Andalusia, Bask Country, Catalonia, Madrid and Other Regions given the reduced number of observations in each one of the other regions), and the economic activity *sector* (from now we distinguish only between Computer Science, R&D and Others given the reduced number of observations in each one of the other economic sectors), we have collected information about the *start-up expenses, export* position (a dummy variable that takes value 1 if the firm exports and 0 otherwise) and the *subventions* received.

[7] More information can be found in Bureau Van Dijk web page. http://Sabi.bvdep.com

[8] From a survey we have sent to Spin-offs, 29% of the firms were created after 2004. It implies that SABI are restricting us in order to include these representative set of firms in our sample.

For each year, we have collected information related with the balance sheet, the income statement and the *number of employees*. About the balance sheet we have information about the *Total Assets* and liabilities and the structure of the Assets, *Intangible Assets/ Total Assets* (I.A) and the structure of the liabilities, *Shareholder funds / Total liabilities* (S.F.), and the ratio *long term debt / current liabilities* (Debt). From the income statement, apart from the *Profits* and *Sales*, we have collected information about taxes, personnel and financial expenses. This last information let us to compute the *imposition tax* of the firm that year, taxes / income before taxes, the average *worker cost*, personnel expenses/ number of employees, and the *interest rate*, financial expenses/long term debt. In order to avoid inflation effects, as the firms were created in different years, we deflated all the monetary variables respect to 1995.

Table 6: Comparison of the samples

	SPIN-OFF	NON UNIVERSITY ORIGIN	TOTAL
R&D	16	10	26
CHEMICAL	9	5	14
BIOTECHNOLOGY	2	6	8
COMPUTER SCIENCE	23	29	52
ANDALUSIA	6	14	20
ARAGON	0	0	0
BALEARICS	1	0	1
CATALONIA	17	7	24
GALICIA	7	3	9
MADRID	10	16	26
BASK COUNTRY	9	9	18
VALENCIA	0	2	2
YEARS OF LIVE	3,04	4,1	3,54
FIRMS	50	50	100

Posar noms complets

The main goal of the empirical Section is to analyze how the Spin-offs deals with the last three phases of Development identified by Vohora et al. (2004), Pre-organization phase, Re-orientation phase, and Sustainable returns phase. For that purpose, first are analyzed the financial conditions when the entrepreneurial commitment juncture has been acquired and consequently, the firm created. Second, we analyze the Growth process and its interrelations with the financial structure of the firms. And finally, we look for the years needed by those firms for obtain sustainable returns.

5.2. – Conditionings at the start-up: Pre-organization Phase.

According to Vohora et al. (2004) the critical juncture of Entrepreneurial Commitment finishes with the creation of the firm. At this point is when we have the first financial information. Table 7 presents the average values for the Balance Sheet and the Income Statement for the initial year of the total firms collected, 50 University Spin-offs and 50 technological firms with non university origin. Moreover, we show whether the averages are significantly different through an ANOVA analysis.

Table 7: Average of the Balance sheet and the Income Statement at the start-up year

	Spin-off	Non Spin-off	Total
Number employees	3,5	6,0	4,8
Balance Sheet			
Total Assets	**123 200**	**416 800**	**270 000*** **
Intangible Assets/Total Assets	0,0891	0,143	0,116
Shareholder's funds/Total liabilities[9]	0,500	0,482	0,490
Long term debt /Current liabilities	0,828	0,679	0,760
Income Statement			
Net sales	**100 500**	**217 500**	**159 000***
Purchases/ Net Sales	0,245	0,297	0,273
Personal expenses/ Net Sales	0,502	0,429	0,470
Other operating expenses/ Net Sales	0,296	0,435	0,371
Financial expenses/ Net Sales	0,012	0,015	0,014
Income (loss) before tax	**-5 500**	**-38 000**	**-20 400****
Interest	0,047	0,032	0,039
Tax	0,2803	0,263	0,274
Conditionings at start-up			
Start-up expenses	4 900	16 300	10600*
Subventions	9 800	22 800	16 300

All the monetary values are expressed in euros of 1995 and refers to the firms' initial year.
The differences of averages are statistically significant when *P< 0,1; ** P < 0,05; ***P < 0,01 In all the cases are used all the firms of the sample excepting for the Shareholder's funds, we omitted 4 firms that have a negative value, and the interest rate, we omitted two firms that have a cost of capital higher than 1.

New Spanish Technological firms tend to be small (less than 5 employees on average), but Spin-offs are relatively smaller than other technological firms (3,5 employees, 100.500€ of *Net Sales* or 123.200 € of total assets versus 6 employees, 217.500 € of *Net Sales* or 416.800€ of total assets) and for the creation of one employment requires much less investment, 35.200€ (123.000/3,5) versus the 69.467 euros needed by the other firms. These differences on investment requirements per employee, explain that although the employee productivity of both kind of firms is quite similar, around 30.000

[9] In order to avoid outliers, at the time of use Shareholder's funds, we omitted 4 firms that have negative Shareholder's funds. Similarly, at the time of using interest rate we omitted two firms that have a cost of capital higher than 1.

€ of net sales per employee, Spin-offs obtain much more sales per euro invested, 0,82€ versus 0,52€.

Referring to the structure of the Assets at the moment of being created, Spin-offs have less proportion of *Intangible Assets* than firms with non university origin. This fact can be interpreted as Spin-offs are created with fewer expenses in Research and Development than the other Technological firms, perhaps because Universities assume part of these expenses. Although the capital required to the owners for the foundation of such firms differs in absolute terms, on average 60.000 euros for a university Spin-off respect to 200.000 euros for a firm with non university origin, the proportion of Shareholder's funds over total liabilities is very similar, in both the capital of the owners represents around 50% of the total liabilities. Besides, referring to external funds, although Spin-offs have relatively less current liabilities and great cost of capital, the differences are not significant. Finally, at the first year, university Spin-offs have less losses, but not just because they are smaller, they relatively work with a lower amount of other operating expenses such as external services, rentals, repairs and maintenance, transports or insurances.

One of the key elements that facilitates or difficult the creation of firms are the amount of financial helps received and the *start-up expenses* needed for its establishment.
Under the name of start-up expenses, the Balance Sheet reflects the expenses that serve to cover legal issues in the start-up of the venture and raising shareholder's funds. These expenses are every year amortized and can increase when the firms rise shareholder's funds. So when we construct the variable *start-up expenses* we consider the maximum value that the account have during the live of the firm, excepting for those firms that has expanded the Shareholder's funds during their live. In that case we consider *start-up expenses* as the ones incurred in the first year. The average value of such expenses is 10.600 euros, although the differences in average values among Spin-offs, 4.900 euros on average, and the other firms, 16.300 euros seems important, this difference is just significantly different to zero at the 10% level.
Under the name of Accrued Income are included official subventions of capital, other subventions of capital, income by deferred interests, and positive differences of foreign currency. So this account, at the initial stages of the firm seems to be a good proxy of the subventions received. In the variable *Subventions*, we include the maximum value

that the account Accrued Income has since the creation of the venture. The average value of such subventions is 16.300 euros, being 9.800 euros on average for the case of Spin-offs and 22.800 euros for the other firms, but these differences does not appear significantly different to zero.

Our purpose now is to determine which variables have an impact to subventions received and start-up expenses. For that goal we propose as explanatory variables the size of the firm (*Total Assets* of the first year), in order to test whether these variables are proportional to the size of the firm, the structure of the balance (*Shareholder's funds / Total liabilities; S.F.*), in order to test whether the amounts of *Start-up expenses* and *Subventions* are related to financial difficulties, and finally, control for differences due to the origin of the firm, its *Export* position, the *Region* where it has been created and the *Sector* where it operates. Results of Ordinary Least Squares (OLS) estimations are shown in Table 8.

Table 8: OLS Subventions and Start-up expenses

	Start-up expenses	Subventions
Total Assets/100	5,85***(0,0154)	6,4***(0,089)
(Total Assets/100)^2	-1,36 10^{-6}** ($5*10^{-7}$)	
S.F.	2155 (2 605)	-2 718 (3 324)
Spin-off	-1 177 (7 386)	15 592* (9 306)
Export	784 (10 875)	28 853**(13 711)
Sector R&D	-7 092 (9 432)	-28 098** (12014)
Sector Computers	870 (8 364)	-28 024***(10 671)
Catalonia	3 132 (10 245)	-30 461** (13 070)
Bask Country	-7 357 (10 840)	-37 400*** (13 824)
Madrid	6 760 (9 923)	-26 625** (12 548)
Other Regions	3 250 (12 015)	-37229** (15 330)
Constant	-1 150 (9 915)	36 309*** (12 190)
R-squared	0,2338	0,4648
nº observations	100	100

P< 0,1; ** P < 0,05; ***P < 0,01; Standard error in parenthesis

From the first column of Table 8 we observe that while the size of the firm has a significant impact on *Start-up Expenses*, the structure of the liabilities does not matter. In particular, Total Assets have a quadratic effect[10] on *Start-up expenses*. While the *Start-up Expenses* estimated for a firm with standard total assets are a proportion of 5,82% ($5{,}85-1{,}36*10^{-6}*270.000$) of such *Total Assets*, for the biggest firm in the sample

[10] The introduction of the square of Total Assets increases the R-Squared in 0,06 so the square effect is different to zero at the 1% of significance.

(with 3.556.000 € of *Total Assets*) the estimated *Start-up Expenses* proportion is reduced to 5,36%. So the estimated percentage of *Start-up Expenses* over *Total Assets* is reduced with the size of the firm. Moreover, neither the origin nor the *Export* position nor the *Region*[11] nor the *Sector* affects the amount of *Start-up Expenses* after controlling by the size.

In Column 2 of Table 8 appears the estimation related with the size of *Subventions*. Now, the *Total Assets* has a lineal[12] effect on the *Subventions* received. It means that the estimated *Subventions* are a constant proportion of the *Total Assets*, concretely a 6,4%. Furthermore, while the structure of the liabilities does not affect *Subventions*, we found several specificities. In particular, Spin-offs receive an estimated subvention of 15.500 euros more than technological firms with non university origin. Similarly, the fact of having an export position tends to increment *Subventions,* an estimated value of 28.000 euros. Chemical and Biotechnology tend to receive estimated subventions around 28.000 euros greater than *Sectors* such as Informatics or Research and Development. Finally, Technological firms from Andalusia tend to receive more *Subventions*, an estimated import between 26.000 and 37.000 euros more than the firms from other regions. The other differences among regions are not statistically significant.

In summary, Spin-offs tend to:

- Be smaller than other technological firms but creating employment of similar quality with relatively less investment, and particularly much less R&D investment. This fact could be explained by the fact that Universities assume part of these investments, especially those made in R&D.
- Similarly to the other technological firms, require a percentage of *Shareholders Funds over Total Liabilities* around 50%. In addition, they have relatively less current liabilities with a higher *interest rate*.
- Have relatively less other operating expenses. The fact of being established at Universities could help to save these costs in the first stages.
- Receive more *subventions*. Behind this result we identify that the presence of the TTOs make Spin-off more efficient at the moment of looking for subventions.

[11] The difference between Madrid and Bask Country, where Madrid need 13 000 euros more in concept of start-up expenses, is only significant at 16%.

[12] When the squared of Total Assets is included in the regression it appears not statistically significant.

While the only determinant of *Start-up Expenses* detected is the size of the firm measured by the *Total Assets*, the *Subventions* also depend on the economic *Sector* where the firm operates and the *Region* where it has been established. Authorities have preferred subventions to Chemical and Biotechnology over firms in other sectors and the government of Andalusia offers greater individual helps to technological firms' creation than the other Spanish regions.

5.3. The Development and Growth: Re-orientation Phase.

Once Technological firms have overcome start-up difficulties, their main goal is to evolve correctly in order to achieve a competitive position in their ordinary activity, and thus grow. According to Vohora et al. (2004) this stage is named Threshold of Credibility and financial issues use to be the most important problems. In order to analyze development and growth we use the unbalanced panel with 354 observations. In order to compare the figures for the first year available, Table 7, we reproduce in Table 9 the same figures for the financial statements of the last year available for each firm. Again we show whether the averages are significantly different through an ANOVA analysis.

Although the value of *Total Assets*, *Net Sales* and *number of employees* that appear in Table 9 are higher that the ones that appear in Table 7, the differences among origin are still important and therefore Spin-offs are significantly smaller than firms with non university origin. This fact let us expect that firms evolve and growth in a similar rate among origin.

From the differences between tables 7 and 9, we detect three facts which seem to indicate that Spin-offs reduce networks with universities among time consistently with Pérez and Martinez (2003). First, whereas the investment required for employee has been doubled (61.500€), the employee productivity keeps constant (31.000€), hence the sales obtained by euro invested diminish from 0,82€ to 0,50€ versus 0,54€ of the firms with non university origin, and subsequently there is a productivity convergence among origin, and hence the incidence of the university seem to disappear. Second, Spin-offs increment the proportion of *Intangible Assets* up to 17,1%, being quite similar to the proportion of the other technological firms (19,8%), thus Spin-offs seem to have the necessity to increment Research and Development expenditure out of the university.

Finally, Spin-offs have a relatively higher amount of expenses, particularly, other operating expenses. This fact probably entails that the aids received from the university such as external services, rentals, or insurances are reduced among time.

Table 9: Average of the Balance sheet and the Income Statement at the last year

	Spin-off	Non Spin-off	Total
Number employees	8	12,8	10,6
Balance Sheet			
Total Assets	**492 000**	**1 465 000**	**978500*** **
Intangible Assets/Total Assets	0,171	0,198	0,185
Shareholder's funds/Total liabilities	0,370	0,340	0,355
Long term debt /Current liabilities	1,830	0,744	1,27*
Income Statement			
Net sales	**247 900**	**798 800**	**529 400*** **
Purchases/ Net Sales	0,288	0,248	0,268
Personal expenses/ Net Sales	0,531	0,422	0,473
Other operating expenses/ Net Sales	0,344	0,444	0,397
Financial expenses/ Net Sales	0,021	0,021	0,021
Income (loss) before tax	**-45 500**	**-108 600**	**-77 700**
Interest	0,043	0,076	0,062
Tax	0,224	0,247	0,235

All the monetary values are expressed in euros of 1995 and refers to the firms' initial year.
P< 0,1; ** P < 0,05; ***P < 0,01

From the differences between tables 7 and 9, we detect three facts which seem to indicate that Spin-offs reduce networks with universities among time consistently with Pérez and Martinez (2003). First, whereas the investment required for employee has been doubled (61.500€), the employee productivity keeps constant (31.000€), hence the sales obtained by euro invested diminish from 0,82€ to 0,50€ versus 0,54€ of the firms with non university origin, and subsequently there is a productivity convergence among origin, and hence the incidence of the university seem to disappear. Second, Spin-offs increment the proportion of *Intangible Assets* up to 17,1%, being quite similar to the proportion of the other technological firms (19,8%), thus Spin-offs seem to have the necessity to increment Research and Development expenditure out of the university. Finally, Spin-offs have a relatively higher amount of expenses, particularly, other operating expenses. This fact probably entails that the aids received from the university such as external services, rentals, or insurances are reduced among time.

Referring to the liabilities, the proportion of *Shareholder's funds over Total Liabilities* has importantly reduced, from 50% to 37% for Spin-offs and from 48% to 34% for other technological firms. This fact indicates that technological firms have the necessity to look for external funds in order to grow. In particular, while Spin-offs tend to look for long term debt, other technological firms base their external financing on current liabilities. This difference in debt strategy among origin seem to explain the difference on the cost of capital, whereas Spin-offs maintain the Interest around 4%, other technological firms has increased the *interest rate up* to 7,6%.

The comparisons above have the problem that not all the firms have the same years of live, so the conclusions could be altered due to the fact that Spin-offs have on average a shorter live (3 years) than the peer sample (4 years). For controlling for these problems we calculate the annual rates of growth using Ordinary Least Squares (OLS) regressions with fixed effects for each firm, where we use as dependent variables the ones that make reference to the size, the structure of the Balance and the *Worker Cost*[13]. As independent variables we use the number of the year since the creation of the firm (*nyear)*, and in order to control for firm's origin we also introduce the number of year multiplied by whether the firm is a Spin-off or not (*nspinoff*). In order to simplify the interpretation of the results we use logarithms for those dependent variables where we maintain the size of the sample; in particular, the ones that make reference to the size and the *Worker Cost*. The use of logarithms allows interpreting the coefficients as the annual growth rate. In Table 10 we show the results.

The results in Table 10 confirms that the size of the firms growth during the first years of life. More concretely, the estimated annual growth rate of the *Total Assets* is 41,7%, the one of the number of employees is 28,5%, while the *Net Sales* growth differ among groups, while firms with non university origin growth at 30,2%, the annual growth rate of the Spin-offs is 46,8%.

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[13] Take note that we do not include expenses as their variation seems to be small and consequently their analysis seem to have small relevance. Furthermore, profits are analysed in next Section.

Table 10: OLS with Firms' Fixed effects

	Ln T.Assets	Ln N. Sales	Ln Empl.	Ln W. Cost	I.A.	S.F.	Debt
Nyear	0,417***	0,302***	0,285***	0,122***	0,016***	-0,02**	0,052
nspinoff	0,064	0,166*	-0,003	-0,0047	0,029**	-0,045***	0,779*
Constant	11,31***	10,81***	0,93***	9,40***	0,089***	0,48***	0,394
Within	0,4183	0,2647	0,433	0,1138	0,102	0,12	0,023
Between	0,1415	0,0238	0,083	0,0409	0,000	0,000	0,29
Overall	0,2209	0,811	0,1986	0,596	0,009	0,0086	0,16
Observations	354	315	261	259	336	318	315
Firms	100	93	90	89	97	96	99

P< 0,1; ** P < 0,05; ***P < 0,01

Table 10 also shows an increase of expenses per worker at an estimated ratio of 12,2% each year. It seems that firms are contracting employees with higher human capital than the ones that were originally in the firm. Consistently with that fact, the importance of *Intangible Assets over the Total Assets* increases significantly each year, a 0,045 points estimated increase for Spin-offs and 0,016 for the other firms. So in two years Spin-offs are at the same level that other firms in Research and Development.

Finally, the need for *Shareholder's Funds over Total Liabilities* is reduced for both groups but at different rates, while the ratio decreases 6,5% yearly in Spin-offs, it decreases only 2% in the other technological firms. Spin-offs seem to substitute such *Shareholder's Funds* with greater Long term debt, although the variable *debt* is only significant at the 10% level.

After this descriptive analysis, we want to explain the main determinants of *Net Sales* growth which seems to be the main objective at the first stages of these firms (Hindle and Yencken, 2004). Accordingly with the Column 2 of Table 10 the estimated annual growths are of 46,8% for Spin-offs and 30,2% for other firms. In particular, we are interested in splitting the growth of *Net Sales* that come from and increase in the firm's investment, *Total Assets*, than those that comes from an increase of the productivity of a euro invested. For that purpose, the logarithm of *Net Sales* is estimated by an Ordinary Least Squares (OLS) regression with fixed effects for each firm, where the dependent variables are Ln *Total Assets* and the variables *nyear* and *nspinoff*[14]. In Table 11 we present the results.

Table 11: Explanations of the Net Sales Growth

	Ln Net Sales
Ln Total Assets	0,653***
Nyear	0,0904*
Nspinoff	0,1344*
Constant	3,19***
Within	0,4341
Between	0,2735
Overall	0,3079
Observations	315
Firms	93

P< 0,1; ** P < 0,05; ***P < 0,01

From Table 11 the annual growth rate of *Net Sales* not explained by the *Total Assets* growth is 22,48% (0,0904+0,1344) for Spin-Offs and 9,04% for the rest of the firms. So the *Net Sales* growth for Spin-Offs, 46,8% estimated in Column 2 of Table 10, is explained basically equally by differences on productivity, 22,48%, than by the *Total Assets* growth. But for no Spin-offs firms, the 30% of the growth of *Net Sales*, see Table 10, mostly comes from the growth of *Total Assets*, 21%, and only a 9% comes from the increment of efficiency.

As the increase of *Total Assets* is an important way of Sales Growth, we ask for the determinants of such increases. In particular, we are interested to ask how the increase of *Total Assets* is produced and financed. For that purpose we include in the equation estimated in the Column 1 of Table 10 the structure of the Assets and the Liabilities as independent variables, reducing to 302 the number of available observations. For comparability of the results we estimate again the equation in Column 1 of Table 10, but now with only 302 observations. All the results are shown in Table 12.

The results shown in the first Column of Table 12 confirms that the growth rate of the *Total Assets* has been financed by *external funds* and the proportion of *Intangible Assets* has not changed significantly.

[14] A multiplicative variable between Total Assets and Spin-offs also has been included but is not significantly different from zero.

Table 12: Ln Total Assets

	Ln Total Assets	Ln Total Assets
I.A.	0,499	
S.F.	-1,980***	
Nyear	0,295***	0,338***
Nspinoff	0,137*	0,243***
Constant	12,41***	11,50***
Within	0,5466	0,4206
Between	0,0805	0,0341
Overall	0,1841	0,1342
Observations	302	302
Firms	93	93

P< 0,1; ** P < 0,05; ***P < 0,01

So the financing of the new assets implies changes in the structure of the firms' liabilities, in particular an increase of the proportion of external funds[15].

In summary, Spin-offs tend to:

- Maintain a smaller size than the other technological firms. Both groups grow *Total Assets* at an annual rate of 42% and *number of employees* at 28,5%. Referring to the Income Statement it appears a convergence in *Net Sales* because Spin-offs grow at 46% annually while firms with non university origin only grow at 30%. Besides, expenses per worker increase at 12,2%, this fact seem to indicate that the new employees provide higher human capital that the ones contracted at the beginning.
- It is observed a reduction of the productivity, a higher investment in Research and Development and a greater amount of other operating expenses. These results could be consistent with a decrease in the networks with the university detected by Pérez and Martinez (2003).
- Increment long term debt in order to cover the necessities of investment. This strategic decision does not change the *interest rate*, therefore the interest rate keep constant around 4%.

Technological firms increase their sales both, by increases in their productivity and in their investments, while the other technological firms mostly use this last way of growth. The increment of *Total Assets* is mostly financed by external financing.

[15] We estimate the growth rate of cost of capital (*interest rate*) in order to test for specificities at the time of looking for external funds. Controlling for outliers (*interest rate*>1) we found that neither, the structure of debt nor the proportion of Shareholder's Funds nor the growth rate, affect significantly *interest rate* growth.

5.4 -The consolidation: Sustainable returns Phase.

According to Vohora et al. (2004) a Technological firm is consolidated in the market when achieve sustainable returns. Moreover, we understand that a firm gets sustainable returns when the firm does not have negative profits anymore, in this sense notice that we are not considering whether profits obtained are sufficient to cover the opportunity costs of *Shareholders Funds*. Table 13 summarizes the firms with sustainable profits and the years needed to obtain it. Only 61% of the firms have achieved sustainable returns before 2004, being practically the same number of Spin-offs than other firms. On average, the Spin-offs need 1,9 years to achieve sustainable returns, a period very close to 2,12 the years needed by firms with non university origin.

Table 13: firms with sustainable returns.

	Spin-off	No Spin-off	Total sample
Firms without sustainable profits	20	19	39
Firms with sustainable profits	30	31	61
Years to achieve sustainable profits	1,9	2,12	2,01

Our purpose is to determine which variables influence the fact of having positive profits. For that purpose we estimate a Logit model where the dependent variable, *profits,* take value 1 if the firm's profits are positive; and 0 otherwise. Take note that this variable does not have variance for the firms that make profits or losses all the years. Therefore, in order to maintain a representative sample we do not introduce firms fixed effects. Moreover, as independent variables we use *Net Sales* in order to test whether sells increment the probability of make profits, the cost of the employees in order to test the importance of the human capital, the structure of the balance in order to test if the fact of making profits is related to financial difficulties, and finally, in order to check for specificities the firm's origin and the *Export* position. In Table 14 we present the results.

From Table 14 an increment of *Net Sales* entails that the probability of making positive profits increase. Take note that this result is consistent with the idea introduced in Section 5.3 that satisfy market necessities and therefore increment *Net Sales* is one of the main objectives of Technological firms (Hindle and Yencken, 2004). Instead a relative investment in *Intangible Assets* reduces the probability of making profits. Notice that this result is reliable as investments in Research and Development tend to need some years in order to affect *profits* positively. It means that the investment made in Research and Development can practically be considered as expenses in the current year.

Table 14: Logit for Sustainable returns

	Profits
Ln Net Sales	0,649***
Ln Work Cost	0,389
I.A.	-1,996***
S.F.	-1,021
Debt	0,017
Spin-off	0,089
Export	0,512
Constant	-10,84***
Observations	198
Pseudo R-squared	0,207

P< 0,1; ** P < 0,05; ***P < 0,01

From Table 14 an increment of *Net Sales* entails that the probability of making positive profits increase. Take note that this result is consistent with the idea introduced in Section 5.3 that satisfy market necessities and therefore increment *Net Sales* is one of the main objectives of Technological firms (Hindle and Yencken, 2004). Instead a relative investment in *Intangible Assets* reduces the probability of making profits. Notice that this result is reliable as investments in Research and Development tend to need some years in order to affect *profits* positively. It means that the investment made in Research and Development can practically be considered as expenses in the current year.

In summary the fact that technological firms achieve sustainable returns depends:

- Positively on *Net Sales*, giving consistency to the idea that the increment of *Net Sales* is one of the most important objectives of technological firms (Hindle and Yencken, 2004).
- Negatively on the investment in *Intangible Assets*, reinforcing the assumption that the results of Research and Development need some years to affect positively profits.

6. – Summary and conclusions.

There has been a huge increment in the literature about TTO's in the last decade, especially on US and related to the success to this contractual formula. According to RedOTRI (2005), this contractual procedure has been successful also in Spain, especially from 2001 to 2004 where around 600 inventions have been commercialised through universities, half of these commercial innovation in the form of Spin-off. Therefore, it is interesting to go deeply into the theoretical and the empirical analyses about their function. In this sense, the paper makes two contributions. First, a theoretical review of the literature based on technology transfer and development of Spin-offs, joining all the models under the same benchmark and secondly an empirical analysis about the conditionings of the creation, development and consolidation of Spanish Spin-offs.

Three seems to be the main questions addressed in the literature, and revised in the paper, about the role of TTO's (1) why TTO's exist, (2) how they can stimulate commercial innovation through universities and (3) under which circumstances TTO might either license or create a Spin-off, with important implications for Universities' policy. Next lines highlight such implications.

Although the TTO has some relevant occupations as specialized services or intellectual property management that can justify its presence, Macho, Veugelers and Perez (2005) argue that TTOs exist mainly because building a reputation allow parties to reduce asymmetry of information and therefore avoid adverse selection problems. These profits increases as more repeated is the interaction with the same agents, or at least with other agents that can observe the results of previous agreements. So it is not clear that the existence of the TTO is optimal for all the Universities. For the case of small ones, with a low number of inventions in dispersed areas of knowledge, the advantages of a TTO is reduced. The information problems also emphasises the need that TTOs establish control mechanisms for the selection of projects in order establish and guarantee their reputation. But the success of the TTO not just depend on the actions of their personnel, they need the collaboration of other agents, mainly the researchers.

Jensen, Thursby and Thursby (2001,2003) emphasised the need that researchers dedicate time to commercial innovation. Considering that it is very difficult to control the kind of inventions that a researcher is doing, no development and thus no commercialisation will be done unless the scientist benefits from doing commercial innovation. The usual way that Universities have to compensate such dedication are either the participation of the scientist in the royalties-equity or fees received by the University. Those universities where the share of royalties that go to the scientist are higher, increases the number of researchers doing this kind of research and the time devoted to their inventions. Take note that those scientist with a more promising career in the basic research arena need more incentives in order to develop commercial innovations, so will be the last to switch basic research to commercial innovations. In this sense, Jensen, Thursby and Thursby (2003) find evidence that the TTO directors feel that the quality of the inventions that are disclosed is low, and therefore high quality faculties have more incentives to follow with their research in new academic projects than disclose the inventions.

But the promises of greater compensations are not sufficient if the TTO does not make sufficient efforts of commercialisation or the firm for developing the invention to commercial products. So the capacity of the TTO to find possible firms and its criteria in the selection of those firms, not just affect the result of one invention, also is going to affect the incentives of future scientist for doing commercial inventions.

Finally about the decision of the TTO whether commercializes through a license or a spin-off, Chukumba and Jensen (2005) argue that scientists has less aversion to applied research when a Spin-off is created, and the fact that search for licensee is more costly, entail that low quality projects with small probability of success tend to be developed through Spin-offs.

But the success of an Spin-off depends on the implication and capacities of the managers and initial inventors, what usually implies (Macho, Veugelers and Perez, 2006) the participation of the inventors as shareholders of the Spin-Off and in the management of the firm, which accordingly with Lazear (2004,2005) requires an additional investment in management skills, or at least, share the direction with a management expert.

The empirical section of this work deals with the problems that Spin-offs have in their development. Following Vohora et al. (2004) we study the main 3 stages since the firm is created: creation or Pre-organization phase, development or Re-orientation phase, and consolidation or Sustainable Returns phase. For that purpose, information about Spin-offs in Spain collecting financial information for 100 Spanish Technological firms created during the period 1995-2004, half of them with university origin. The full sample is an unbalanced panel with 354 observations, hence on average each firm has 3,5 years.

Obviously, the final goal of a new firm is to consolidate Sustainable Returns. We found that only 61% of the firms have achieved positive profits consistently before 2004. This group needs, on average, two years in order to get positive returns in a sustainable way. Furthermore, from the variables analysed, only two variables affect sustainable profits; positively, the Net Sales; and negatively, the ratio of Intangible Assets over Total Assets. The fact that investments in Research and Development usually need several years in order to become commercial innovation, could explain that an increment of Intangible Assets produce losses in the current year, but probably generate future incomes that are not included in our analysis.

The most significant effect is related with the Net Sales of the firm. For that purpose are analysed the determinants of the firms' annual sales growth, that on average are 46% for Spin-off and 30% for the other technological firms. In this sense, independently on the origin around 20% of the Net Sales growth comes from the increase in the firms' investments, which has been mostly financed through external funds. The rest of the Net Sales Growth can be explained by the increment of efficiency. Consequently, University Spin-offs tend to increase significantly more the efficiency than the rest of technological firms; probably because their initial skills limitations.

During the Re-orientation phase there is significant variation on the principal variables analyzed. In particular, size measured by Total Assets and number of employees importantly increases, keeping constant the differences among origin, University Spin-offs or not. Worker Cost also raises, indicating that human capital tend to increase. Finally, technological firms tend to reduce Shareholder's funds, decreasing on average from 49% up to 35%. This fact means that in order to grow it is necessary to look for external funds incrementing debt, this process differ among origin, while Spin-offs prefer long-term debt, firms with non university origin prefer current liabilities. Even though this difference, the cost of capital is not significantly different among origin.

Pérez and Martinez (2003), find that University Spin-offs with the time tend to decrease networks with university. This could explain the evolution of three variables, a reduction of the productivity that indicate less collaboration of the university, a higher investment in Research and Development out of the university, and finally, a greater amount of other operating expenses that indicate a reduction of the aids of the university such as rentals or insurances.

Vohora et al. (2004) define as Pre-organization the phase where the firm is created. During this phase University Spin-offs tend to be smaller than other technological firms but creating employment of similar quality with relatively less investment, and particularly much less R&D investment. This fact could be explained by the fact that Universities assume part of these investments, especially those made in R&D. Moreover, Spin-offs have relatively less other operating expenses. The fact of being established at Universities could help to save these costs in the first stages.

Apart from the origin, we focused on two variables that can affect the conditionings at start-up, Subventions and Start-up Expenses. Spin-offs receive more subventions at the start-up than firms with non university origin. The presence and the mediation of the TTO's can explain this fact; therefore the TTO's facilitate the access to such funds. Apart from the origin, the size of the firm, region and sector where it operates impact the degree of subventions received. In particular, big Spin-offs that belong to Biotechnology or Chemical sectors and are from Andalusia tend to receive more subventions. Finally, size measured by Total Assets is the only variable that significantly affects Start-up Expenses.

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Appendix 1: Spanish Spin-off classified by Universities

(In italics firms that appear in SABI)

Universidad De Almería (1 Spin-off)	**Universidad Carlos III** (18 Spin-off)
5ingor	Aula Feduca
Universidad Autónoma De Barcelona (18 Spin-off)	Arquimea Ingeniería S.L
Ab-Biotics	Centro De Plataformas De Servicios Compartidos Para Pymes
D+T Microelectrónica	Enerlimp, S.L.
Activery	Ergodomus, S.L.
Davantis	*Gamma Solutions, S.L.*
Aqualab	Greenback And Asociados S.L.
Ecomunicat	Ingeniería Viescas, S.L.
Ebiointel	Intecdom, Soluciones Domóticas, S.L.
Spora	Intelis Solutions, S.A.L.
Hexascreen	Logistec, S.L.
Fit-Fundació	Midea
Inspecta	*Némesis Soluciones, S.L.*
Hysteresis	Nethalis S.L.
Univet	Plataforma Negonation, S.L.
I2m-Design	*Progresión Soluciones De Mejora De Procesos, S.L.*
Icar	Simula Consulting
Muf	Smartunited.Biz
Musicstrands	**Universidad Complutense De Madrid** (1 Spin-off)
Scytl	Natural Biotec S.L.
Universidad Autónoma De Madrid (3 Spin-off)	**Universidad De Córdoba** (1 Spin-off)
Afigen S.L	*Inersur Automatización, S.L.*
Circadies S.L	**Universidad De La Coruña** (7 Spin-off)
Genica Innova	*Lambdastream*
Universidad De Barcelona (23 Spin-off)	P3
Crystax Pharmaceuticals	Nomasystems
Enanita	Auganosa.-
Era Biotech	*Enxenio*
Oleoyl-Estrone Developments Oed	Agroambiental
Oryzon Genomics	CRM- Enxeñería E Innovación Tecnolóxica.
Diverdrugs	**Universidad De Extremadura** (2 Spin-off)
Xcellsyz	Coveless Ingeniería, S.L.L
Advancell in Vitro cell technologies	Sicubo, S.L. (Informatica)
Thera	**Universidad De Gerona** (10 Spin-off)
E-Sense Systems	*Agents Inspired, S.A*
Biocontrol Technologies	Sisltech
Ntec 106	Mellitas, S.L
Infintec	Eap, S.L.
Neurotec Pharma	Dset
Xop	Aqsense
Uban	Tr Composites
Omnia Molecular	Tecno Artes, S.L
Agrasys	Microbial
Neuroscience Technologies	Vortex. Factoria De Càlculs
Universidad De Cádiz (2 Spin-off)	**Universidad De Granada** (10 Spin-off)
Easy Industrial Solutions	Icr 1991. Ingeniería Y Control Remoto S.A.
Milethos Automotive	Logic Factory
Universidad De Cantabria (5 Spin-off)	Hydraena S.L.L.
Inesco Ingenieros S.L	Pergamentum S.C.A.
Transmodalbots	Lorgen G.P. S.L.
Acorde, S.A	Unison
Telnos Sistemas Opticos Y Telecomunicaciones, S.L.	DSI Spain
Gestion De Informacion Territorial, S.L.	Iliberi

Auditorias Ambientales De Andalucía	Aluvial, S.L. Consultoria Ingenieria Ambiental y Geotecnia GEOCYMN)
Tecforma Plataforma De Servicos, S.L.	Ambiental d'Enginyeria i Assessorament, S.L.
Universidad De Les Islas Baleares (7 Spin-off)	Anunzia Solucions Tecnològiques, S.L.
Alimb6	APC Systems BCN, S.L.
Ibitec	Aplicaciones electrocardiográficas, S.L.
Albatros Marine Technologies	Arlas Invest, S.L.
Biogenia	Arrows Software, S.L.
Laboratorios Sanifit	Astron Biomedical, S.L.
Tagrv	Aularius, S.L.
Sciware	Autana Technologies, S.L.
Universidad Jaume I (1 Spin-off)	Axis, S.L.
Previ (Psicología Y Realidad Virtual)	AZ Engin, S.L.
Universidad De León (2 Spin-off)	BACAB Information Systems, S.L.
Centrotec	Baolab Microsystems, S.L.
Bioges Starter	BCN Events Comunicación, S.L.
Universidad Miguel Hernández De Helche (2 Spin-off)	Biocom21, S.L.
Innofood I+D+I S.L	Bioglutamic
Nutracitrus S.L	Bionanomics
Universidad De Murcia	Blaunet Web Factory, S.L.
Artbiochem S.L	CCStar, S.L.
Draco-Tic S.L	Centuno Syiluppi, S.L.L.
Universidad Del País Vasco (26 Spin-off)	Cerfilter, S.L.
3d The Movie Virtual S.L	Codiumnetworks, S.L
Airg S.L	Communi.ty, S.L.
Ander Medioambiente	COMPASS Ingeniería y Sistemas, S.A.
Área Wireless S.L	COMPEGPS, S.L.
Arista Interactiva S.L	Compostadores, S.L.
Bricocanal S.L	CompraLis, S.L.
Dynakin S.L	Comsequencer Networks, S.A.
Efaber Soluciones Inteligentes S.L	Corporation Capricornio, S.L.
Eurocasbil Estudios Y Proyectos S.L	Crystax, S.L.
Fundación Cidetec	CSC, S.L. (Conservación de sustratos celulósicos)
Fundación Inbiomed	DAEM Interactive, S.L.
Ikerlat Polymers S.L	Delclos Consultors, S.L.
Indaba Consultores S.L	DENEB Latinoamérica, S.A.
Ingeoman	Diasolar, S.L.
Kam Consultaría Y Proyectos De Telecomunicación	DOC on Time, S.A.
Lastebide S.L	EIMODE, S.L.
Medicalai S.L	Elephant Memo, S.L.
Neurki Control De Equipos S.L	E-Mascaró Consulting, S.L.
Norurbi S.L	Encuestas-Internet, S.L.
Sistemas Acuarológicos Marinos S.L	EnginDat, S.L.
Zabait	Enginyeria Mapex, S.L.
Zy Consulting Tecnologías Avanzadas S.L	ENTEC Enginyeria i Serveis, S.L.
Captiva, Soluciones Y Seguridad	ESCOM Gabinete de Enginiería, S.L.
Imagina Studios S.L	Espacios Solar Ingenieros, S.L.
Dominion-Pharmakine S.L	FabChannel, S.L.
Histo Cell Ingeniería De Tejidos S.L	Forecco Technologies
Universidad Politécnica de Cataluña (149 Spin-off)	Forest Jou
4cLerks, S.L	Fractus, S.A.
Abaxyon Europe, S.L	Free Power, S.L.
ADICIONA Servicios Informáticos, S.L	Global SIO, S.L.
AD-Teramics, S.L.(Advanced Technical Ceramics)	Greenlane Biodevelopements, S.L.
AdvanCare, S.L	Hyds, S.L.
Advanced Communications & technologies, S.L	i21 Consultors, S.C.P.
AEC Center Net, S.L.	IALE Tecnología, S.L.
AENT, S.L. (Arquitectura, Enginyeria I noves tecnologies)	IBQ –Investigaciones Bioquímicas, S.L. – BIOSA
Age Business S.L.	ICAR Vision Systems, S.L.
AidaCentre, S.L	IHG (Information Highway Group), S.L.
Aiguasol Enginyeria- Sistemas avançats d'energia solar térmica, S.C.C.L.	IMAGIAM, S.L.
AIRA, S.L. (Asesoramiento Industrial en Robótica y automatización)	InetSecur, S.L.-PERSEO
Alea Business Software S.L. (Aleasoft)	INGENT Group Systems, S.L.
Algorismia S.L.	Justinmind, S.L.
Alkimia Consulting, S.L.	Kroopier

Mania Internet Studios, S.L.	*Inventa Soluciones S.L*
Marcià Codinachs, S.L.	I4 Innovación En La Inspección Industrial De Imágenes S.L
Maths For More, S.L.	*Leq Ingenieros S.L.*
Megacolor Display Portátil	Orange Software S.L.
Melcart Projects, S.L.	Rbz Robot Design S.L.
Microdesk, S.L.	Rpm Wireless Solutions S.L
Mp-Bata Consultoria Medioambiental, S.L.L.	Sip Sistemas Integrales De Producción S.L.
Npg-Emregetech, S.L.	***Intelia Consultores***
Nub3d, S.L.	E- intelligent solutions S.A.
On Site Asistencia, S.L.	**Universidad Pontificia Comillas De Madrid** (2 Spin-off)
Open Alliance Software Libre, S.A.	3bol
Open Studio Networks, S.L.	Casintel
Opentends, S.L.	**Universidad Publica De Navarra** (12 Spin-off)
Openwired, S.L.	Gaia Software
Paci Enginyers, S.L.	PRD Especialista En Riesgos
Perception Technologies, S.L.L.	Indeso
Praesentis, S.L.	INADE-EMP De Auditorias Energéticas
Prakton, S.L.	Instalación De Redes De Datos (DISCOM)
Radiant, S.L.	Seinco
Rankdom Systems, S.L.	*Id Ingeniería Domótica*
Rbs (Road Beacon Systems), S.L.	Symex
Rededia, S.L.	Dael Digital
Rig Barcelona S.C.P.	IMAGINA Servicios De Internet Móvil
Rilaic, S.L.	Agronavar
Safelayer Secure Communications, S.A.	Sensolab
Safiratec, S.L.	**Universidad Ramon Lull** (6 Spin-off)
Scylt Online World Security, S.A.	*Tatamia Solutions S.L*
Sensofar-Tech, S.L	*Imente Global S.L*
Serveis De Participació Interactive S.L.	*Geotics Innova S.L*
Serveis D'internet Javajan, S.L.	*B2i Design And Industrialization*
Simulator, S.L.	Futurlink
Siop, Simulacions Òptiques,	Nafree
Sit Consulting, S.L.	**Universidad Rovira Y Virgili** (1 Spin-off)
Smart Information Systems, S.L.	Simple S.L
Solenn Technologies, S.L.	**Universidad De Santiago De Compostela** (11 Spin-off)
Solomenu.Com, S.L.	*Hifas Da Terra S.L*
South-Wing, S.L.	*Keramat S.L*
Special Pi, S.L.	*Galchimia S.L*
Step2u, S.L.	*Celtinova S.L*
Summum Media Art, S.L.	Advancell
T3dt	Biogea S.L
Tanakj Vision	Pharmatools S.L
Tarpuna Iniciatives Sostenibles Scp, S.L.	Pexego Sistemas Informaticos
Teccon Evolution, S.L.	Neoker S.L
Technology Assurance Solutions, S.L.	Mestre Lad Research S.L
Tecnologia I Innovació Empresarial, S.L.	Signo S.L
Tfo, Fiberopt, S.L.	**Universidad De Sevilla** (4 Spin-off)
Tinytronic, S.L.	*Green Power Technologies*
Visiometrics, S.L.	*Ingeniatrics Tecnologías*
Universidad Politécnica De Madrid (17 Spin-off)	Intelligent Dialogue Systems (Indisys)
Agnitio	Anafocus
Agora Systems S.A.	**Universidad De Vigo** (2 Spin-off)
Altiria Tic S.L.L	Imatia
Artica Telemedicina	Azteca Consulting De Ingeniería
Cinco Ingeniería Y Consultoría S.L.	**Universidad De Zaragoza** (4 Spin-off)
Daedalus	Ebronautas
Dinarq Desarrollo Integral De Arquitectura	Nuevos Soportes Gráficos
E&Q intelligent integrated solutions S.L.	Laboratorio De Simulación De La Luz
	Arvet Aragón

Appendix 2: List of 100 firms used in the empirical analysis

Spin-off	CDTI
Activery Biotech Sl.	A&B Laboratorios De Biotecnologia
Advanced In Vitro Cell Technologies S.L.	A4 Ingenieros Consultores S.L.
Aerosol Industrial Research Group Sociedad Limitada.	Advanced Dynamic Systems Sl.
Agents Inspired Technologies S.A.	Agrenvec S.L.
Agora Systems S.A.	Alhambra Soluciones Y Servicios Sociedad Anonima.
Altiria Tic Sll.	Alma Bioinformatics S.L.
Arista Interactiva S.L.	Analisis Y Simulacion S.L.
Artbiochem S.L.	Andalplast S.L.
B2i Design And Industrialization S.L.	Bioazul Sl.
Bricocanal Sociedad Limitada.	Biomedal S.L.
Celtinova Sl.	Bionor Transformacion Sociedad Anonima.
Crystax Pharmaceuticals S.L.	Bionostra S.L
Daedalus Data Decisions And Language S.A.	Biotechnology Institute I Mas D S.L.
Diseno Y Tecnologia Microelectronica Aie	Biotechnology Institute S.L.
Diverdrugs S.L.	Calidad Concertada Nuevas Tecnologias Sa
Dominion Pharmakine Sociedad Limitada.	Canvax Biotech S.L.
Easy Industrial Solutions Sl.	Catenon Sa
Enantia Sl.	Centro Tecnologico De Los Astilleros Medianos Y Pequenos Soermar Sa
Enxenio Sl.	Comerciando Global S.L.
Eurocasbil Estudios Y Proyectos Sociedad Limitada.	Consultores Integrales En Telecomunicaciones Consulintel Sl
Galchimia S.L.	Cordoba On Line S.L.
Gamma Solutions S.L.	Datapixel S.L.
Genyca Innova Analisis Y Diagnostico Genetico Sl.	Eina Informatica Sl.
Geotics Innova Sl.	Euroespes Biotecnologia S.A.
Green Power Technologies S.L.	Gamc Sistemas De Informacion S.L.
Hifas Da Terra S.L.	Goal Systems S.L.
Ibitec Sl.	Idelt Ingenieria De Desarrollo De Prototipos S.L.
Icar Vision Systems S.L.	Industria Transformazione Resine Bilbao Sociedad Limitada.
Ikerlat Polymers S.L.	Infor Pyme Solutions S.L.
Imente Global S.L.	Ingeniatrics Tecnologias S.L.
Indaba Consultores S.L.	Ingenieria Diseno Y Desarrollo Tecnologico S.A.
Inersur Automatizacion Sl.	Instituto De Monocristales Sociedad Limitada.
Ingeniatrics Tecnologías S.L.	Know How Group Of Business Colleges S.R.L..
Ingenieria Domotica S.L.	Lantek Automatizacion S.L.
Intelia Consultores S.L.	Macromoon Soluciones Multimedia S.L.
Inventa Soluciones S.L.	Mediterranea De Investigacion Cientifica Sociedad Limitada.
Keramat S.L.	Movelis Software Sl.
Lambdastream Servicios Interactivos Sl.	Neocodex S.L.
Lastebide S.L.	Newbiothecnic S.A.
Leq Ingenieros S.L.	Onmedic Networks S.L.
Muf Laboratori D Imatge Art I Animacio S.L.	Pevesa Peptonas Vegetales S.L.
Nemesis Soluciones Sl.	Quimicas Nevada Sociedad Anonima.
Neoker Sl.	Recovery Labs S.A.
Ntec 106 Sl.	Robotnik Automation Sll.
Oryzon Genomics S.A.	Secuenzia Pixels Sll
Progresion Soluciones De Mejora De Procesos Sl.	Secuware S.L.
Q&E Intelligent Integrated Solutions S.L.	Sensia Sl.
Scytl Secure Electronic Voting Sa	Sistemas Avanzados De Control Sa
Tatamia Solutions S.L.	Synera Systems S.L.
Univet Servicio De Diagnostico Veterinario S.L.	Technical & Racing Composites S.L.