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THE EFFECT OF CAPITAL STRUCTURE DECISIONS ON TECHNOLOGICAL INNOVATION

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INTRODUCTION

The goal of this work is to explore the interactions between capital structure decisions of technological firms and the effects that such decisions produce on their innovative output.

The elaboration is structured in 5 chapters, the first three focusing on the different topics required to dissect the fundamental elements of the discussed issue, the fourth exploring how such dynamics in general have developed in the Italian context, and the fifth one being an empirical attempt at replicating some specific research questions, based on the literature in chapter 3, on the Italian case.

The first chapter introduces the concepts related to technological innovation, in order to establish the ground base for further discussion. The first paragraphs present a definition of what economic literature depicts as technological innovation and then precedes into the analysis the various identifiable kinds of innovation and the different dimensions along which it can be studied, such as radical vs. incremental, continuous vs. discontinuous, closed vs. open innovation paradigms. Then, the discussion touches the sources of innovation, to give a picture of what the landscape originating innovative processes is. After elaborating on the sources, we then arrive at the core of the chapter, which is the discussion on how to measure a process like innovation. Indeed, the difficulties inherent to such measurement are brought to light, such as the latency between investment and results, the creation of intangible assets and the causal ambiguity of the development of new ideas. Following the relative literature, the different metrics useful to the measurement of innovative processes are then identified in R&D statistics, Patent data, Innovation surveys and Product announcements. These metrics will be used in the remaining of the thesis as the units by which we can compare and measure innovative activity, keeping in mind the limitations of each one of them. The chapter concludes then with the presentation of why innovation is such an important topic in modern economic research on several levels, such as the importance of the valuation of intangible assets in stock markets and the repercussions that innovative activity has both on a macroeconomic and microeconomic level.

The second chapter is where the topics at the core of this dissertation start to be examined. The issues connected to the capital structure of innovative firms are presented, underlining the peculiarities that characterize them in conjunction with the financial markets. Indeed, we expose how the assumption of financial markets efficiency can't be held valid in this situation. This shapes a modified pecking order for technological firm, which emerges from credit rationing problems. Indeed R&D investments present several peculiarities that distinguish them from other industrial investments. The fact that the mid-term expected result of R&D investments is an intangible activity, represented by new knowledge, and that these investments are subordinated to higher uncertainty due to their long-term, high risk-high reward nature, makes them inherently less appealing to external investors with low risk tolerance. Furthermore, the appropriability of the new knowledge produced, the asymmetric information arising between investors and entrepreneurs, and finally moral hazard issues, all contribute in creating an investment not appealing to traditional financial intermediaries. As a consequence we see how innovative firms have to adopt a financing cycle approach to overcome financial constraints, where specific financial resources are ideal at each respective life-stage of firms. The remaining part of the chapter analyzes the different financing methods used in conjunction with the aforementioned life stages and their characteristics: from informal investors such as Angel investors, to Venture Capital funds, IPOs and M&As as buyouts exits for investors and the importance of stock markets in such instances, and Crowdfunding.

While in the second chapter we discuss how the innovative context influences the capital structure of technological firms, in the third chapter we arrive to the core of our literature review. In this instance indeed, we see this phenomenon from another perspective, or, how the capital structure and financing methods undertaken influence the innovative output of firms. The first evidence we find is that, overall, financing intermediaries do have a positive impact, on an industrial level, over the innovative output. We see indeed how informal investors do have a positive impact; on the other hand some critical points emerge with entrepreneur incentives to innovate. Indeed, we see how the capital structure influences entrepreneurs in their choice of undertaking innovative projects and ultimately may hinder the innovative output. We start to see in this instance how a public or a private ownership does have an impact on innovation. The following part of the chapter explores indeed how the decision to undertake a public ownership, through an IPO or an M&A, has an impact on the firms' produced innovation. We see how empirical evidence gathered by Berstein (Bernstein, Does Going Public Affect Innovation?, 2012), highlights that the quality of innovative output sprouted from firms who completed an IPO is lower when compared to firms which filed for an IPO but ultimately withdrew it. This happens due to several reasons, such as the pressure from public investors on managers to undertake safer investments due to the short-term mindset that characterizes shareholders, the departure of pre-IPO inventors after the IPO is completed, which ultimately leads to a turnover of human capital. M&As are also examined, and they present an intermediate result between private ownership and IPOs with regards to the degradation of innovation quality, but once again emerges firms acquired by private ownerships have better innovative outputs than those acquired by public ownerships. At the end of the chapter, we also analyze how the legal environment has a deep impact on the ability of firms to produce innovation. Indeed, the more labor laws are stringent concerning termination and allow employees to possess a long-term relationship with a firm, the more short term failures are undervalued and the stress is shifted on long-term results, which ultimately leads to more time for long-term, risky investments such as R&D ones.

After concluding with the third chapter the review of literature, the fourth chapter tries to take a picture of the Italian environment concerning the financing of innovation. We immediately identify what is called "the Italian gap" concerning the innovative output of our industrial and policy system compared to comparable European countries, and start analyzing the various factors that take part in its creation. The chapter then focuses on the problems more strictly tied to the financing of innovation, and it is immediately clear that both early stage financing and stock markets are not as developed as in peer countries. This takes us back to the credit rationing issues underlined in chapter 2: it is assumed that without the creation of a better environment for investors who wish to fund innovative firms, through the development of stock markets and better information sharing between banks and entrepreneurs, the gap between the innovative activities in Italy will be much harder to reduce.

In the final chapter, an empirical approach is undertaken to try to find some answers, with regards to the Italian context, to research questions emerged in chapter 3 concerning the relationship between going public through an IPO, and the innovative output of such firms. In the spirit of the research by Bernstein, we extracted from the Consob database the list of all prospects of companies who filed an IPO from 2002 to 2012 (CONSOB, 2015). Of these companies, we have therefore reported those who ultimately completed the IPO and those that withdrew it. For each firm that either completed or withdrew the IPO, we have then noted the patents filed in the years before the IPO filing and afterwards, using the online available database of the "Ufficio Italiano Brevetti e Marchi" (Ministero Italiano dello Sviluppo Economico, 2015). Keeping in mind that the sample is small compared to other countries, the findings have highlighted an overall increase of patent applications leading up to and in the years following the IPOs when considering patents in absolute numbers, with a slightly higher performance for those who withdrew the IPO compared to those who didn't.

The second part of the chapter though, takes a modification on the dataset to view, instead of the overall patent numbers, the relative share of patents produced by firms in the years around the IPO compared to their overall patenting activity from 1989 to 2015, in order to compensate for some firms having very high numbers of patents compared to the rest inflating the overall results. This approach created different results: we see that indeed that patenting activity does have an increase at the IPO event and then drastically reduced, even though at higher levels when compared to 5 years previous to the IPO. This induces us to think that patenting activity may be used by Italian firms as a window-dressing tool prior to the IPO. The differences between the two datasets also highlights that there is a trend for bigger companies with higher R&D investments to have a better performance than small companies: this may be related to the credit rationing problems discussed in chapter 2 and 4 with regards to the Italian situation.

1. TECHNOLOGICAL INNOVATION

In order to proceed with the analysis of the interactions between the capital structure of a company and its technological innovativeness, first we have to define what it's meant by innovation in modern economic literature, how it is measured, and why it is a relevant topic.

I. Defining Innovation

Following the literature concerning the nature of innovation in business organizations and environments, we can come up with a comprehensive definition of the process itself. An interesting definition of Technological Innovation is found in a paper by Dosi: technological innovation is the solution, meeting with budget and market attractiveness requirements, of problems which are not easily solved with the available information and knowledge in the industry (Dosi, 1988). Indeed, in order to be innovative, a solution must involve "discovery" and "creation" (Dosi, 1988), drawing from previous state of the art "formal knowledge and specific and uncodified capabilities" (Dosi, 1988).

The process is then defined as the search, development, and adoption of new processes and products as the result of the interactions between capabilities and stimuli generated within each firm and within industries in conjunction with external factors not dependent on the current industry conditions such as the scientific advancement in different branches (Dosi, 1988), the supply of technical capabilities and skills for the innovative process to take place (Dosi, 1988), and ultimately the market conditions driving the investments in such process with the perspective of ultimately achieving profits for investors (Dosi, 1988).

Following this perspective, Technological innovation composes itself as a dynamic and complex process which can manifest itself in different ways, which can be categorized according to different parameters.

Innovation can be either radical or incremental (Freeman, 1974). These two types of innovative effort are placed at the exact opposite spectrum one from the other. On one hand, radical innovation is a revolutionary, market-changing breakthrough which changes the nature of the service or product which was being marketed in the industry before (Dodgson G. S., 2008); it is often related to relevant leaps in scientific research and discoveries, and the innovation changes significantly, in one single leap, both the product and the market. On the other hand, incremental innovation is characterized by a long series of small steps which modify existing products or services and slowly update them in order to keep them competitive on the market and cumulatively improve their performance (Dodgson G. S., 2008). Another point of difference between these two types of innovation is also the investment required to achieve their results: while radical innovation focuses on basic research and thus needs a greater investment and interaction with research institutions such as universities and laboratories, incremental innovation is mostly based on internal small progressive changes, also affecting the diffusion patterns of the different kinds of inventions involved in the innovative process (Dodgson G. S., 2008).

Furthermore, innovation can be continuous or discontinuous (Dodgson G. S., 2008). Continuous innovation is related to the previous definition of incremental innovation, it is technological advancement which doesn't affect "the existing ways of doing things" (Tushman, 1986). Given that companies usually have a difficult time adopting innovative technologies due to the fact that they feel more confident betting on previous success, managers may need to discontinue previous routines and products in order to follow the right innovative strategy and obtain competitive advantage (Dodgson G. S., 2008).

Modularity is another characteristic which is representative of different ways of following an innovative route. This kind of innovation doesn't affect the core, or architectural part of the product or service offered, instead it is achieved by innovating its components. On the other side of the spectrum, innovation can also be achieved following an architectural route (Henderson, 1990), which means attempting to improve the state of the art with a systemic approach, putting less emphasis on the single modules.

Innovation can also sprout from the appearance of a dominant design regarding a product or service category (Abernathy & Utterback, 1978). The innovative pattern is modified whenever a winning product class becomes dominant in the market and forces the competition to adhere to its standard.

On a final note, it is of interest discussing a key driver of the innovative process: a closed-innovation environment or an open innovation environment

(Chesbrough, 2003). Historically, companies wanted to keep the innovative process internal due to the risks of diffusion and subsequent loss of potential value for their internally financed research and development effort. This configures a Closed Innovation paradigm, where each company builds a wall between their knowledge and the external environment. This paradigm was the standard up until it became apparent that the benefits of sharing knowledge when working on innovative projects started to overcome the risks. The Open Innovation paradigm is an innovative effort which involves different entities sharing knowledge and creating partnerships in order to achieve greater results and generate a better innovation process (Chesbrough, 2003).

II. Sources of Innovation

We now have defined what innovation is and some key drivers to analyze the dimensions which can characterize the process. In this paragraph the main concern will be finding out from which entities innovation comes, and how. In order to do so we may first need to make reference to Schumpeter and his works. He stressed the importance of finding the right mix and new combinations of technologies, knowledge, and markets for firms (Dodgson G. S., 2008).

The mix is often composed by several different sources for the innovative process. While traditionally the firm internal R&D teams and laboratories are the first thing which come in mind when thinking about innovation related to entrepreneurship, sources are actually varied and many. In order to explore the sources of innovation, it is needed to look for a mix of different knowledge sources, which may or may not be internal to the firm. In fact consultants, customers, suppliers and universities are all external to the firm, but can have a huge role in jump-starting and refining the innovative process, and firms must make an effort in coordinating the various external sources as well as the internal ones. (Dodgson G. S., 2008)

Given these assumptions though, the importance of the several different sources of innovation varies depending on the business sector in which the firm competes and of course the country.

It is interesting to take a look at the results from the Community Innovation Survey (CIS), which is a survey executed by national statistical offices throughout the European Union and Norway and Iceland, as it is described on its website:

"The CIS is a survey of innovation activity in enterprises. The harmonized survey is designed to provide information on the innovativeness of sectors by type of enterprises, on the different types of innovation and on various aspects of the development of an innovation, such as the objectives, the sources of information, the public funding, the innovation expenditures etc. The CIS provides statistics broken down by countries, type of innovators, economic activities and size classes." (Community Innovation Survey (CIS)).

Here we have a look at the data for the CIS 4 report regarding the sources of innovation for European firms in the 2004-2006 periods:

Sources	*Manufacturing*	*Services*
Within the enterprise	37%	40%
Other enterprises within the enterprise group	7%	13%
Suppliers of equipment, materials and components	19%	20%
Clients and customers	27%	31%
Competitors	11%	14%
Universities and higher education institutes	4%	6%
Government and non-for-profit research labs	3%	3%
Professional conferences, meetings and journals	9%	15%
Fairs and exhibitions	17%	14%

Table 1.1: Sources of Information for European firms. Percentage of innovating enterprises selecting the respective source as highly important. (Dodgson G. S., 2008)

We can see from this table that in the EU area internal R&D accounted for around 40% of the enterprises as the most important source of information in order to innovate, which is a good measure (for both manufacturing and services firms) of how varied the situation can be for each firm regarding where to go in order to access innovative information.

This is also relevant when looking at it in an open innovation perspective (Chesbrough, 2003). In fact, as long as the knowledge accessible outside of the company is scarce and of little use, there is no point for firms in reaching out. As the knowledge created outside firms has become of great value for innovative firms, the mix of sources greatly changed the landscape of the innovative process and the open innovation paradigm has been possible: it is very rare in modern business for companies to only rely on the internal knowledge in the pursuit of innovation. It is not rare at all to try to acquire innovation in different ways other than internal R&D. This is especially important when thinking about the reasons which may or may not drive the decision for an innovative firm to go public and raise equity funding or not and how financing structure may be influenced by the innovative landscape and sources, which we will see in a later chapter.

III. Measuring Innovation

At this stage we need to assess how to have a measurement of the innovative activity which can drive our later evaluations as objectively as possible. This is actually a challenging matter: in fact trying to have accurate measurements of the innovative activity has often led to confusion and failure. (Dodgson G. S., 2008)

This is due to several reasons. The first of them is that there is latency between when the innovative effort is made and the time at which the effects of such effort become evident and measurable. This also depends on the type of innovative effort; usually radical innovation sprouting from base research may need years before having commercial results, due to lack of present technology to compliment it or market issues to go along with other factors.

Another problem is the very definition of innovation: often a product or service may be deemed innovative where in reality there is no novelty in it other than a superficial change. At the same time there is ambiguity in separating processes from outputs. Some indicators measure inputs of innovation while others outputs, it is impossible to measure the process. This problem is indeed related with the first one: having really long innovative processes means having really long periods of time without a precise measurement of the ongoing activity. (Dodgson & Hinze, 2000)

Furthermore, because of the variety of the sources of innovation of which we talked in paragraph ii, it is difficult to allocate in which measure each contributor to the innovative process participated. In other words: it's hard to measure how much R&D, marketing, customer demand, external sources or other entities contributed to the creation of the new product or service.

Given all of these limitations, a pattern has been established, in time, in measuring innovation. In fact the main indicators used in this kind of analysis are:

- R&D statistics
- Patent data
- Innovation surveys (as the CIS quoted in paragraph 2)
- Product announcements (Dodgson & Hinze, 2000)

a. *R&D statistics*

The collection of R&D Statistics is organized by the *Frascati Manual* by the Organisation of Economic Cooperation and Development (OECD). This manual gives the guidelines in order to create a common framework of reference for measuring the Research and Development activities statistics.

The manual states that R&D is the:

"creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture, and society, and the use of this stock of knowledge to devise new application"

(Organisation for Economic Cooperation and Development (OECD), 2002)

It divides research into three branches:

- Basic research: experimental or theoretical research intended to uncover knowledge regarding the underlying foundations of phenomena and observable facts without direct implications or immediate use for commercialization.
- Applied research: research intended to acquire new knowledge regarding a specific practical aim or objective.
- Experimental development research: research founded on existing previous knowledge deriving from prior research or experience directly intended to produce, improve or install new materials, products or services.

  (Dodgson G. S., 2008)

Even though the Frascati Manual gives directions on how to break down the R&D process and categorize each activity, measuring R&D and producing accurate data is still a challenge. In fact, modern firms rarely rely exclusively on the R&D department for the creation of innovative outputs and it is still a challenge to precisely associate the costs sustained to create innovation to the exact party involved because of their multitude. (Dodgson G. S., 2008)

On a macroeconomic level though we can see how the R&D expenditures vary along the years and how it has evolved. Consulting the OECD webpage for statistics on R&D Expenditure per Country as a percentage of GDP, we derive the following table:

Gross domestic expenditure on R&D As a percentage of GDP per year								
Country	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Australia	1,73	..	2,01	..	2,26	..	2,20	..
Austria	2,24	2,46	2,44	2,51	2,67	2,71	2,79	2,75
Belgium	1,86	1,83	1,86	1,89	1,97	2,03	2,00	2,04
Canada	2,07	2,04	2,00	1,96	1,92	1,94	1,85	1,74
Chile	..	..	..	0,31	0,37	0,41	0,42	..
Czech Republic	1,20	1,35	1,49	1,48	1,41	1,47	1,55	1,84
Denmark	2,48	2,46	2,48	2,58	2,85	3,16	3,07	3,09
Estonia	0,85	0,93	1,13	1,08	1,28	1,43	1,63	2,38
Finland	3,45	3,48	3,48	3,47	3,70	3,94	3,90	3,78
France	2,16	2,11	2,11	2,08	2,12	2,27	2,24	2,25
Germany	2,50	2,51	2,54	2,53	2,69	2,82	2,80	2,84
Greece	0,56	0,60	0,59	0,60	..	..	..	..
Hungary	0,88	0,94	1,01	0,98	1,00	1,17	1,17	1,21
Iceland	..	2,77	2,99	2,68	2,65	..	..	..
Ireland	1,23	1,25	1,25	1,29	1,46	1,76	1,71	1,72
Israel	4,29	4,43	4,51	4,86	4,77	4,49	4,34	4,38
Italy	1,09	1,09	1,13	1,17	1,21	1,26	1,26	1,25

Japan	3,13	3,31	3,41	3,46	3,47	3,36	3,26	..
Korea	2,68	2,79	3,01	3,21	3,36	3,56	3,74	..
Luxembourg	1,63	1,56	1,66	1,58	1,66	1,72	1,48	1,43
Mexico	0,40	0,41	0,38	0,37	0,41	0,44	..	..
Netherlands	1,93	1,90	1,88	1,81	1,77	1,82	1,85	2,04
New Zealand	..	1,14	..	1,19	..	1,30	..	..
Norway	1,57	1,51	1,48	1,59	1,58	1,76	1,68	1,64
Poland	0,56	0,57	0,56	0,57	0,60	0,67	0,74	0,77
Portugal	0,74	0,78	0,99	1,17	1,50	1,64	1,59	1,49
Slovak Republic	0,51	0,51	0,49	0,46	0,47	0,48	0,63	0,68
Slovenia	1,39	1,44	1,56	1,45	1,66	1,85	2,09	2,47
Spain	1,06	1,12	1,20	1,27	1,35	1,39	1,39	1,33
Sweden	3,58	3,56	3,68	3,40	3,70	3,60	3,39	3,37
Switzerland	2,82	..	..	..	2,87	..	..	..
Turkey	0,52	0,59	0,58	0,72	0,73	0,85	0,84	..
United Kingdom	1,69	1,72	1,74	1,77	1,78	1,84	1,80	1,77
United States	**2,55**	**2,59**	**2,65**	**2,72**	**2,86**	**2,91**	**2,83**	**2,77**
EU27	**1,73**	**1,74**	**1,76**	**1,77**	**1,84**	**1,92**	**1,91**	**1,94**
OECD Total	***2,18***	***2,22***	***2,26***	***2,29***	***2,36***	***2,41***	***2,38***	**..**
Last updated: 27 May 2013; disclaimer: http://oe.cd/disclaimer								

Table 1.2 – Gross domestic expenditure on R&D As a percentage of GDP per year (OECD, 2014)

From this table, we can then derive the trend and the relative expenditure on R&D for EU27 countries, USA and the overall OECD trend.

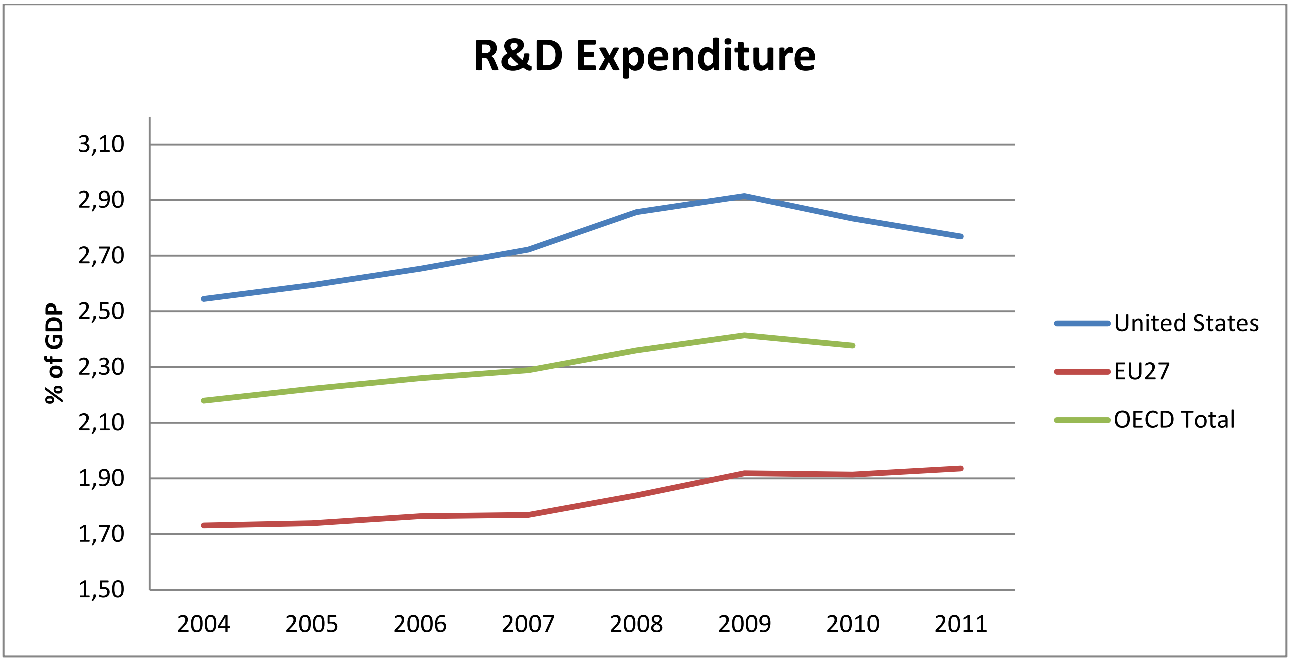


Table 1.3 – Graphical representation of the R&D expenditure trend in the USA, EU27 and OECD Total

As we can see, USA invests a higher percentage of its GDP on Research and Development when compared to EU. Overall though, the expenditure in percentage of GDP has been growing steadily up until 2009, where the amount invested started to take a negative trend, and slowly decrease. In fact the economic crisis in 2008 affected the innovativeness of the worldwide market, and we can see the results in the above graph. Even though the impact on business innovation has varied across different sectors and countries, according to OECD, uncertainty over market conditions, along with financial constraints, have hindered investment in innovative activities. (OECD, 2012)

On the other hand virtually all OECD nations have set R&D expenditure targets. As an example the EU had a 3% of GNP target to be spent on R&D in 2010. (Dodgson G. S., 2008)

The trend has been overall positive in the long run, and R&D expenditure is one of the key drivers to understand the degree of innovativeness of a country. Even though it remains a less than perfect measure of innovation input, it still is a useful metric. It is also very useful with regards the three different kinds of research to also understand how a company, within a business sector, positions itself in terms of degree of pursued innovativeness by composing its investment in basic research, applied research and experimental development (Dodgson G. S., 2008).

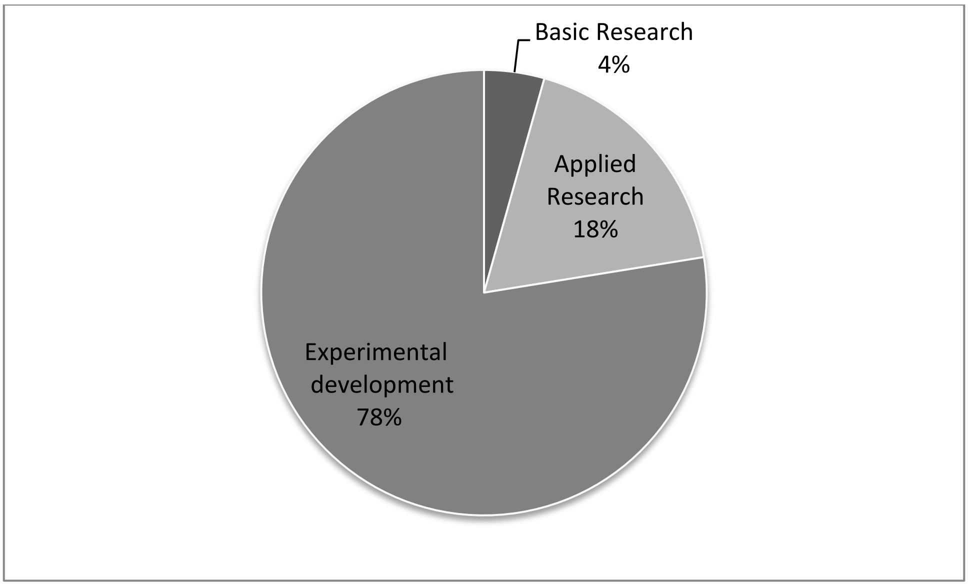
Concerning how the investments are divided across these three different categories, we can also consult a table from the OECD database for the USA statistics. For the last 10 years, the USA investment in R&D activities has been, expressed in 2005 PPP dollars, been composed as follows:

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012
Basic Research	7835	8667	8384	11268	12368	14784	16371	13020	13955
Applied Research	45432	45284	51173	57570	46864	41055	44906	47186	50756
Experimental development	155034	172208	188112	200429	231449	226554	217700	233887	251989
Total	208301	226159	247669	269267	290681	282393	278977	294093	316700

Table 1.4 – R&D Investments in the USA in PPP 2005 Dollars for Basic Research Applied Research and Experimental development (OECD, 2014)

In percentage values:

	2004	2005	2006	2007	2008	2009	2010	2011	2012	Avg
Basic Research	3,76%	3,83%	3,39%	4,18%	4,25%	5,24%	5,87%	4,43%	4,41%	**4,37%**
Applied Research	21,81%	20,02%	20,66%	21,38%	16,12%	14,54%	16,10%	16,04%	16,03%	**18,08%**
Experimental development	74,43%	76,14%	75,95%	74,44%	79,62%	80,23%	78,04%	79,53%	79,57%	**77,55%**



Tables 1.5 & 1.6 – Percentage data of table 1.4 and Pie chart graph representing how USA investment is divided between the three kind of R&D

As the pie chart shows, in the last 10 years on average in the USA, the enterprise and business sector invests the majority of its funds into the experimental development sector of their R&D expenditure. This is probably due to the more tangible and short term returns that this kind of research allows, while Basic and applied Research have more of a long-term approach along with suffering a higher degree of the aforementioned problems with R&D cost identification and involved parties, when valuing the future returns of the investment. At the same time pursuing radical innovation, which is the goal of Basic Research, is way riskier than just following an incremental innovative pattern.

b. *Patent Data*

Statistics regarding patent data are another important source of information regarding innovation. They retain several advantages as indicators:

- They require codification of technology: concerning its form, function and novelty, and thus containing a comprehensive amount of information on a firm's technological activity.
- Patents are examined by patent offices: therefore an awarded patent is an independent evidence of the novelty of a technology over the previous state of the art.
- Since patents in many settings have to be renewed periodically by paying to the awarding institution, important information can be obtained regarding the value firms give to their intellectual property.

  (Dodgson G. S., 2008)

On the other hand, using patents as a measure of innovation presents the issue that, patents themselves, don't always produce effects on the market. They may never develop into a commercialized product or service and therefore is more of a measure of invention than innovation (Dodgson G. S., 2008).

The definitions of Patents in USA and EU are the following:

- *USPTO:* Property right granted by the Government of the United States of America to an inventor "to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States" for a limited time in exchange for public disclosure of the invention when the patent is granted. (Lederman & Saenz, 2005)
- *EPO*: Legal title granting its holder the exclusive right to make use of an invention for a limited area and time by stopping others from, amongst other

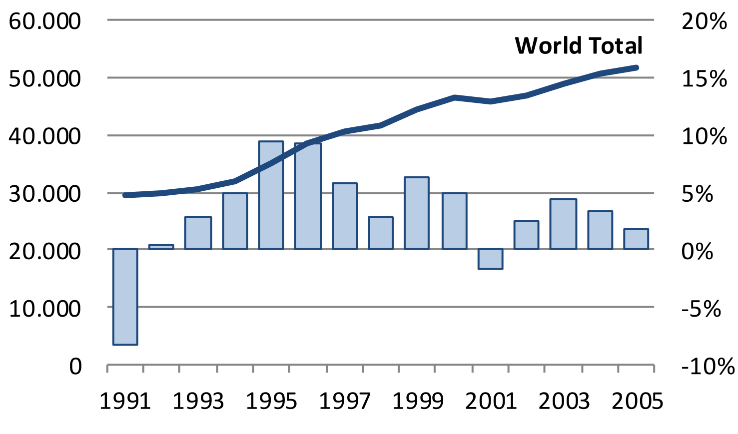
things, making, using or selling it without authorization. (Lederman & Saenz, 2005)

According to the OECD, the United States, Japan and the European Union demonstrate similar inventive performance, contributing to almost 90% of total triadic patent families (which is patents filed under all three patenting regimes) in 2005 (OECD, 2008). Also, patenting activity is concentrated in specific regions which produce a large share of the total (i.e. The Silicon Valley in California, USA).

Very few patent applications are filed by universities: only 4% of all international filings were signed by superior education institutions, while 80% of the applications were filed by the private sector in 2003-2005 (OECD, 2008).

Patent data has been found to be correlated with attractiveness of countries, to a certain extent. The following graph shows the correlation between the two indicators:

Number of triadic patent families and growth rate



Notes : Triadic Patent Families are defined as a set of patents taken at the European Patent Office (EPO), the Japan Patent Office (JPO) and granted by the US Patent and Trademark Office (USPTO) to protect the same invention. Patent counts are based on the earliest priority date, the inventor's country of residence and use fractional counts. Data mainly derive from EPO Worldwide Statistical Patent Database (October 2007). Figures from 1999 onwards are estimates.

Source: OECD, Patent Database, June 2008.

c. *Innovation surveys*

Innovation surveys and databases are another way of measuring innovation. (Smith, 2005). This kind of research initially focused on an *"object-oriented"* approach, which is counting the number of innovation occurring in certain space and time frame. In this kind of analysis it has to be mentioned the survey, the first of this kind, performed by the Science Policy Research Unit (SPRU) at the University of Sussex. Eventually, it generated the SPRU Innovation Database in the 1970s and 1980s (Pavitt, 1984). The measurements were taken using the scan of technical journals and reporting major innovations. The reported data were then classified categorizing the sector, origin, use, and type. The *"object-oriented"* approach though has limitations: it is time consuming and the information gathered is difficult to collect. (Dodgson G. S., 2008). Similarly to patent data, it is also needed to make sure that the innovations listed do get commercialized, and not simply announced.

Similar to this approach, is the practice of collecting new product announcements made by technical press as a measure of innovativeness. It is a good measurement of small and incremental product developments, but on the other hand, it is hard to actually tell when a product is indeed an innovation over the state or the art, or just a new version of an old product. (Dodgson G. S., 2008)

In the 1990s innovation surveys became more popular and other databases, such as the EU CIS mentioned in the earlier paragraphs, started mapping out the innovative activities across different countries. These surveys are referred to as *"subject oriented",* since they actually ask firms about topics related to their innovative activities, companies are presented a number of questions regarding the nature of their new products (such as if they were improvements, new to the market or new to the firm), and processes (Klenknecht, 2002).

The advantages of using surveys over other measurements of innovation are several. Surveys draw on large samples, involving firms from different sectors. This helps fill in the blanks where data coming from R&D statistics or Patent Data doesn't help get the full picture. As all other methods for measurement, it does have its flaws: they are surveys and are afflicted by all the problems that such an investigation has intrinsically: biased data can be an issue. Additionally, innovation surveys data still remains a lesser tool in the minds of managers (Dodgson & Hinze, 2000).

IV. The Market Valuation of Knowledge Assets

Innovation is worth financing, for private investors, only if it is able to create profits. Because of the delay which occurs between the investment in an innovative process and the timing of the economic return, current profits don't represent a complete indicator of the returns to innovation. For private companies with publicly traded stock, stock value has been used as a measure of the value of an innovation, but it is of limited use for private equities which are not traded on efficient stock exchange markets and thus can't have the same accuracy in market valuation. (Czarnitzki, Hall, & Oriani, 2006)

In order to proceed with this analysis, we have to define what knowledge capital is. In equilibrium, the market valuation of an asset can be represented as a function of the expected rate of return of the investment and the market supply of capital for that asset (Hall, 1993). Starting from this concept knowledge capital can be defined as follows.

First defining V_{it} as the value for firm I at time t as a function of its assets:

$$V_{it} = V(A_{it}, K_{it}, I_{it}^{1}, \ldots, I_{it}^{n})$$

Where:

A_{it} *= book value of tangible assets,*

K_{it} *= replacement value of the firm's technological knowledge capital*

I_{it}^{j}*= replacement value of the* j^{th} *intangible asset*

Assuming the single assets are purely additive, and ignoring other intangible assets to simplify the model, the market value of a firm can be expressed as:

$$V_{it} = b\,(A_{it} + \gamma K_{it})^{\sigma}$$

Where:

b = market valuation coefficient of a firm's total assets

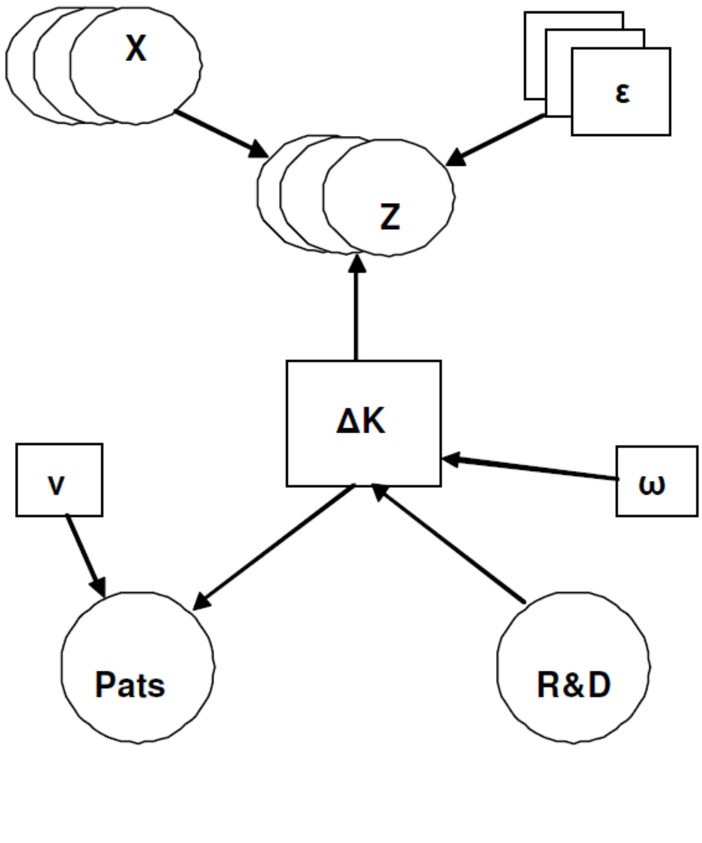
γ = the relative shadow value of knowledge capital to tangible assets

And then

bγ = absolute shadow value of knowledge capital to tangible assets

In essence, the product $b\gamma$ represents the investor's expectations about the effect of the capital invested in technological knowledge K_{it} on the discounted value of present and future earnings of the firm, and γ is the differential valuation of the knowledge capital compared to tangible assets. Assuming $\gamma=1$, a dollar spent in knowledge capital has the same effect on the stock market valuation of a dollar spent on tangible assets. On the other hand if $\gamma>1(<1)$ the stock market evaluates knowledge capital more (less) than tangible capital (Czarnitzki, Hall, & Oriani, 2006).

This concept though is difficult to define empirically because of the great number of kinds and sources of knowledge. In order to face this complexity the following diagram shows how to measure the addition to knowledge capital during a set time period:



The measurement of knowledge capital (Pakes & Griliches, 1984)

Where:

ΔK = addition to knowledge capital K in a set time period

R&D= Research & Development activity

Pats = Filed Patents

v, ω= random disturbances

Z= Performance Indicators (stock market value of the firm included)

X= Investment and labor input

ε= Unobservable influences

This diagram shows how the addition to knowledge capital receives input from observable R&D activity which produces observable results in patents and performance indicators, which are in turn also the output of investment and labor input. (Pakes & Griliches, 1984)

Following these scheme, the measurement of Knowledge capital (as stated in previous paragraphs) has generally followed the route of either R&D-based or patent-based, each way with its advantages, and producing different results when trying to measure knowledge capital.

Concerning R&D investments the following has been found:

- R&D Investments are generally evaluated in a positive way by stock markets (i.e. γ>0).
- Market valuation of R&D has progressively decreased over time from 1970s to 2006.
- There is a striking difference between US and UK, and Germany and France. The estimated coefficients of R&D capital are less than 1, meaning that they are valued less than investments in tangible assets, less than the

coefficients emerged in other studies for US and UK. (Czarnitzki, Hall, & Oriani, 2006)

Whereas patents have shown the following results:

- Including patents in the market value equation in addition to R&D, according to several studies, adds a small amount of information over what is obtained using exclusively R&D statistics.
- Patents, for most studies, contribute positively to the market value of a firm, results are similar in firms from US and Germany
- Where both patent applications and patent grants are both measurable, granted patents have a larger marginal shadow value to knowledge capital than patent filings. In essence, R&D activity manifests itself with the patent filing and has the potential to add some value to the knowledge capital. However, only when the patent is granted and the firm can use the R&D for commercial purposes it reveals its full addition to the value of knowledge capital (ΔK). (Czarnitzki, Hall, & Oriani, 2006)

The aforementioned study by Czarnitzki, Hall & Oriani, draws several interesting conclusions regarding the valuation of knowledge capital. According to their findings, the obsolescence rate for R&D investment is somewhat greater than 15%, probably around 20-30%. R&D appears to be more valued in UK than in other countries, implying that firms in the UK may be underinvesting in R&D.

Furthermore, coefficients measuring patent data are more variable than R&D coefficients, because of the heterogeneity of specifications patent data presents.

Compared to R&D, patent data looks to have a smaller effect on firm value and, finally, the impact of knowledge capital on the market value varies considerably across sectors, depending on technology and industry characteristics. (Czarnitzki, Hall, & Oriani, 2006).

V. Outcomes of Innovation

a. Macroeconomic Level

The impact that technological advancement has on economies has been the centerpiece of the Solow Neo Classical Model, where technological advancement drives the trajectory of the growth model. Indeed, technological progress is the parameter which affects the total factor productivity of a country, and ultimately doesn't allow countries with lower capital stock and low technological parameters to catch up with countries with larger capital stock. In fact, contrary to what would be expected given the diminishing returns of growth with larger capital stock due to depreciation over time, countries with a low technological parameter will have a lower growth in the long term even given their lower starting capital stock (Solow, 1956). In essence, technological advancement and efficiency are the key drivers to sustain growth over time and create GDP, which in the end is what determines the well-being of a country.

To further analyze the correlation between technological innovation and GDP growth of a country it's worth mentioning the following analysis by Daniel

Lederman and Laura Saenz from the World Bank in their 2005 study (Lederman & Saenz, 2005).

The aim of the paper is to fill in the void of a paper analyzing the data on innovation available at the time with data concerning the growth rates of countries over the course of time and find the correlation between the two factors that was never analyzed precisely in the previous endogenous growth models (Lederman & Saenz, 2005).

The findings of the paper indicated that rich countries tend to have much higher levels of patents and R&D expenditure when compared to developing countries, quoting the key phrase of the paper findings:

"The econometric analysis reported in this paper suggests that innovation capital is positively correlated with the level of development." (Lederman & Saenz, 2005).

b. Microeconomic level

On the microeconomic level of analysis, innovation can create a virtuous environment where society, firms and individuals benefit from it in terms of quality of life or even personal happiness. (Dodgson G. S., 2008)

The diffusion of innovation is an effect which on the long run is able to deeply modify the perceived needs and the market itself. Thanks to the falling cost curves of innovative products, which during the life cycle of a product make innovations available to a wider market, the lifestyle and values of a market can rapidly change and shape new forms of needs and widening the variety of products for customers (Dodgson G. S., 2008).

In order to achieve diffusion, innovations need to observe the so called Rogers 5 factors for innovation adoption:

- *Relative advantage* over the competition products or services. The adoption of the innovative product is more likely if it retains an advantage in quality, features or price over the other products/services. Of course, the bigger the advantage, the better.
- *Compatibility* with the existing values, past experiences and needs of potential adopters.
- *Complexity,* as in, the more complex a product/service is, the harder it is for it to achieve diffusion.
- *Trialability,*or how much an innovative product/service is available for testing by the final user before its sale. Not being able to try beforehand can hinder the ability of an innovation to gain the approval of the market.
- *Observability* of the product, or how easy it is to notice the innovation. A very observable product is more likely to gain the attention of the mass market (i.e. smartphones are very observable because they are carried with the owner all of the time and very visible, whereas home personal computers never leave the house and even though they may be very innovative, they have less observability because they never leave the house).

Innovations which are perceived to have better Relative Advantage, Compatibility, Trialability, Observability and lower Complexity will have a better chance at fueling mass adoption and diffusion. (Rogers, 2002)

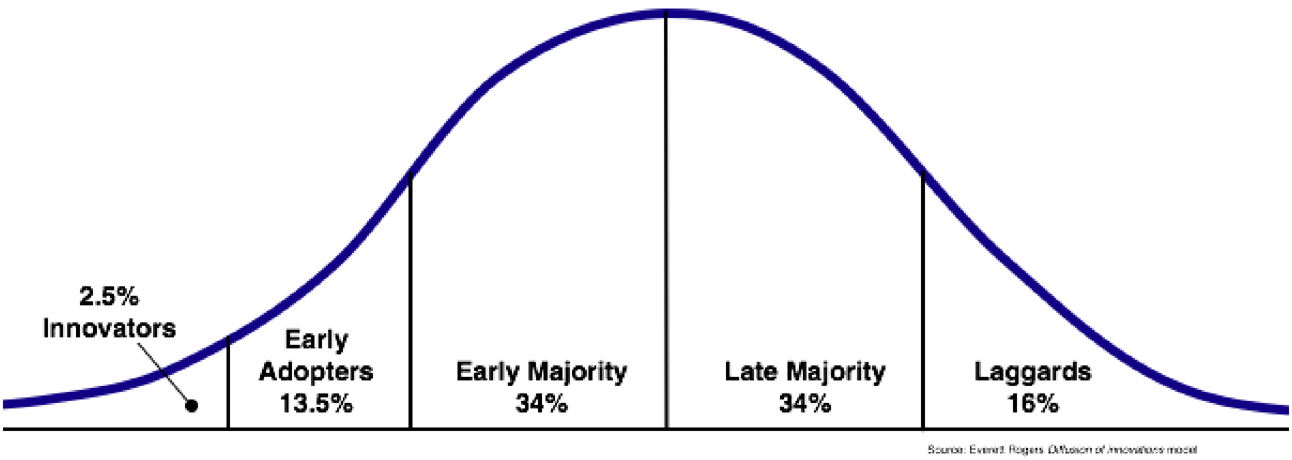
On the same topic of adoption, there is also to consider the segmentation of the users of innovation with regards to their different preferences and willingness to approach a new product or service. Rogers presents several different users with different adoption traits, listed increasingly in time of adoption following the release of an innovation:

- *Innovators* are the users who like to experiment with new things and are risk prone, accepting the risk of failure in return for new features and experiences offered by the new innovative offer. They may act as gatekeepers for introducing new ideas to the mass market.
- *Early adopters* are usually key opinion leaders who influence a number of people with their reviews and valuations.
- *Early majority adopters* are the followers of the early adopters. They are the ones who accept the opinion of the latters and start building the diffusion network, with adoption coming a little later in time.
- *Late Majority adopters* are the users who wait for the innovation to reach a considerable diffusion before actually trying it. They are concerned with the safety of the innovation, but do follow the pressure of the environment adopting it.
- *Laggards* are not easily influenced by peer pressure and are reluctant to adopt new products or services. They value the cost of

failure higher than the other categories and therefore will wait until they are forced to switch to the new technology before adopting.

These categories are just ideal and don't fit precisely how innovation is diffused in the market. The same user may be considered a Laggard for a specific kind of innovation while sporting a different stance with regards to others. (Dodgson G. S., 2008)

As an example of this adoption curve, this is the graph for adoption of tablets in Singapore:



(Ashworth, 2010)

From the graph you can see the trend of diffusion of an innovation, impacting initially only a small percentage of the total users, and then performing a bell-shaped diffusion rate, reaching its peak between the Early and Late Majority as time from the innovation progresses.

Diffusion is very hard to achieve though. The rate of failure of innovative products and services is very high, and only a few achieve very high profitability. Out of all the innovations in a portfolio, usually a very low percentage accounts for the profits, and the rest accounts for losses. (Cellini, 2012)

Innovations are mere options for the future, most of them will never be realized, or will be and will fail on the market. Not innovating though is not sustainable for any enterprise that wants to be on the market in a sustainable, long term, fashion. The process of trial and error is very risky, but the rewards are extremely high in case of success: diligence persistence, talent and luck are required to pursue it. (Dodgson G. S., 2008)

VI. Chapter Conclusions

In this chapter we analyzed what innovation is, how it is measured and its impact and effects a macroeconomic and microeconomic level, and on the market valuation of a firm.

These topics are the fundamentals on the concept of Innovation which will be later reprised in order to proceed with the analysis of the effects of capital structure on the degree of innovativeness of firms, where R&D statistics, Patent metrics and the other concepts will be used in order to examine how this interaction works and corporate financing and innovation do influence and shape each other in innovative firms.

2. FINANCING INNOVATION

In this chapter we will examine how the capital structure of technological firms is influenced by their innovative nature, after an analysis of the characteristics of financial markets and the inherent market imperfections.

I. Market Efficiency and restrictions of Technological Innovation

Following the assumption of efficiency of financial markets, given that no information asymmetry is present between investors and firms, and consequently all of the investors possess perfect information, every company should be able to return to all the aforementioned investors a positive Net Present Value (NPV) for their investments. Therefore, the use of internal (auto-financing, insider risk capital) or external (credit, bonds and external risk capital) funding should be indifferent (Oriani, 2005).

If external investors share the same set of information as insiders do about firm activities, the cost of external resources should be the same of internal resources. On this matter, Fama makes a distinction between three different degrees of efficiency of markets:

- Weak form, where available information is only represented by historical share prices;
- Semi-strong form, where all publicly available information is taken into consideration when valuing company shares;

- Strong form, where investors have all possible information available about firms with publicly traded shares (Fama, 1970).

This last formulation of the financial markets assumes that information is publicly available and free from cost. On the other hand, it is also possible to define efficient markets when information is costly. In this case, the price of traded shares reflects the relative information available at the valuation date, where the marginal benefits of taking an action according to that information set are equal to the marginal costs of information itself (Jensen M. , 1978). Both these two definitions of market efficiency bring us to the progressive rebuttal of a perfect market efficiency assumption: internal and external funding are not indifferent solutions, financing constraints may emerge, and consequently not all profitable investments of a company can or will be financed (Oriani, 2005).

Concerning specifically the financing of innovation, several problems emerge other than the traditional ones about the funding process. R&D investments present for the potential investor some peculiarities when compared to traditional investments. First of all, the mid-term expected value of such investments is an intangible activity, represented by new knowledge. The definition of the latter and measurement present several problems, largely still not solved (as seen in the previous chapter). Furthermore, the expected return for R&D investments is subordinated to higher uncertainty when compared to other industrial investments. These aspects can bring to critical failures of the market which require specific elaboration on the financing models of R&D activities.

Four critical aspects have to be considered:

- The appropriability of the economic value of knowledge;
- The gap between social returns and private returns of R&D investments;
- Asymmetric information;
- Moral hazard. (Oriani, 2005)

In order to discuss the first point, we need to mention the Arrow paradox. It states that, since the use of knowledge is not exclusive, imitation processes can reduce or completely deny the economic benefits for the innovator, with a negative effect for firms on the appeal of R&D investments (Arrow, 1962). The adoption of protection of intellectual properties discussed in the first chapter does mitigate the problem, but doesn't remove it. Therefore, in markets where innovation is not easily protected from imitation by competitors and diffusion, it will be harder to find investors willing to put resources in new technological innovation projects.

The second critical point was proposed in its fundamental contribution by Nelson and sprouts from the conclusion that social returns of R&D investments, represented by the benefits to the community, are higher than the private returns for the company investing in innovation. While private returns just create a surplus for the producer, surplus represented by the higher profits that the latter will be able to obtain thanks to the innovative effort, social returns can be considered as the better price-quality ratio of products and services purchased by the market, and the simultaneous benefits on other products and processes in other industry sectors (Nelson, 1959). The returns result higher in relationship with base research activities, which have a larger scope and possible applications, not being strictly bound to a material product/service or process.

Although, since the returns for the private investors are only represented by their own surplus, the investment in R&D, and especially in base research, is suboptimal if only financed when considering the social benefits. This market imperfection justifies then the presence of public financing of industrial research (Oriani, 2005).

Finally, asymmetric information and moral hazard are the last two critical issues which definitely put into question the perfect efficiency assumption for the innovation financing market.

Information asymmetries are created from the inventor having a better knowledge of the nature and possible technical and market success of the innovation with respect to the external entities financing the innovation itself. This implies that external investors may require a higher rate of return for the resources destined to R&D activities, when compared to internal financing. In fact, an informed investor on company activity will be willing to, given equal conditions, receive lower returns on the capital allocated on research when compared to an external, non-informed investor. The latter is incurring in a higher risk of making a bad investment. This situation creates issues with transaction efficiency of financing capital, limiting the available amount of financial resources for innovation and increasing its cost.

The asymmetric information problem was first studied by George Akerlof, and can be applied to the innovation capital market as it presents the same condition of information discrepancy between the commercial parties of the famous second-hand cars market used in his work (Akerlof, 1970).

Concerning other kinds of frictions, several studies have highlighted that the financing constraints with regards to the innovative process is worse for younger companies and companies heavily based on the development of new technologies (Himmelberg & Petersen, 1994) (Ennew, 1996) (Guiso, 1998). This situation is caused by the great information asymmetry between investors and inventors. In fact this situation especially characterizes small and young technological companies, which may induce the investors to charge higher costs for their capital compared to what they request to mature companies.

Finally, moral hazard problems related to R&D can sprout as a consequence of agency problems and the separation between ownership and control (Jensen & Meckling, 1976). The issue emerges with managers, whose professional path is bound in the long term to the life of the specific company they work in. Therefore, managers have a higher adversity to risk compared to shareholders who, having the chance of diversifying their investments with portfolio strategies, prefer investments with higher returns and risks. As a consequence, managers may focus on short term returns instead of long term investments (R&D being one of them), since shorter investments usually have a safer outlook. Also, reducing the control that ownership has over management reinforces the problem. The presence of institutional investors, like investment funds, pension funds or other financial intermediaries may reduce the problem with a more active approach towards company decisions (Oriani, 2005).

II. Sources of Financing for Technological Innovation

As mentioned in the previous paragraph, a company may use internal or external sources to fund their technological innovation. If financial markets were efficient, all the financing methods should have the same cost and the company should be indifferent to the several sources of financing available. Given the inefficiencies mentioned in the previous paragraph though, a hierarchy among financing methods should appear (Myers & Majluf., 1984).

Because of the information asymmetry, internal resources should be the first source of financing, external ones becoming an option only if internal funding is not enough to cover the investment, due to the higher cost for the firm external financing. Conversely, internal resources are often not capable of financing all the R&D projects of a company: thus financial constraints may limit the ability to innovate of a technological firm (Calderini, Oriani, & Sobrero, 2004).

When the only option is external financing, debt is usually not very effective in financing R&D investments because of the following reasons:

- Because of the nature of debt contracts, based on a fixed remuneration schedule, creditors can't have any rights to the company net profits if the firm is having a positive trend, while suffering a high risk in the case the debtor bankrupts. When the uncertainty over the results is high, like it usually is for R&D investments, the expected return for investors may become negative, thus convincing potential creditors to not concede loans.

- As mentioned before, information asymmetries are an important factor of R&D investments and may lead potential investors to refrain from giving credit to innovating companies. This phenomenon, known as credit rationing, creates a scenario where even though R&D investments have a positive expected return, they are not financed because of the lack of available resources. This situation has also been demonstrated to get worse off for smaller, younger and high-tech firms (Himmelberg & Petersen, 1994).

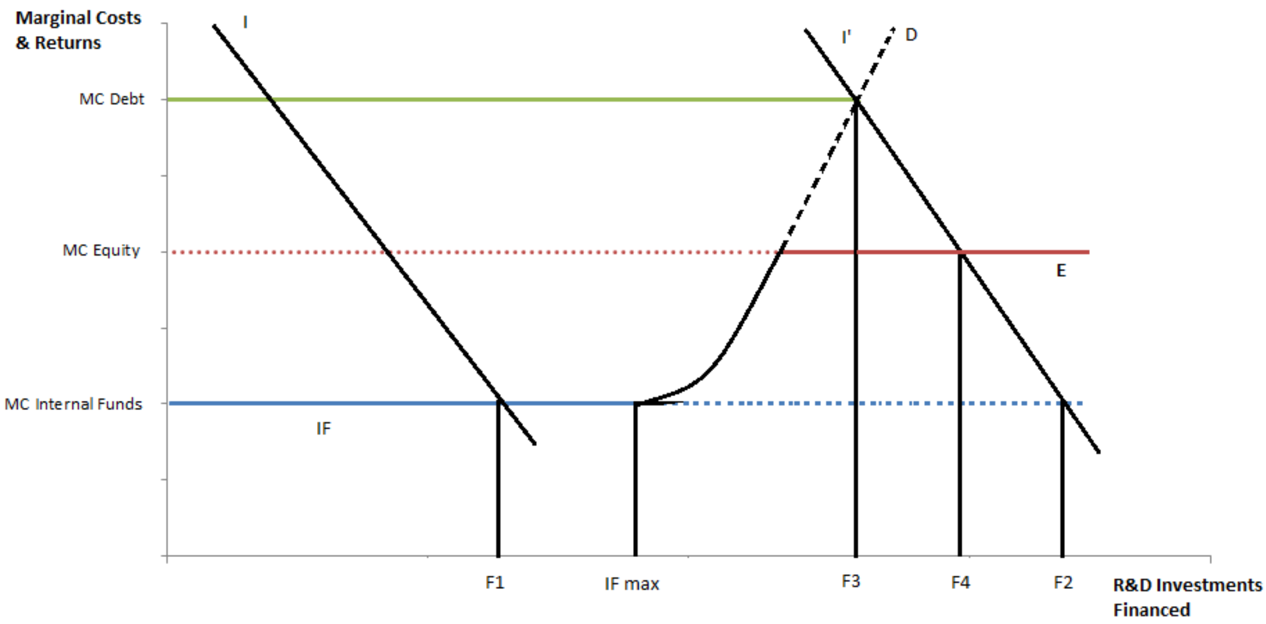
- The final product of R&D activities the production of knowledge. Knowledge is an intangible asset and therefore doesn't offer any tangible security to be pledged to creditors. In fact, often loans are given only with tangible assets pledged as security for the creditor, and tangible assets are usually very abundant in innovating projects (Oriani, 2005).

Therefore, when technological innovating firms need external financing, they usually use equity funding to finance their innovations. This happens because of several reasons:

- Unlike debt, equity does not require collateral resources as security for the shareholders.

- Returns for shareholders don't have an upper limit as debt holders have (in their case, represented by the interest they receive for the loan), and fully benefit from any positive results by the innovating firm.
- Additional equity raises don't affect bankruptcy risk (Oriani, 2005).

The above characteristics can be visualized through the following graph.



Adapted from: (Oriani, 2005)

This graph shows in the vertical axis the marginal costs and returns of R&D investments and the financing sources; on the horizontal axis the amount of R&D investments financed. The firm has available a certain amount of internal financing (in the graph ***IF max***), composed by the firm's cash flows, that are assumed to have a constant marginal cost. The ***I*** curve represents the demand of R&D Investments, which has a negative slope since R&D investments have diminishing marginal returns given a limited amount of investment opportunities.

The firm finances R&D investments until the equilibrium where financing sources marginal costs equal marginal returns of the R&D investments. In this case, ***F1*** represents the point where the equilibrium is met.

Let's assume that an external shock, like a breakthrough technological discovery, the demand curve moves to the right (***I'***) because of a higher demand of R&D investments. The movement also implies that for any given level of investment, higher marginal returns will be required. If the capital market was efficient without information asymmetries on the firm's investments, it would be possible keep financing R&D at a constant marginal cost, obtaining a new equilibrium at the new R&D investments amount at ***F2***. But because of the aforementioned imperfection of the financing markets for technological firms, credit rationing reduces the financial resources available, and may hinder the ability to receive external financing at all and positioning the maximum possible financing to ***FI*** max, clearly not reaching an equilibrium with the demand curve ***I'***.

Even if there was available Debt, its marginal cost curve would be very elastic given the aforementioned problems of debt financing of R&D projects, eventually reaching an out of the equilibrium cost of financing (***D***). The higher the financing demanded for R&D investments, the higher the returns creditors would ask for the greater risk they would be facing. The equilibrium would be met at ***F3***, but the firm would probably prefer the equity financing route before getting to ***F3***. Indeed, if available, equity would have a lower marginal cost level, since more equity issuance doesn't increase company bankruptcy risks, contrary to what happens with debt. On the other hand, equity still has a higher marginal cost when compared to internal resources, because of internal asymmetries in the firm and the monitoring costs generated by agency costs.

The firm should then finance its R&D projects with equity instead of debt from the point where the debt marginal costs are equal to equity marginal costs, because, for a higher demand of investments, equity will reach equilibrium at lower marginal costs.

Udell described the financial development of a firm, finding for each stage of its growth the optimal financing method. From its work, a possible financing gap in the early life of an innovative company emerges, when the latter can't fund itself in a sustainable way with internal capital (Berger & Udell, 1998). Thus, in order to finance further innovative projects, it needs to access the equity markets. Equity financing usually takes place through markets organized in two different forms.

Public equity is represented by risk capital that can be obtained by publicly listed companies. On the other hand, private equity is risk capital obtainable by non-listed firms thanks to specifically created funds. Investments in private equity include *venture capital* and *buyout* (Calderini, Oriani, & Sobrero, 2004), of which we are going to talk in the following paragraphs.

It has to be noted though that the development of a share market greatly favors the buyout ability of venture capitalists that, through the IPO and listing of the new firms, can monetize the original investment.

a. An introduction to the Financing Cycle

As we have seen, classical capital structure theory from the Modigliani & Miller propositions may not apply for new, privately held technological firms because of the assumptions of no transaction costs, perfect information, full access to all of the alternatives between debt and equity (Modigliani & Miller, 1958). Thus, the pecking order varies according to the imperfections related to the life cycle stage of the firm. According to Coleman and Cohn, a specific pecking order theory is especially relevant for privately held small firms, because of the information asymmetries. Since these firms don't have the obligation to publish annual reports and their financial statements are not publicly disclosed, outsiders cannot know the financial conditions of the firm. This, as seen in the previous paragraphs, leads to a high risk perception of the new firms and consequently raises the cost of external funding (Coleman & Cohn, 2000).

Therefore, a "life cycle" financing pattern has been found for firms undergoing growth. According to the work of Berger and Udell, small, privately held firms are "informationally opaque", and therefore have issues in obtaining external financing resources. As a consequence, they tend to rely on insider financing like the personal financial resources of the owners, and, as in the case the firm is profitable, internal funding. However, when the firm needs to undergo new projects to funnel its growth, these financial resources are not enough anymore. Thus, when the ownership has to turn to external financing, their preference is for debt rather than equity, since debt doesn't make them lose any control of the venture. Finally, as the firm grows it becomes less informationally opaque, and eventually the high cost of debt makes it less desirable than external equity, which finally becomes a viable choice for the now grown firm. (Berger & Udell, The Economics of Small Business Finance: The Roles of Private Equity and Debt Markets in the Financial Growth Cycle, 1998).

b. Stock Markets

The availability of liquidity through organized stock markets has historically fueled the diffusion and the development of new technologies. Stock markets have an impact on innovation mostly through the following three functions:

- Stock markets are a source of financing through equity, which is less costly under certain conditions (explored in the previous paragraphs) compared to debt.
- Stock markets operate as a signaling tool for managers concerning their internal investment decisions. According to financial theory, the market value of a firm without debt should be equal to the present value of asset-generated future cash flows. Price variations of a listed firm's equity, after information concerning their investments is disclosed to the public, describe what the market thinks about the effect that those investments will have on future cash flows and therefore the company value. This mechanisms works as a signaling tool with regards to their investment decisions.
- Finally, stock markets ease and smooth control transfer between different entities thanks to their institutional nature. The constant

threat of an hostile takeover forces the listed companies' management to achieve optimal results.

These three characteristics are closely intertwined. In fact, the listed firm streams a flow of information to the market through its official documents and institutional communications, while the market makes a valuation of the firm according to the information it receives and makes adjustments on the firm's shares price. Because of the threat of hostile takeovers, the firm's decisions will be taken with the objective of maximizing share value to minimize the risk of the latter happening. On the other hand though, the mechanism can have issues because of the information asymmetry between outsiders and insiders, who could be tempted to raise the cost of equity in order to give shareholders a high return to avoid that they sell their shares. The higher cost of equity could then lead to a reduction of R&D investments, especially, as we have seen in previous paragraphs, for young and highly technological firms (Oriani, 2005).

Because of this issue, governmental authorities in many countries created dedicated markets for young and technological firms, to allow them to be listed and collect funding in an efficient way. This has been achieved with less restrictive requirements for the IPO on such markets even to small and young firms. As mentioned in the previous paragraph, the existence itself of such markets is also a complement for the venture capitalists when they have the need to cash out, and makes the whole process more effective. Indeed, the creation of the Nasdaq Index in the US has had an important positive impact to the growth of the venture capital business (Oriani, 2005), and the creation of similar new markets has also helped the financing of new and small companies in France, Germany and Italy (Bottazzi & Rin, 2002).

c. Angel Investors

As we have seen, early financing usually comes for small firms through informal channels. Angel investors, or Business angels, are indeed informal venture investors, who fill a void in the risk capital market for new firms. Indeed, business angels provide the majority of unsecured funding for smaller capitalized firms in the US (W.Wetzel, 1983). The financial market they create is imperfect but vital for small firms with limited access to external funding (Haar, Starr, & Macmillan, 1988).

Angel investors share some demographic characteristics, as reported from the study from Haar & alia, are experienced investors, highly educated (usually with an MBA or a postgraduate degree) and with high incomes. They tend to have experience in stocks, bonds and venture capital funds as well as informal risk-capital ventures. They are motivated by the potential for high return and capital appreciation of their investments into small firms.

Angels invest in a wide range of venture projects, with a preference for high technological manufacturing firms, because of their high risk-high return profile. Indeed, they expect a high rate of return and, on average plan to liquidate their investments in a span of 3-7 years (Haar, Starr, & Macmillan, 1988).

The referral network is a very important part for this informal financial market. Indeed, informal investors mainly approach close contacts such as friends, relatives, colleagues and business associates. The latter are inclined to be supportive and follow a trusting investment behavior pattern, based on the recommendation of the angel investor. Investing through this pattern ensures that the capital requirements are met exclusively through the referral network. On the other hand, the study from Haar et al. suggests that also inviting an external professional in the venture funding gives the investment a better probability of success, because of their higher skill in evaluating successful prospects. Thus, the better strategy may be to provide the funding through the network and get the help of external professionals in the screening of venture pitches (Haar, Starr, & Macmillan, 1988).

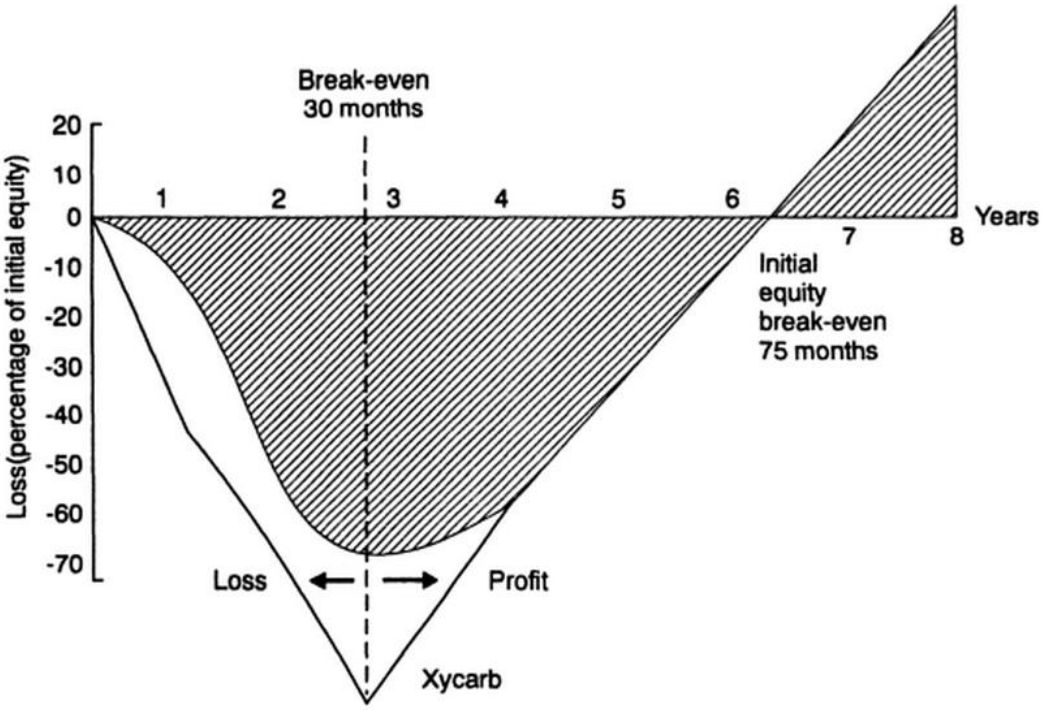
Some aspects of such kind of investments are critical in order for them to be successful for the investor. Indeed angels should only invest in ventures in which the entrepreneur can be relied on in the evaluation and management of the venture's risks. Gambling entrepreneurs are dangerous, as they raise the risk of the investment, which is already high, and create agency problems. (Haar, Starr, & Macmillan, 1988).

d. Venture capital and buyout

The Venture Capital process indicates all the financing through venture capital funds to young and highly technological firms that couldn't receive traditional financing methods (bank debt and bonds) because of their intrinsic risk and the very low liquidity of their activities. Different situations may be comprised in this definition (Oriani, 2005).

In general, Venture Capital investments take into consideration a long-term approach, where it takes longer time frames to achieve a breakeven point and even longer to achieve the equity break-even. This is often in contrast with the mindset of traditional investors who generally favor short term investments due to their lower risk. In the following graph, the payback period of firms owned by the Dutch venture capital firm Indiviers is shown from 1972 to 1982. In order to achieve the break even, on average 30 months were needed and 7 years to recover the investment. This is largely why no bank or institutional lender would concede financial resources to these kinds of firms (Bygrave & Timmons, 1992).

Initial Losses by Small New Ventures



Source: **Indivers.**
Note: **Average of 157 companies at various stages of development USA, 1972–1982.**

(Bygrave & Timmons, 1992)

According to the European Venture Capital Association and the National Venture Capital Association from USA, an investment in order to be considered venture capital, needs to possess the following characteristics:

- It must be financing a firm with high growth potential in the early stages of its activity.
- The financed firm strategy must be based upon the marketization of an innovative technology, the access to a new market or the new application of an already existing technology.
- The shares held by the financing entity into the new company have to be relevant.

Financing needs may vary in a significant way during the life cycle of a company. New companies which go through the venture capital cycle face a sequential series of stages, accompanied by a parallel development of financing needs. We will proceed into the description of the aforementioned different stages of the venture capital cycle.

At first, the company is in an embryonic stage, called **Seed**. In this moment, the entrepreneur idea has not yet been tested, and the main activity consists in running tests with the new technological solution which, if successful after the testing phase, will develop into the creation of a prototype. The financing needs of this stage may vary according to the technological nature of the innovation, but it can only be satisfied with investors possessing a long term results orientation and a high risk acceptance.

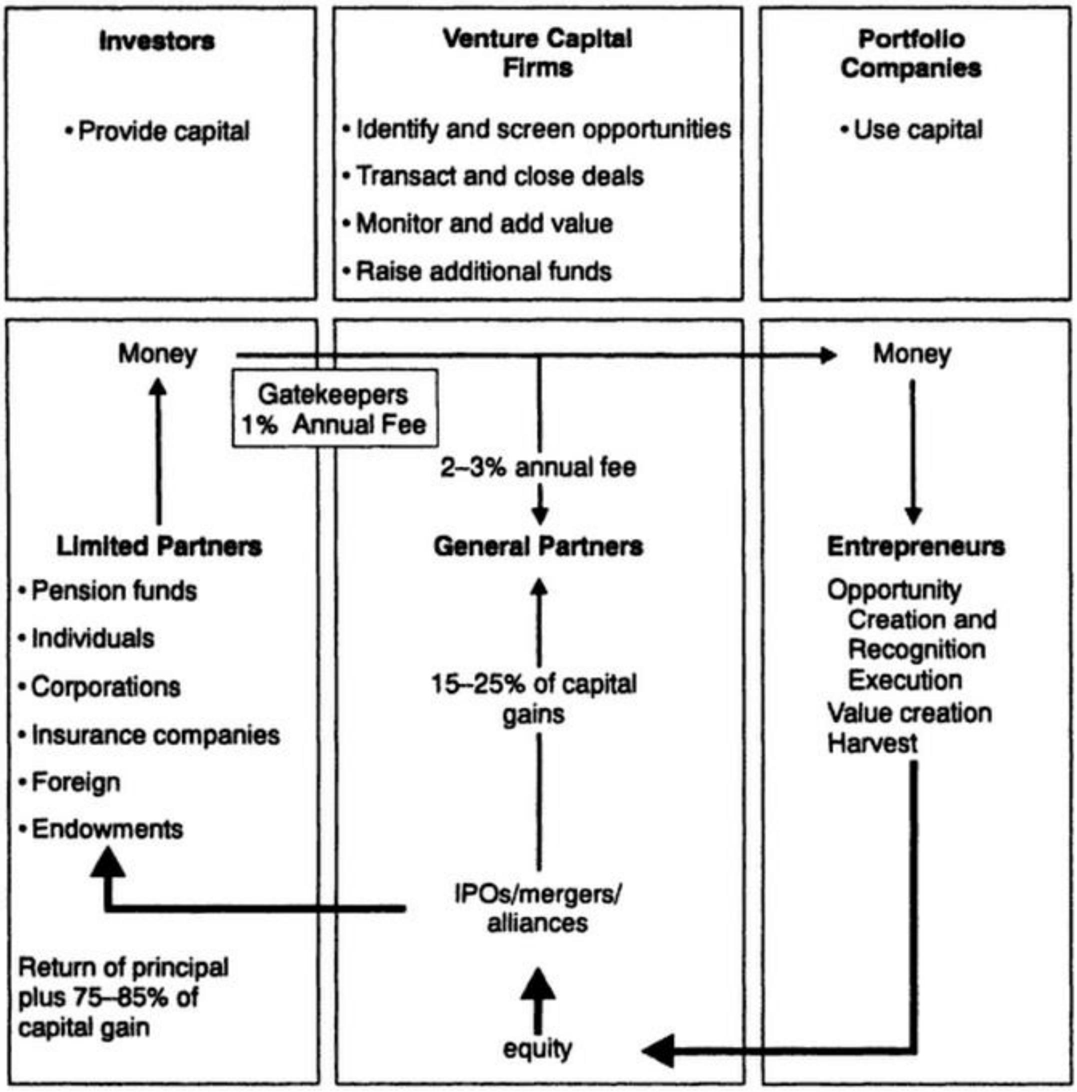
The following stage is characterized by the actual creation of the company, **"Start-up"**. In this time, the company further develops the product, analyzes the market in a deeper way and revises its business plan according to its needs. This stage ends with the creation of a significant customer base. Financing needs during this period are usually represented by the management team and technical staff retribution, marketing expenses and equipment investments. Risk is still high because of the highly volatile sales volume.

First Growth. After the initial sales, revenue volume starts to grow rapidly and, consequently, company problems and needs begin to change. Working capital raises and the firm's growing cash flows still cannot cope with the costs to continue growing. The company needs then to have access to more external financing. On the other hand, risk is decreased at this stage compared to the previous ones, so potential investors won't be just the ones looking at the long term, but also those with a short-term mindset.

Sustained Growth. If the firm survives successfully to the previous stages, its growth rate starts to get stable and it is definitely considered a growth business. The company still has external financing needed, but has now acquired a stability which allows it to access new forms of financing.

Cash-out. This is the stage where original investors choose to sell their stake through the listing of the firm or the acquisition of the latter by another company. (Sandri, 1988)

Following this structure and its various stages of economic and financial development of the financed firms, venture capital financing is usually organized in a series of sequential financing rounds, at the end of which the investor may decide to continue the investments and how many resources to allocate according to the previous performance and the evolution of the events, or terminate them. The legal foundation of venture capital is usually represented by a partnership agreement for the creation of the fund. The venture capital takes the role of general partner, obtaining the duties and responsibilities of organizing the fund, finding the investors, collecting the needed capital and selecting the opportunities. Investors participate as a limited partner, supplying capital and receiving their returns, but are not involved in the managing of the fund.



(Bygrave & Timmons, 1992)

The graph shows the interactions of the various parties involved in the venture capital cycle. The specific peculiarities of the financing structure of venture capital make it one of the principal instruments sustaining innovation for smaller and younger companies. Indeed, this process can fill the gap created between entrepreneurs and external investors in the early stages of firm development thanks to its ability to select a portfolio of opportunities which in its overall composition supplies a return suitable to the risks undertaken. Because of the asymmetric information theory of the financial markets, venture capital helps smoothing the financing process of younger companies because it reduces the problem through the acquisition of detailed information about the financed companies and their relative industrial sectors. This happens thanks to venture capitalists spending most of their time in contact with the companies which are part of their portfolio, and taking over a fundamental role not only during the start-up, but also in the subsequent growth stages when the firm needs a large strategic view in order to face the emerging challenges created by their growth itself. Venture Capital companies also create a bridge between the investors community when the financed firms are able to become listed in an organized stock market, in the maturity stages of the start-up (Oriani, 2005).

Empirical studies confirm that the venture capital cycle favors technological innovation both at a macroeconomic level (Kortum & Lerner, 2000) and for single firms (Bottazzi & Da Rin, 2002) producing a higher numbers of new patents filed, economic growth rate and returns. But these advantages are only available to industrial sectors with intellectual property regulations, where new firms can protect their intangibles in their early development stages. Furthermore, venture capitalists only contribute to the financing needs of the new firms in their early stages, demanding that the latter finance themselves with the equity market in order to obtain new resources when maturity is reached (Oriani, 2005).

Exit strategies are indeed an important part of the venture capital cycle, since it is the moment where the initial investors have their return, and there are some issues with this kind of strategy. The type of exit is not only relevant for the investor, but also for the entrepreneur, who has to acknowledge that the venture capitalist will exit his venture, and therefore that his company will be bought by another firm. Or, if he wants to keep the ownership of the firm, has to find the buyout capital through an IPO on the stock markets (Black & Gibson, 1998).

The difference between the two exit strategies are several, the first of them being that an IPO keeps the firm independent while a trade sale doesn't. Thus, many entrepreneurs tend to prefer the IPO over a trade sale, as they enjoy keeping a managing role in the company, which leads to conflict between venture capitalists and the respective entrepreneurs over the exit strategy (Schwienbacher, 2008).

Therefore venture capitalists tend to acquire rights beforehand on the exit strategy in order to be able to force an exit strategy. The exit strategy though is not indifferent to the value of a firm: in fact they can have substantial effects on the future performance of the venture. According to Schwienbacher, more innovative and profitable technological firms are more likely to go the IPO route. On the other hand less innovative ventures, based on imitative or derivative projects, tend to be acquired by larger companies.

The exit strategy decision may create agency problems, since entrepreneurs receive private benefits from their decision of staying independent through an IPO after the exit by the venture capitalist. This in the end influences how the company is shaped in the first place, making entrepreneurs prone to favor business and R&D strategies which lead to an IPO over an acquisition, and ultimately raising the risk of failure because of excessive innovation.

In the end, the exit strategy ends up having an impact on financing habits of innovative firms, and therefore shaping innovativeness itself and product market outcomes (Schwienbacher, 2008).

e. **Crowdfunding**

An alternative and presently trending way of financing new ideas is represented by crowdfunding. With this process, an entrepreneur overcomes the aforementioned financing constraints for innovation by trying to raise capital from a wide audience, instead of a small group of investors (Belleflammea, Lambert, & Schwienbacher, 2014).

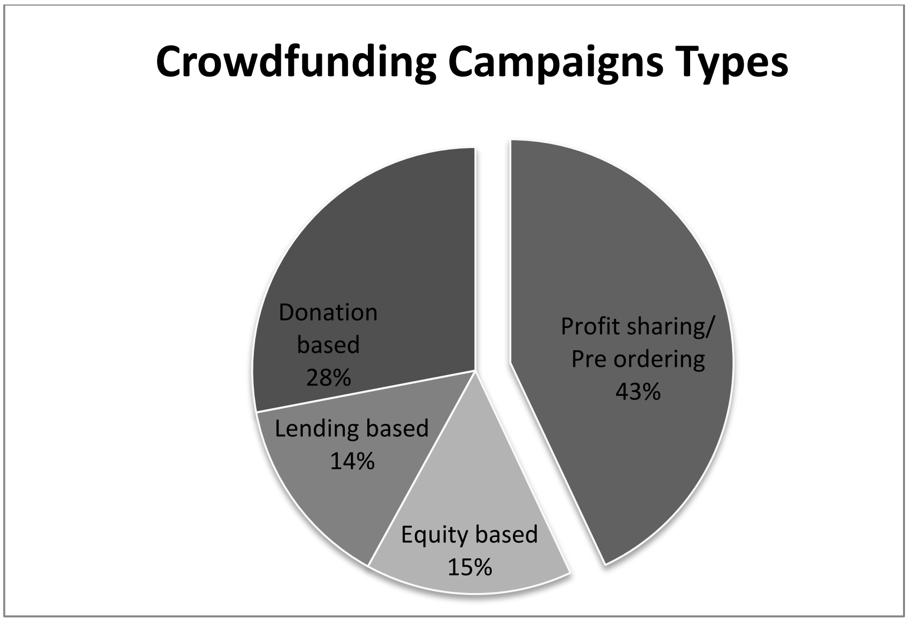
The Crowdfunding method derives from the "Croudsourcing" concept that, similarly to how Crowdfunding works, is based on the interaction between the firm and a large audience in exchanging ideas and information and having the "crowd" involved in the development of new products and projects (Bayus, 2013).

Following the definition of Belleflammea, Lambert, & Schwienbacher, Crowdsourcing can be described as the following:

> *"Crowdfunding involves an open call, mostly through the Internet, for provision of financial resources either in the form of donation or in exchange for the future product or some sort of reward to support initiatives for specific purposes."*
>
> (Belleflammea, Lambert, & Schwienbacher, 2014)

The reward for the financing crowd can be either monetary or non-monetary; sometimes the crowdfunding campaign is based on the exchange of future products or services, other times just in exchange of recognition or voting rights.

As we can see from the following pie chart, pre-ordering and profit sharing Crowdfunding campaigns methodologies are the prevalent crowdfunding methods companies are undertaking.



Data from (Belleflammea, Lambert, & Schwienbacher, 2014)

Sample of 348 crowdfunding platforms in 2011.

Preordering and Profit sharing are essentially campaigns based on the exchange of present day funding by the crowd, in return of a product not yet produced by the company in the case of Preordering, or in return of future sales profits in the case of Profit sharing.

It’s interesting how some cases studied indicate that crowdfunders are usually have a high willingness to pay and are motivated by more than just the product consumption (Gerber, Hui, & Kuo, 2012). At the same time, being crowdfunders is in itself a reward for them due to the feeling they get of being part of a “privileged” community (Belleflammea, Lambert, & Schwienbacher, 2014).

Roots of this behavior can be also found in the adoption segmentation reported in the first chapter: crowdfunders are usually part of the “Innovators” group, who are eager to try new technologies and are extremely willing to experiment with innovative products. In conclusion, crowdfunding generates social interactions that are in itself motivation for the crowd to participate in the funding project, which in turn makes this this financing route a viable alternative for small and innovative companies who are having trouble gaining access to financial resources for their projects, due to the aforementioned problems of financial market imperfections with regards to small and innovative firms.

Kickstarter, one of the website platforms where it is possible to launch a crowdfunding campaign, by the end of 2014 reports the following metrics:

Projects and Dollars

Category	Launched Projects	Total Dollars	Successful Dollars	Unsuccessful Dollars	Live Dollars	Live Projects	Success Rate
All	**195,7**	**$1.45 B**	**$1.25 B**	**$179 M**	**$25 M**	**5,399**	**39.95 %**
Games	14	$292.88 M	$257.56 M	$32.00 M	$3.31 M	437	34.40

%

Film & Video	42,084	$253.66 M	$211.63 M	$40.12 M	$1.91 M	702	39.23 %
Technology	9,865	$227.25 M	$190.34 M	$28.51 M	$8.40 M	756	24.59 %
Design	11,656	$226.36 M	$196.51 M	$24.61 M	$5.24 M	503	35.57 %
Music	34,815	$132.99 M	$120.42 M	$11.31 M	$1.26 M	632	53.68 %
Publishing	21,635	$63.22 M	$52.95 M	$9.48 M	$792.56 K	530	30.93 %
Food	11,474	$62.44 M	$51.20 M	$10.14 M	$1.09 M	492	30.20 %
Fashion	9,202	$48.94 M	$41.08 M	$6.43 M	$1.43 M	367	26.66 %
Art	15,361	$45.52 M	$39.19 M	$5.80 M	$518.44 K	313	44.70 %
Comics	5,03	$33.61 M	$30.74 M	$2.58 M	$284.45 K	100	50.10 %
Theater	7,227	$29.17 M	$25.71 M	$3.29 M	$171.07 K	105	62.43 %
Photography	6,248	$17.47 M	$14.61 M	$2.70 M	$163.15 K	162	31.42 %
Dance	2,361	$8.19 M	$7.57 M	$539.29 K	$80.52 K	45	67.18 %
Journalism	1,831	$5.28 M	$4.45 M	$722.45 K	$108.11 K	90	27.69 %
Crafts	2,901	$4.36 M	$3.53 M	$732.47 K	$92.69 K	165	28.07 %

(Kickstarter Stats, 2014)

We can see from this chart how it has raised 1.45 Billion dollars, with campaigns being successful overall 39.35% of the time. On the other hand, due to an obvious correlation bias, the successful campaign money is 86.2% of the invested money, across a multitude of industrial segments. That is the percentage of the money invested in Kickstarter campaigns resulting in the promised exchange of products with funders: a rate sufficiently high to make the crowdfunder confident of not losing his investment.

According to Forbes, Crowdfunding has been a "tremendous tool" in producing sales, with an average quarterly increase in sales of 24%, and 341% increases for equity based raises in post crowdfund quarterly sales. It has also been reported that overall in 2014 Crowdfunding campaigns achieve a very interesting ROI of $813 Dollars per hour spent running it. Overall, at the present day, it is a rising method for the development of innovative projects (Conner, 2014).

On the other hand though, there are several concerns with the asymmetric position between the entrepreneur and the crowd, during the crowdfunding practice. Especially in pre-ordering campaigns, due to this information disparity, the final product quality is subject to high volatility. First, because the product is not yet on the market and it is not available for any trial or testing by the audience. Furthermore, final products are only described with a promise of what they will actually be like once the campaign is complete. This situation generates a moral hazard problem: because high quality products cost more to produce compared to low quality ones, with the campaign already backed, the entrepreneur may use the asymmetric information situation to increase its profits by mimicking a high quality product, while actually sustaining lower costs. This is why entrepreneurs should seek signaling methods in order to communicate to the audience their high quality standards (Belleflammea, Lambert, & Schwienbacher, 2014).

Crowdfunding is thus not only a financing decision, but involves also a mix of operating choices. While it is indeed a way for entrepreneurs to raise money for their projects when other financing methods are precluded to them, pre-ordering campaigns also affects sales and future production level, with price setting occurring at the same time as the funding. On the other hand, profit sharing campaigns are purely financial decisions, since the operating income is the same as with traditional funding.

Other differences between pre-ordering and profit sharing methods concern the right fit of each method, according to Bellaflammea, pre-ordering is the best route with the low financing needs, while profit-sharing is best when there is a higher demand of financial resources (note that this statement assumes that financing level needed should always be measured compared to the market size). On the other hand, profit sharing should be the best route for projects with high information asymmetry because of the moral hazard problems discussed above.

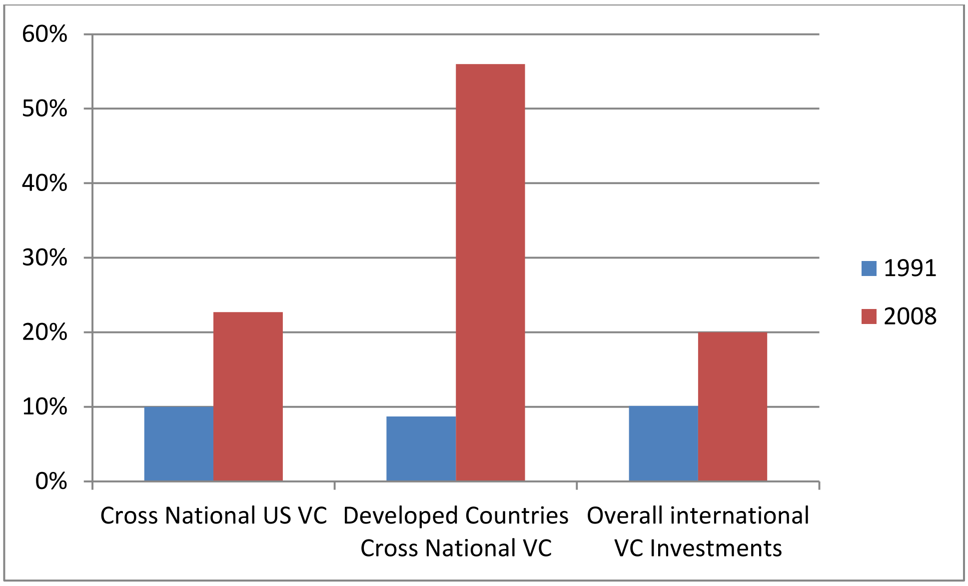
Finally the crucial issue for entrepreneurs should be building the "right community" of crowdfunders following their financing and operating needs. Entrepreneurs have to provide the right environment in order for the crowd to perceive the benefit of their participation in the campaign. Following the form and extent of the benefits at the disposal of the community, the entrepreneur should then choose the right campaign mechanism. The community created around the project is indeed a crucial tool in the hands of the campaign creator: in the absence of the non-monetary benefits given by the sense of participation of the crowd in the project, price discrimination is not possible and crowdfunding can never be more profitable than the traditional funding methods (Belleflammea, Lambert, & Schwienbacher, 2014).

III. The impact of Technological Innovation and Globalization on entrepreneurial finance.

During the last two decades, financing innovation, especially in the form of venture capital financing and similar funding methods, has gained higher importance through the years on an international level, while also undergoing changes during the same time span (Chemmanur & Fulghieri., 2014).

According to the related literature review by the Oxford Society for Financial Studies, this happened mostly because of two phenomena: the impact globalization and of technological innovation itself.

Concerning globalization, in the US Venture Capital investments in foreign projects and foreign investments in Venture Capital have raised from 10% of total investments in 1991 to 22.7% in 2008. Influencing these numbers is the growing amount of capital put into cross-national VC investments from developed countries internationally, which increased from 8.7% in 1991 to 56% in 2008, along with the parallel overall increase in international VC investments overall in the aforementioned countries, from 10.1% to 20% in the same time span (Chemmanur & Fulghieri., 2014). Thus, Venture Capital is becoming less restricted to country specific investors and the trend appears to have an impact on entrepreneurs of technological firms, who can look for international VC backing for their innovative projects in parallel to national resources (Chemmanur & Fulghieri., 2014).



Globalization data of VC
Data from: *Chemmar & Fulghieri 2014*

Technological Innovation, as mentioned above, is the second game-changer concerning entrepreneurial finance in the last 20 years. The developing of Internet and related technologies have greatly eased the ability to communicate and share despite long distances, without having to sustain heavy costs. This has been of great impact on financial markets and intermediaries such as venture capitalists, private equity firms and investment and commercial banks (Chemmanur & Fulghieri., 2014). This has been relevant in reducing the costs of monitoring for Venture Capitalists or in general any financial institution having investments not at the reach of their hand. In the end, this trend opened up national borders for investors and innovative entrepreneurs, a phenomenon strictly related to the above mentioned globalization of VC investments (Chemmanur & Fulghieri., 2014).

IV. Chapter Conclusions

In this chapter we have analyzed the particular condition of small, innovative firms in relation to their financing strategies. Information asymmetries and agency problems create a potential credit rationing problem, which, in turn, creates a different environment in the financial pecking order compared to the classical, Modigliani & Miller, assumptions. We see how these financing methods are developed and how they manifest themselves through the life cycle of a firm, from initial informal investors which provide private capital, to the venture capital funds up until the buyout and investor exit through IPOs and M&As. We have also explored the emergence of crowdfunding as a mean of collecting early financial resources, and tackled the raising importance that globalization is also having on all these financing strategies for innovative firms.

3. THE EFFECT OF CAPITAL STRUCTURE DECISIONS ON INNOVATION

After examining how Capital Structure of an Innovative firm is influenced by the Innovative processes and the market imperfections related to them, in this chapter we will follow the literature which tries to determine the impact of capital structure decisions of technological firms on innovation itself.

I. Financing decisions impact on Innovation

Financing methodologies for innovative firms spur a number of questions concerning the impact financial intermediaries may have on the innovativeness of firms themselves.

- Do financial intermediaries play an important role in stimulating innovation?
- If they do have a relevant impact, what kind of intermediary is the best in fostering innovation?
- What is the nature of the optimal contract between financial intermediaries and entrepreneurs in order to maximize innovation?
- How much does industry structure of financial intermediaries, and especially the competition level between them, affect the innovativeness of the firms they finance?

There are two clear channels through which financing can affect the innovativeness of a firm. The first one is the source of financing, as in the nature of the intermediary and the financing contract. In fact, these two parameters may affect the availability of financing resources at various stages of the technological firm, increasing the cost of capital and therefore the number of projects that the firm can sustain. The second channel is represented by the provisions of the firms' financing contract with the intermediary. Indeed, they may affect innovation by modifying the incentives for inventors and other employees engaged in innovative activity during the financing cycle of the firm (Chemmanur & Fulghieri., 2014).

Financing intermediaries have been argued by literature and practitioners to nurture entrepreneurial firms more than by just financing their projects. Through intensive monitoring, help in the development of high-quality management teams, the network they bring with them and their leverage with suppliers and customers, intermediaries have a remarkable impact on firms in their portfolio. These inputs by investors should lead to higher growth and performance in the portfolio of firms of Venture Capitalists or Angels. While there is some evidence supporting the above claims concerning venture capitalists (Hellmann & Puri, 2000) (Chemmanur, Krishnan, & Nandy, How Does Venture Capital Financing Improve Efficiency in Private Firms? A Look Beneath the Surface, 2011), to this day there is little evidence that examines such statements with regards to Angel investors since they are usually funders of early-stage ventures, as seen in chapter 2, and data is not publicly available. We will examine the impact of Angel Investors on the innovativeness of companies in the next paragraph, and later on the issues related with Venture Capital funds in general.

II. Angel Financing impact on the performance of Technological Firms.

In order to explore if Angel financing has an impact on the innovative performance of the firms in their portfolio, we will follow the work by Kerr, Lerner and Shoar, that tries to fill the gap in literature regarding evidence supporting this assumption.

Angel investors are increasingly structured as semiformal networks of investors, meeting at regular intervals to assess pitches of business plans submitted by entrepreneurs. They then may decide to conduct further due diligence on the pitches and invest their resources in some of the latter. The paper uses data on start-ups the pitched for two prominent US groups (Tech Coast Angels and CommonAngels) in the period from 2001 to 2006. In order to obtain meaningful data, they had access to confidential records of companies approaching the angel networks. In these records were contained the level of interest assigned by angels, the financing decisions made and the results of financed ventures (Kerr, Lerner, & Schoar, 2014).

Thus, the authors were able to make a comparison between funded and unfunded ventures that made the pitch to the same investor through the interest level numbers. In order to remove any ex-ante selection bias in the evaluation of the firms which got funded, the authors identify a threshold of interest level over which the firms where funded and underneath were not. With this technique, they have been able to make a comparison between companies which got the funding by a small margin and those who didn't get funded by a small margin, minimizing the selection bias (as in, they could discriminate the performance differential between the companies without the inherent differences caused by the quality of the firm itself) (Kerr, Lerner, & Schoar, 2014).

The results of their investigation outlined two clear patterns:

- Interest levels expressed by angels are fundamental in the process of choosing to fund or not a firm (not surprisingly).
- Between firms selected around the same quality range (measured by the interest scores), those who received funds overall look more successful than those that did not receive financing. Indeed, the funded firms have presented the following statistics:
    - They are 20%-25% more likely to survive for at least four years.
    - 9%-11% more likely to successfully reach an exit through an IPO or an acquisition.
    - 16%-19% more likely to either have grown to at least 75 employees or having reached a successful exit.
    - 70% higher chances of obtaining entrepreneurial finance and on average receive roughly two additional financing rounds.
    - 16%-18% more likely to have a granted patent.

We can conclude, looking at the above empirical evidence, that angel funding does have an impact on the ability to innovate, among other advantages, of technological firms with a comparable entrepreneurial quality (Kerr, Lerner, & Schoar, 2014).

III. Venture Capital Financing and Product Market Innovation

In the previous chapter we discussed how financial markets and institutions react to the innovative nature of technological firms trying to get resources to fund their projects. In this instance the focus will be on how Venture Capital impacts technological innovation itself.

a. Overall Impact of VC on Innovativeness of Technological Firms

Following the literature from the last 20 years, it is pretty much assessed that Venture Capital does enhance the overall innovative effort of technological firms (Kortum & Lerner, 2000) (Mollica & Zingales, 2007) (Ueda & Hirukawa, 2008) (Popov & Roosenboom, 2008). Concerning in particular the Euro-zone, following the findings of the work from Popov & Roosenboom, it was estimated that during the time period from 1991 to 2004 in a group of 18 selected European countries private equity investments have an economically and statistically relevant effect on technological innovation. They estimate that the impact of an euro of private equity funding innovation compared to an euro of industrial R&D processes is positive and significant, thus making Venture Capital investments impact innovation for a good percentage of overall R&D output. Indeed, private equity accounts, in the aforementioned time frame, for somewhere between 8% and 18% of industrial innovation. This data set on the other hand highlights that European risk capital markets are allegedly less efficient than US risk capital markets, due probably to slow labor market reforms and the deregulation of investment activity by large institutional investors, like pension funds and insurance companies. (Popov & Roosenboom, 2008)

On the other hand, even though in these works it has been proven that Venture Capital spurs innovation at industry level, the impact on the innovativeness of single companies receiving the financial resources is yet to be examined. In order to do so we need to make reference to the work by Gonzalez-Uribe from Columbia University on the topic, the impact of Venture Capital on a firm's innovativeness. In this paper the latter has been measured through patent statistics for single firms, suggesting some interesting developments. Using data at company level from US start-ups, Venture Capital has shown to not only affect the rate of innovative activity, but also its quality. Indeed, using patent citations as a measure it can be evaluated how VC affects quality, novelty, and nature of the research output of VC backed firms (Gonzalez-Uribe, 2013).

The results show that the increase in innovative activity on firms backed by private equity is consistent with industry-level results concerning the number of patent filings. In other words, innovation is stimulated by Venture Capital not only on an overall industrial level, but each single company which goes through the financing cycle gets more innovative (Gonzalez-Uribe, 2013).

A second result though is that Venture Capital is associated with a decrease in the quality of firm's R&D output, although it is not completely explained just by the use of Venture Capital as a financing method (Gonzalez-Uribe, 2013).

The sample of VC backed firms in the US, from 1976 through 2008, is found to have sustained a relevant increase in the scale of innovative activity after VC funding. The quality of R&D output decreasing though, as measured in citations of patents produced, is explained by the greater effort on the development rather than the filing of new intellectual property. During the transition which ultimately leads to commercialization of products (as seen in the previous chapter of this thesis), patents start to concern marginal parts of the invention, pursuing and incremental innovation pattern. This happens probably due to Venture Capitalists focus on reducing time to bring their products to market and less on further long term, radically innovative research (Hellman & Puri., 2002) (Gonzalez-Uribe, 2013).

b. Entrepreneur Incentives to Innovate.

Venture Capital influences the innovative output of the firms in their portfolio through several drivers. The incentives to innovate for entrepreneurs themselves are definitely one of the relevant topics on the matter, and got some attention in recent literature. How the preferences of entrepreneurs can affect the innovative output is at the center of the paper by Manso (2011). In his work, he highlights the consequences and drawbacks associated with the separation between ownership and control in Venture Capital, applying the classic principal-agent problem (Berle & Means., 1932).

In order for VC to motivate entrepreneurs to be more innovative, there needs to be a proper incentives structure to avoid the mentioned agency problems.

Because of its peculiarities of long-term approach and high rate of risk and failure, motivating innovation should be structured in a different way from standard pay-for-performance schemes. Since innovation processes are about exploring untested approaches that are likely to result in failure several times before actually giving a return, punishing failures with low rewards and termination may have an adverse effect on innovation (Manso, 2011).

The optimal compensation scheme for innovative entrepreneurs should then tolerate (if not reward) early failure and reward long term success. This evidence is gained through the use of a model based on the "Bandit problem", where the agent is uncertain about the true distribution of the available actions' payoff. In this frame of reference, innovation is the discovery through trial and error. The tradeoff then arises between the exploration of new untested actions and the exploitation of well-known actions. Exploring untested actions may reveal potential superior actions to the already known one, but on the other hand may reveal itself as a waste of time and resources only revealing inferior actions to what is already discovered. While well-known actions ensure a reasonable pay-off, they may also prevent the discovery of superior actions (Manso, 2011).

Within this model, the threat of termination by the principal has an ambivalent result. While it forces the agent to stay focused on his work and performance, it also encourages him to always exploit already known actions without exploring anything, because it is a safer solution. Furthermore, feedback on performance and long-term commitments also have an important role in motivating innovation, because they allow to monitor the path in another way than just the entrepreneurial results, which is the goal of incentive schemes not stressing just short term results. Overall, if incentive schemes for innovative entrepreneurs have too much stress on the event of early failure and favor short term success over long term results, then they have a negative effect on the overall innovativeness of firms (Manso, 2011).

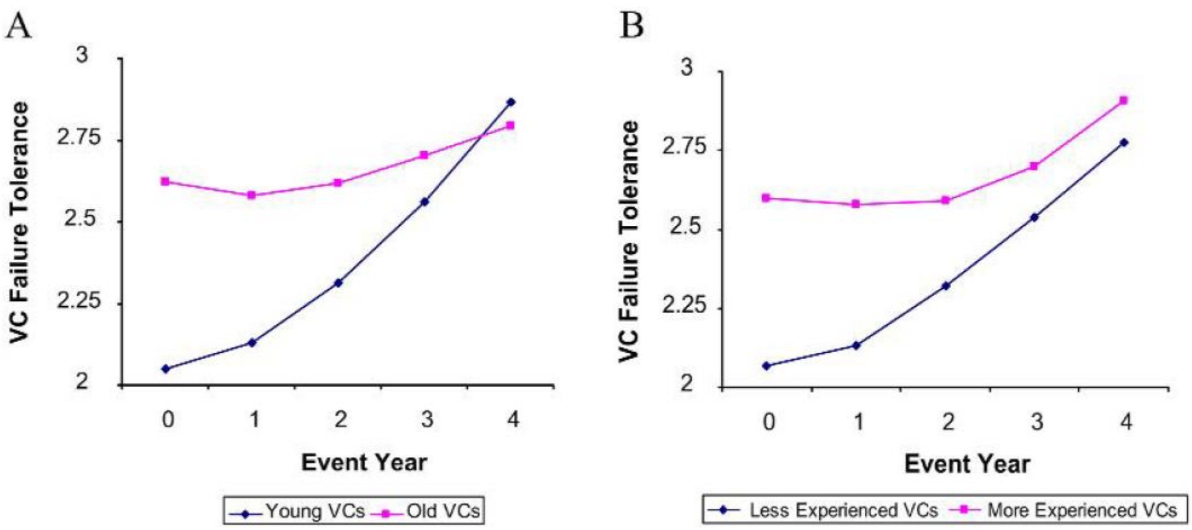
c. Impact of Venture Capitalists on Innovation

Following the topic of the previous paragraph, it is apparent that Venture Capitalists tolerance for failure has an impact on the innovative performance of the firms in their portfolio (Chemmanur & Fulghieri., 2014). Since the Venture Capital is a high-risk-high-return industry, the investors' attitude toward failure is a crucial factor of the development and performance of their portfolio of firms. In their work, authors Tian and Wang (Tian & Wang., 2014), have examined the previous statement, capturing the failure-tolerance of investors and obtaining the relative performance.

Investors are active in the Venture Capital process and have an important role as decision-makers, thus if they possess low tolerance to failure they may liquidate early their projects as soon as the first unsatisfactory results happen, and in the long run may deny the chance for the firms themselves to be innovative.

It was measured as the failure tolerance of an investor by its tendency to continue investing in a project even though such project doesn't meet the prefixed milestones. Given the financing rounds as stage-gates where performance is measured and the decision to continue financing or not projects is taken, measuring the Venture Capitalists who financed the projects with failed milestones was considered a good proxy of investors with high failure tolerance.

In turn failure tolerance itself is assumed to be determined by two frictions: capital constraints and career concerns for investors. The results of their study highlight that indeed high failure tolerance is particularly important for ventures that are exposed to a high risk of failure, since it allows them to have the upper hand on early difficulties and realize their unexpressed innovative potential. Capital constraints and career concerns distort negatively VC failure tolerance, and consequently have an impact on innovativeness, and from the study it emerges that young investors suffer more than experienced investors from this frictions. Indeed, younger investors become more failure tolerant after a relaxation of capital constraints and having achieved stability in their career path.



Failure tolerance by investors by age and experience (Tian & Wang., 2014)

In the graph, we can see how in the early financing stages (event year), investors older and with more experience tend to be much more failure tolerant than the younger and less experienced counterparts, reaching a more similar level of failure tolerance in later financing rounds.

Thus, a long term approach from investors and the ability to accept early failure in order to achieve better innovative results in later stages results are paramount to exploit all the potential innovation in each fund portfolio of firms (Tian & Wang., 2014).

IV. The decision to go Public or Private for Innovative firms and its impact on Innovation.

Innovative firms are influenced in their innovativeness by their choice to maintain a private ownership or going public (Ferreira, Manso, & Silva., 2012), According to the work by Ferreira, Manso and Silva maintaining a private ownership structure incentives innovation whereas public ownership disincentives it. The authors try to demonstrate this assumption using a model where the ownership affects the managers' incentives to innovate and explains the elements that compose the decision to go public or private. Indeed, this decision is affected by the relative profitability of innovative and conventional projects (Ferreira, Manso, & Silva., 2012).

The model they structured takes in consideration a risk-neutral insider of the innovative company, who has to decide between investing in a conventional project and in an innovative project. According to the definition in previous literature, a conventional project is the exploitation of existing ideas while the innovative project is the exploration of new ideas (March, 1991). Both the conventional and the innovative project produce cash flows in two consecutive periods. Meanwhile, the insider has the option to liquidate his stake before the project completion at the end of the first period.

If the firm is under public ownership, cash flows are observable and the insider cannot liquidate his stake at the end of the first period in case of bad news because it wouldn't be profitable, as the information about the low cash flows would be publicly disclosed. As a consequence, there is no tolerance for failure in a public company environment. Moreover, prices of publicly traded shares react quickly also after good news about the project cash flows. This rapid incorporation of good news in the share prices creates incentives to a short-term mindset for insiders. In turns, this short term mindset results in managers preferring conventional projects, since the latter have a higher probability of early success than innovative ones. In the model developed by the authors, the incentives are demonstrated to be biased towards conventional projects in firms publicly owned, whereas the incentives in private firms are biased towards innovative projects. As a consequence, with the other parameters held constant, the optimal structure of ownership is dependent on the life cycle of the firm itself. In fact, innovation is very important early in the life of a firm, when they start to experiment with different kinds of products (Keppler, 1996). Consequently, firms should start with a private ownership structure to provide incentives for exploration and experimentation. Furthermore, whenever a firm needs to undergo a major restructuring, it makes sense that they undertake a private ownership structure, as it is better for the firm to reinvent itself outside of the public eye (Ferreira, Manso, & Silva., 2012).

The evidence that private firms are more innovative than public firms is also retrieved from empirical studies (Lerner, Sorensen, & Strömberg., 2011). Indeed firms invest in more disruptive innovation after being acquired by private equity funds. In the study by Lerner, Sorensen & Strömberg, emerges that the most significant enhancements in the quality of registered patentets (as in, patents with the most citations), were registered in public-to-private ownership transitions.

In conclusion, the core result is that public and private firms invest in fundamentally different ways. Private firms are likely to take more risks investing in more innovative products and technologies and pursuing radical innovation. Therefore, privately owned firms will be undertaking project with higher complexity, harder to describe to the public and with less or non previous testing, creating a higher information asymmetry with the public and therefore creating a high-risk-high reward environment. Adding on top of that, organizational change is also more probable under private ownership. Mergers and acquisitions, divestitures and organizational changes and practices are more easily motivated.

On the other hand, publicly owned firms choose more conventional products as the main focus of their managers is about current earnings. Complex projects are difficult to pursue as the market could not understand them and may react negatively as the information is disclosed. On the other hand, cash-flow volatility will be lower when compared to privately owned firms, at the expense of the innovativeness of the firm itself.

Finally , it emerges that there is an appropriate time for being privately owned and publicly owned. Firms are likely to go public after a technological breakthrough and the focus shifts on exploiting it. On the other hand, firms may go private when suffering permanent negative productivity shocks, in essence when the technology at their core or their business model becomes permanently unprofitable. It has been found that firms go public when reaching the apex of their productivity, after which the latter declines (Chemmanur, He, & Nandy, 2010). Thus, firms going public to "harvest" their technological breakthrough are consistent with this result (Ferreira, Manso, & Silva., 2012).

V. The effect of going public on Innovation: empirical evidence.

In order to evaluate how the decision to go public by a technological firm affects its innovativeness, we will make reference to the paper by Bernstein by Stanford University. In his work, the researcher compared the innovative activity of firms that went public with the innovative performance of firms that filed for an IPO, but ultimately withdrew. The dimensions touched by the decision to go public or remain privately owned are three:

- Internally generated innovation;
- Productivity and mobility of individual inventors
- Acquisition of external innovation (Bernstein, 2012).

As we have seen in the second chapter of this thesis, ideally in frictionless financial markets selling equities publicly should have no effect on innovative activity. However, given the market imperfections the following two different views suggest that going public is not indifferent to the innovative output of a firm.

The “financing” view suggests that financing frictions that emerge are eased by going public, thus enabling the firm to access capital. R&D investments are more sensitive to financing constraints than other investments due to information asymmetries, long-term and risky results and the fact that it can only offer intagibles as securities, as also seen in chapter 2. Thus, according to the “financing” view, diversifying idiosyncratic risk through public equity markets to a large number of parties may loosen the financial constraints of innovative firms, allowing them to enhance internally generated innovation, attract human capital and technology acquisitions (Bernstein, 2012).

The other view is defined as the "incentives" view, of which we discussed in the previous paragraphs of this chapter. Ownership dilution and changes in governance of a firm could lead to a change in the portfolio of innovative projects, focusing on safer, incremental innovative efforts. After the IPO filing, inventors may have weaker incentives to pursue a radical innovation strategy due to the dilution of their claims on incremental innovations. Furthermore, the increase in wealth they receive may lead to their departure from the firm. Finally, it all adds to the topic at the center of the previous paragraph: the change in mindset of managers of publicly traded firms are incentivizes them to go for short-term and non innovative projects at the expense of long-term innovative ones, due to public pressure on the company share prices and career concerns. (Ferreira, Manso, & Silva., 2012). In addition, managers may prefer to acquire already existing technologies instead of developing them. This is thanks to the improved capital availability that an IPO may offer, in conjuncture with a better acceptance by the stock market of an acquisition thanks to its transparency compared to an internal R&D project. An acquisition in fact should be, in theory less prone to failure (Bernstein, 2012).

In order to have a better understanding of the two aforementioned views, the author uses standard patent-based metrics. In order to achieve empirically significant results, the author needed to remove the inherent selection bias associated with the decision to go public. In fact, firms choose to file an IPO at a specific stage in their life cycle, and this generates a biased result of the effects that the IPO produces (Jain & Kini., 1994). As mentioned above, companies may indeed choose to go public following an innovative breakthrough (Pástor, Taylor, & Veronesi, 2009) and having achieved significant productivity improvements (Chemmanur, He, & Nandy, 2010). Therefore, there may be distortion in results of only chosing companies filing for an IPO in the evaluation of their performance, as in the results are mixed in the effects that are simply caused by the life cycle of the company. In order to overcome this bias, Bernstein creates a dataset of innovative firms that applied for initial registration statement to go public at the US Security and Exchange Commission and either completed or withdrew their filing. This dataset allows the results to compare the innovative activity of firms that completed the IPO with private equity firms that were at a comparable life-cycle stage (Bernstein, 2012).

The empirical approach used starts with the assumption that the firm innovation following the IPO fiing can be expressed as the sum of future innovation opportunities (regardeless of being public or private) and the effect ownership structure has on innovative performance. So, the post IPO innovative performance can be written as:

*Innovative performance = Q+c*IPO*

Where "*Q*' is the unobserved quality of the IPO applicant firm's future innovative projects, and *IPO* is a dummy that indicates whether the issuer completed the IPO filing (IPO=1) or remained private (IPO=0). The empirical goal is to estimate "*c",* which is the impact of public ownership on the innovativeness of the firm.

The results obtained with this empirical method all assume that the short term stock market variations don't have an impact on long term innovativeness of a firm, while having an impact on the decision to complete an IPO or withdraw (Bernstein, 2012).

The results show a significant link between public ownership and innovation, the decision to adopt a public capital structure causes a substantial decline of around 40% in innovation novelty as measured by patent citations. On the other hand, there is no apparent change in the number of patents. This implies that the transition from private ownership and the public equity markets leads firms to change the nature of their R&D investments towards more conventional projects.

The effects of the IPO on the innovativeness are then examinated along the other two dimensions other than internal innovativity. Namely, the author studies the effects on individual inventors productivity and mobility over time. The innovation produced by the latter declines in quality following the IPO, and key inventors have higher chances to leave the company. On the other hand, the new status of the firm also enhances the chances of the firm to attract new inventors, which mitigates the effect of historical inventors leaving.

The third effect studied is the likelihood that new public firms acquire other companies in the post-IPO years. The results show that public firms acquire a substantial number of patents through M&A, with acquired patents representing nearly a third of total patents owned by firms' in the five years after the IPO. Furthermore, the quality (as in, the numer of citations) of patents is higher for the acquired intellectual property when compared to those internally generated in the years following the IPO (Bernstein, 2012).

Transitioning to public equity markets has an impact on the strategies companies use to pursue innovation. Publicly traded firms choose an incremental innovation route when internally financing innovative projects, while relying more significantly on the acquisition of external technologies. This change happens in correspondence with a substancial inventor turnover after the completion of the IPO. Supporting this result, the author also finds evidence that managerials incentives do matter, as highlighted in the previous paragraphs of this chapter. Greater job security for managers allows them to have less pressure from the market, thus resulting in a smaller decline in innovation novelty along with a lower turnover rate for inventors.

Wages for hightly educated scientists and engineers represent a significative portion of a technological firm R&D investment. As a consequence, transitioning to equity markets affects the firm's human capital. Indeed, key employee retention may become difficult after the IPO since options are vested, ownership is diluted and firm governance changes. On the other hand, stock options and easier access to capital may ease the acquisition of new human capital. In his empirical study, Bernstein identified a sample of roughly 16000 inventors, identifiyng three inventor categories:

- Stayer – inventors with at least a patent before and after the IPO filing in the same firm.

- Leaver – inventors with at least a single patent in a sample firm before the IPO and at least a single patent in a different firm after the IPO filing.
- Newcomer – inventors having at least a single patent after the IPO filing in a sample firm without any pre-IPO patent in the same firm, with at least one patent at a different firm pre-IPO.

	IPO Firms					Withdrawn Firms				
	count	mean	count	mean	difference	count	mean	count	mean	difference
Pre-IPO Filing:	*Leavers*		*Stayers*			*Leavers*		*Stayers*		
Scaled Citations	3743	2.37	3806	2.12	0.253***	708	2.36	558	2.74	−0.374**
Scaled Number of Patents	3743	1.1	3806	1.01	0.088***	708	1.21	558	1.29	−0.085
Post-IPO Filing:	*Newcomers*		*Stayers*			*Newcomers*		*Stayers*		
Scaled Citations	6787	1.62	3806	1.41	0.210***	506	1.4	558	3.11	−1.709***
Scaled Number of Patents	6787	0.86	3806	1.28	−0.423***	506	0.86	558	1.14	−0.274***

Patent Activity of stayers, leavers and newcomers between IPO and withdrawn firms (Bernstein, 2012)

In the above table, we cana see how the different inventor categories performed in innovative activity in both IPO firms and withdrawn firms. In IPO firms, leavers produced more novelty patents and a higher number of patents in the three years before the IPO filing when compared to stayers. In withdrawn firms, this trend is reversed: stayers produced higher quality patents before the IPO filing.

Newcomers in IPO firms on the other hand produce higher quality patents compared to stayers, but in lower quantity. Similarily to the previous comparison between leavers and stayers, the trend is inverted in firms that withdrew their IPO filing. Indeed, the quality of patents by newcomers is lower thant those inventors who stayed in the same firm pre and post withdrawn IPO.

Finally, always assuming the non-influence of stock market drops on the long term innovative performance, the author concludes that going public leads to a departure of inventors that were the fautors of higher quality patents than stayers, in contrast with firms that withdrew their IPO where the opposite is occurring.

Additionaly, it is found that IPO firms are substantially more likely to hire new inventors, in a magnitude measured as an increase of 38,8% in likelyhood when compared to IPO who withdrew the filing. This has an impact on the human capital accumulation process, since, as mentioned before, post-IPO the more innovative inventors leave the firm and the productivity of stayers is lower, the ability to attract new inventors with higher innovativeness than the stayers mitigates the problem (Bernstein, 2012).

VI. M&A Exits and Innovation

In connection with the previous paragraph, it ha sto be noted that the IPO exit is not the only available option to retrieve financing and "cash-in" the investment. Indeed, as seen in chapter two, the destiny of many growing technological firms is to be acquired by companies with larger capitalization. In the paper by Aggarwal & Hsu (Aggarwal & Hsu, 2014), a similar approach is undertaken to the work of Bernstein to measure the impact of both kinds of entrepreneurial exits on the innovativeness of a firm. The pool of firms used for this empirical analysis have shown some interesting patterns.

The pool itself is composed bu biotechnology firms founded between 1980 and 2000 in the US, monitored up until 2006 to evaluate the implications of the exit choice on their innovation. As confirmed by the other studied, innovation quality has been greater under private ownership and lowest under public ownership. Acquisition exits hold an intermediate position between the two. Indeed, M&A innovation quality is enhanced by private acquirers when compared to public ones, due to lesser technology overlapping between the acquirer and the target (Aggarwal & Hsu, 2014).

The results from their statistical evaluation of collected data returned that post-M&A firms have experienced a 22% increase in patente applications and a 7% decrease in forward patent citations (at a 1% significance level). In conclusion, an M&A does, on average, boost the amount of innovation produced, but the quality of such intellectual property declines compared to the pre-M&A stage (Aggarwal & Hsu, 2014).

VII. Legal environment impact on Innovation

As a final topic, we have to face the importance that legal environment has on the innovative framework. In their study on the impact of labor laws on the innovativeness of technological firm, Acharya, Baghai, and

Subramanian empirically test how wrongful discharge laws affect the adoption of innovative projects by firms. Indeed, protection of employees against unjust dismissal is found to be a factor in the attitude towards innovative projects (Acharya, Baghai, & Subramanian, 2010).

Stringent labor laws are associated with inefficiencies and rigidities by literature (Botero, Djankov, La Porta, Lopez-De-Silanes, & Shleifer, 2004), in particular concerning negotiation or termination of employment, it is easily predictable that removing to freely negotiate leads to inefficiencies in later stages of company life. On the other hand, as we have seen with the incentives for entrepreneurs of technological firms previously, stringent labor laws may have a positive impact on innovation. Indeed, not punishing short-run failures might have an effect on the attitude of employees towards innovative, long term projects. The paper examines this problem empirically and manages to outline that dismissal laws, or, laws that make it hard for firms to freely terminate the contract with employees, do have an ex-ante positive incentive on innovation (Acharya, Baghai, & Subramanian, 2010).

In order to run this test, the authors developed a theoretical model that considers an incomplete contracts setup in which the firm cannot reward innovative pursuits sufficiently since it can't disciminate between bad luck from poor effort. The inability to make such a distinction, it may be efficient to ex post dismiss employees for their failures, even though acting in this way weakens the incentive to innovate ex-ante. The proxy of labor laws conditions used in the data has been an index developed by

Deakin et al. (2007), where the evolution of differences in employment protection legislation in five countries – US, UK, France, Germany and India – from 1970 to 2006 is synthetized. The index analyzes labor laws on forty dimensions, grouped in the following categories:

- alternative forms of labor contracting,
- working time,
- dismissal,
- employee representation,
- industrial action (Deakin, Lele, & Siems, 2007)

Since the index takes into account countries that amount for 72% of all patents filed during sample period, it represents a good sample for testing the authors' hypothesis. The changes in dismissal laws have been used to analyze the impact they have on innovation. The result of this empirical study does indeed highlight that both in cross-country and within-US setting, dismissal laws seem to have a positive impact on innovation. The significative nature of the results spur the question of wether such laws are necessary to promote innovation. Firm-level contracts might not be enough to provide employees with the adequate incentives to innovate. One possibility is that innovation has positive externalities and thus institutions and policy makers support innovation, in order to obtain socially efficient investments in innovative projects. Another path may be that firm-level contracts don't have the force of commitment that laws have. Because of the risks involved with the results of innovation, contracting ex-ant is difficult, rendering private contracts with incentives to innovate susceptible to renogotiation, therefore diluting the ex-ante incentive effects. Because laws are much more difficult to alter for private parties than firm-level contracts, protection from the laws in the form of stringent dismissal laws can make the contract more time-consistent with the innovative projects compared to privately negotiated contracts.

As also mentioned im previous paragraphs, firms may be short-term oriented or have a myopic top management. Poor firm governance of top management might prevent efficient long-term contracts with employees. The "internal governance" of firms can be improved by the law by extending the horizon of employees and, indirectly, inducing top management to provide better long-term incentives. Labor laws therefore have an important positive effect on innovation and economic growth, in the form of dismissal laws shifting the time horizon of employees from short-term to long term and allowing them to undertake efficient, long-term, innovative project (Acharya, Baghai, & Subramanian, 2010).

VIII. Chapter Conclusions

In this chapter, we have analyzed how capital structure and ownership decisions impact the innovativeness of firms, along a review of recent literature on the topic. It has been highlighted the role of Angels and Venture Capital in fostering innovation, as well as the issues that arise due to the principal-agent situation that arises between investors and entrepreneurs. The essential issue is that, because of market pressure due to observability, there is a timing discrepancies between the short-term results wanted by a public ownership structure and the long-term focus that the more innovative projects possess. This ultimately leads to private ownership being better at fostering disruptive innovation, while public ownership puts his focus on more incremental, safer projects. This is apparent also in the review of studies that face the impact that exits have on innovativeness: both IPOs and M&As have been empirically found to depress the quality of innovation of previously privately owned firms. Finally, it was assessed how laws impact innovativeness, finding that strict labor laws do indeed produce a better innovative output. We can then see how firm-level innovation is a product of many factors, and is largely influenced by the life cycle of firms themselves.

4. FINANCING INNOVATION IN ITALY

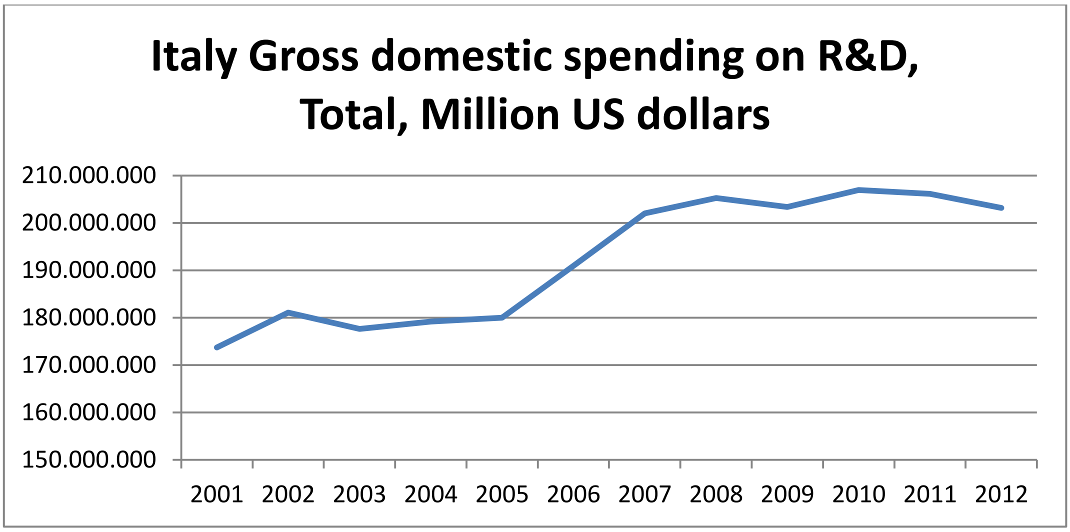
In chapter 1, we saw how innovation is empirically measured, its sources and its outcomes on the economic structure of a country. Chapter 2 examined how the innovative nature of firms has created specific ways of providing financing for technological firms. Finally, in the previous chapter, we saw how the financing structure of a company in return impacts the quality and quantity of innovative output of a firm. In this instance, we will apply these concepts on the specific case of Italy, and assess its current state with regards to its innovative performance, how it is financed and if the financing methods adopted by Italian entrepreneurs are indeed able to foster innovation itself.

I. Macroeconomic indicators of innovative activity in Italy

Recently, innovation has gained a very important role in the economic debate because of its role as a driver for economic growth for high-income countries and its ability to overcome social and environmental challenges. Because of the financial and economic crisis from 2008, developed countries are seeking new drivers of growth and it is one of the only paths for industrialized countries to face globalization and international competition. Therefore, continuous innovative effort is a key element for countries to achieve competitiveness. Concerning Italy in particular, with the adoption of the Euro, the option of national currency depreciation to raise the international appeal of its exports has been an unavailable instrument. This situation eventually put even more stress on the Italian system which often relied to this strategy to raise the competitiveness of its products instead of betting on investments in innovation (Benvenuti, Casolaro, & Gennari, 2013).

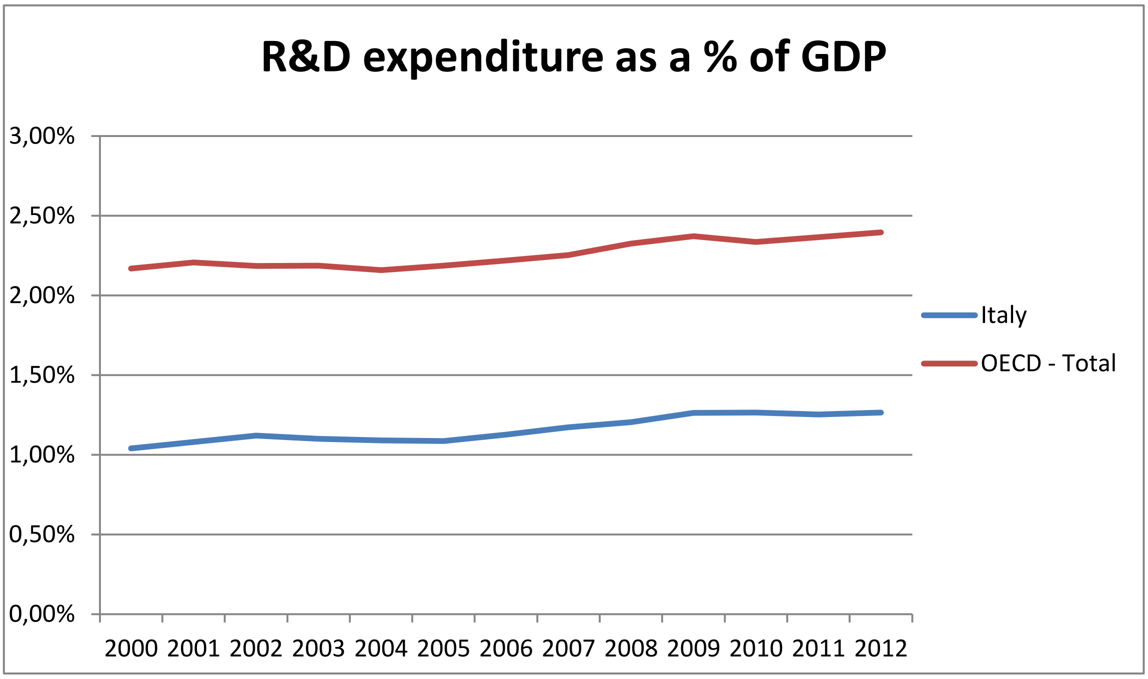
As a result, in the last ten years the Italian economy has not adjusted to the global scenario, eventually scoring a worse performance than peer European countries in terms of GDP growth, productivity and employment (Brandolini & Bugamelli, 2009).

As we have seen in chapter one, R&D expenditure is a good proxy to estimate the innovative activity of an entity. First of all, we will examine what the performance with regards to innovation has been for Italy recently.



(OECD, 2014)

The above graph shows the total expenditure on R&D projects made in Italy from 2001 up until 2012. Data is taken from the OECD database (OECD, 2014). We can see how the expenditure (reported in millions of USD dollars equivalent) has been consistently growing from 2001 to 2008. As mentioned in Chapter 1, the global economic crisis in 2008 did have an impact on R&D expenditures all around the world, because of institutions and firms overall cutting costs in order to maintain profitability (OECD, 2012). Afterwards the trend has been pretty much stable, with overall expenditure marginally trending down in later years.

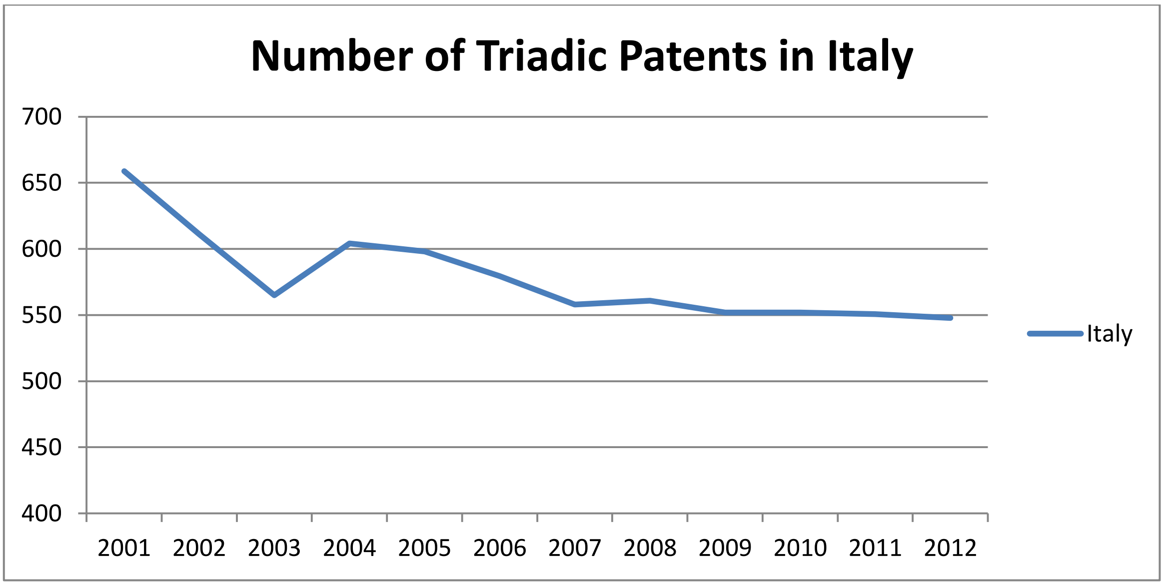


(OECD, 2014)

The fluctuations in R&D spending that may have derived from the negative impact of the GDP decline Italy has sustained during the economic crisis in 2008 and subsequent years, may have had a significant impact on the amount of R&D that has been financed in relative GDP terms. In order to have a better proxy of how much Italy has committed regardless of the effect of a depressed GDP, in this second graph we can see the values in percentages relative to Italian GDP. The graph outlines how the value has been roughly constant on its levels from 2000 on, trending slightly upwards with time. Comparing Italian data with the OECD average though, we can see that there is clear gap in innovative effort compared to the average. Indeed, Italy invested in 2012 only 1,27% of its GDP on R&D expenditure, versus the OECD average of 2,40%: a striking 30,88% less.

We can start to see the outline of what will be called, later in this chapter, the “Italian GAP”.

Seeing the amount of input being funneled in innovative projects, it makes sense to see how the creation of knowledge is performing. As stated in chapter 1, we can use patent data to have an idea of how the output performance of R&D investments is progressing. Once again, we will make reference to the OECD database to have an idea of the Italian overall innovative effort in recent years.



(OECD, 2014)

While expenditure has grown in the examined time frame, we can see how the number of triadic patents granted in Italy has declined, flattening post-2008. From these numbers we can see that higher expenditure levels didn't produce a better innovative output from a quantitative standpoint. This issue may be explained through the analysis of several factors and looking for answers to some key questions:

- How is the economic environment impacting innovation?
- Do technological firms have sufficient access to financial resources in their growth stages?
- In order to maximize the innovative output, is a private or public ownership structure indifferent for technological firms?

In order to explore possible answers to these questions, we will start by analyzing the Italian environment.

II. Innovation gap factors

Some of the factors originating the innovation gap are found in the characteristics of the Italian productive system itself, such as:

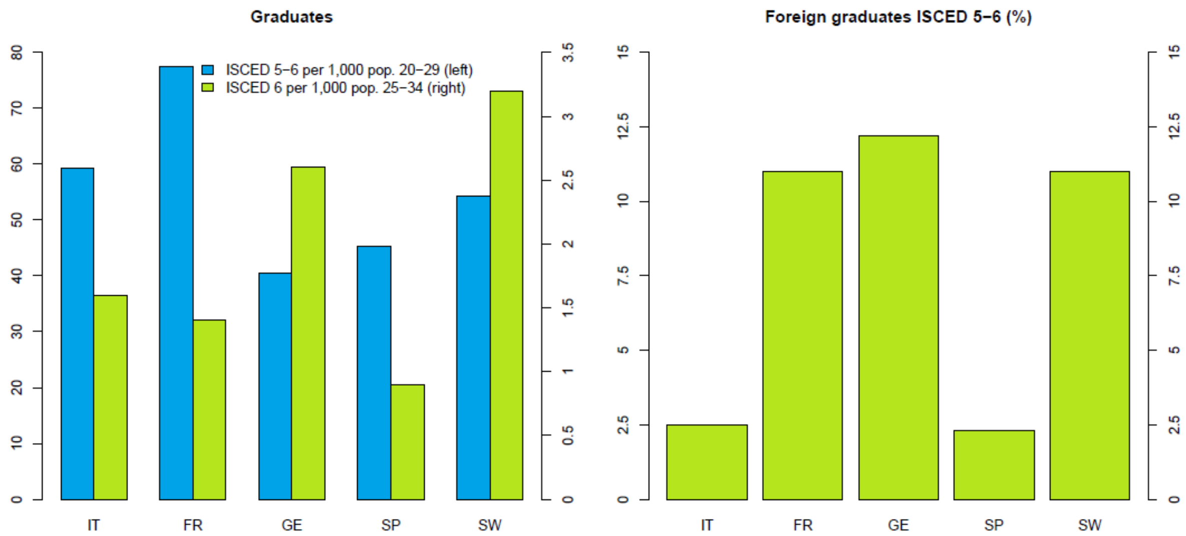
- Large share of small firms
- Sectorial focus in low-technological industries
- Human capital shortage
- Financial constraints
- Limited effect of public incentives

(Bugamelli, Cannari, Lotti, & Magri, 2012)

a. Human capital and education

The innovative output of a country is highly dependent on the quality and quantity of human capital, in essence its ability to retrieve workers with the appropriate set of skills and competences. Indeed, a firm with highly technological R&D projects will require employees with a very high degree of scientific knowledge (Messinis & Ahmedb, 2013).

In order to evaluate the human capital quality, we examine the amount of population of young age with a tertiary education title.

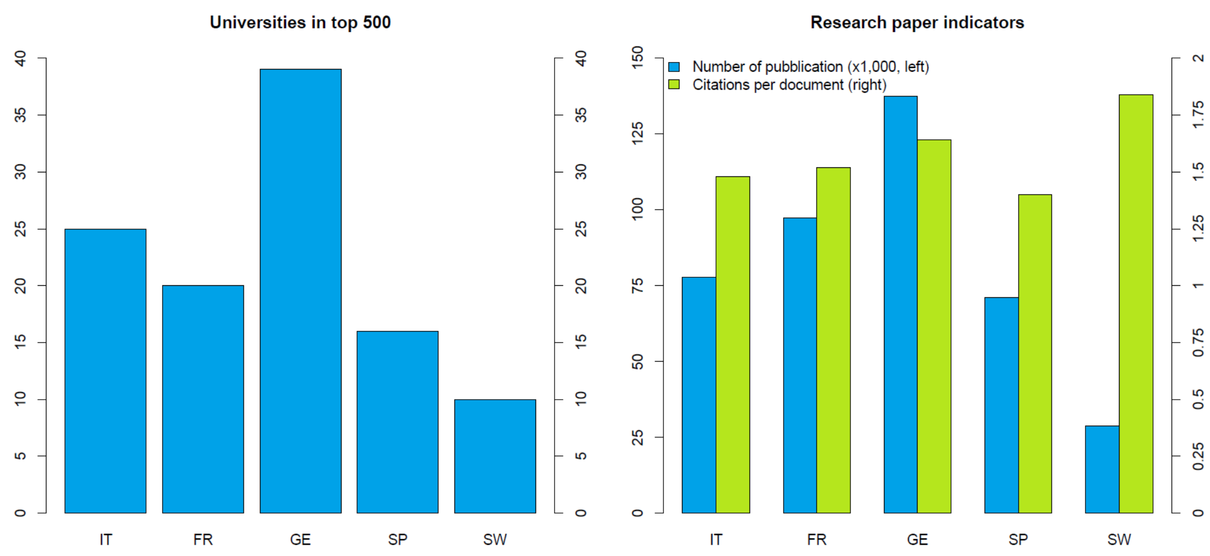


Graduates in comparison with other European Countries in 2008/2009 (Eurostat, 2014)

According to data from Eurostat, the percentage of the Italian population between 20 and 29 years old with a tertiary education degree was 6%, marginally more than the Swedish and notably more than the Germans

(Eurostat, 2014). However, this information may be distorted by the reform of tertiary education that Italy underwent in the years previous to 2008. In fact, the time required to get a first level tertiary education title has been reduced to 3 years for most academic paths, thus inflating the number. We can see how these numbers become less impressive when compared with Germany and Sweden if we shift the analysis to doctoral level titles, while on the other hand maintaining higher levels when compared to France and Spain (Eurostat, 2014).

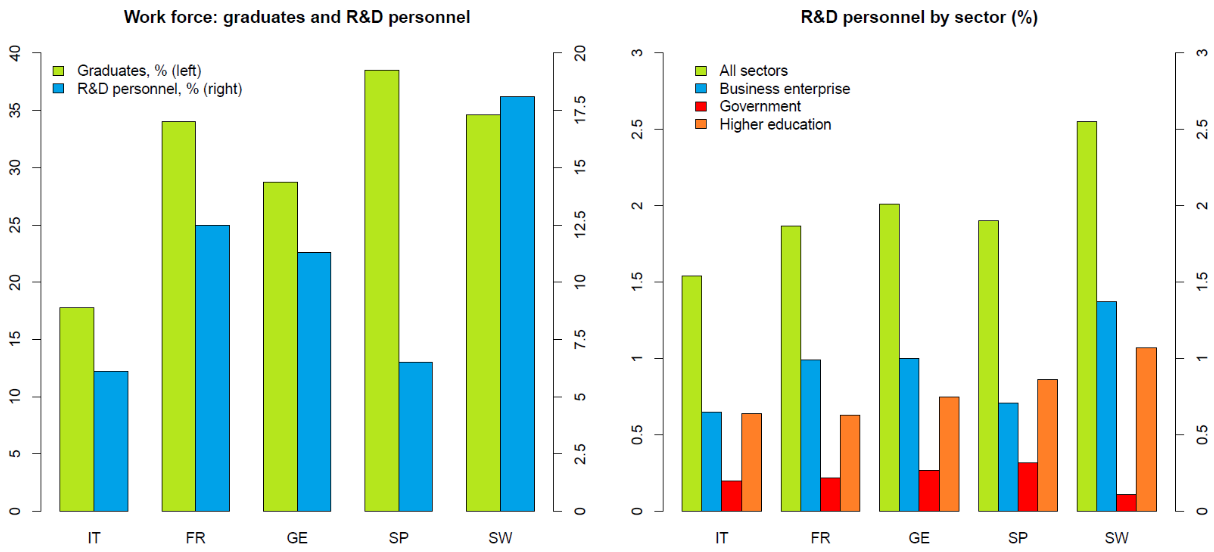
Another human capital factor contributing to the increase in innovative activities is the presence of high-level research institutions and universities, in particular when it is significantly intertwined with the business sector. In order to assess the attractiveness and level of universities and research institutions, we can use the number of foreign students in the Italian university system, which we can see from the graph above. We have a very limited presence of foreign graduates in our system, only 2.5% in 2009, where Germany, France and Sweden all have figures above 11% of total graduates.



International ranking of research
(Benvenuti, Casolaro, & Gennari, 2013)

On the other hand, we can see from the *Leiden* ranking of scientific impact of a country's universities that Italian institutions have a higher impact on scientific research than France, and also more than Sweden (even though this number is distorted by the fact that Sweden has way less universities than other peer European countries) (Benvenuti, Casolaro, & Gennari, 2013). Along with the quality of universities, a good proxy to see the quality of human capital produced by a country is the quantity and quality of scientific publications. In the second graph above, the SCImago Journal and Country ranking is used to assess how Italian published articles are received by the international community. We can see that Italian scientific publications are lower in number compared to France and Germany. The published articles though have a better performance if we take into account their quality, as in, the average number of citations per article (the green column of the graph). The Italian education system is comparable to the peer group of European countries when concerning number of graduates and quality of research, while its main problem is its international attractiveness, along with the lacking of an open collaboration with firms (Benvenuti, Casolaro, & Gennari, 2013).

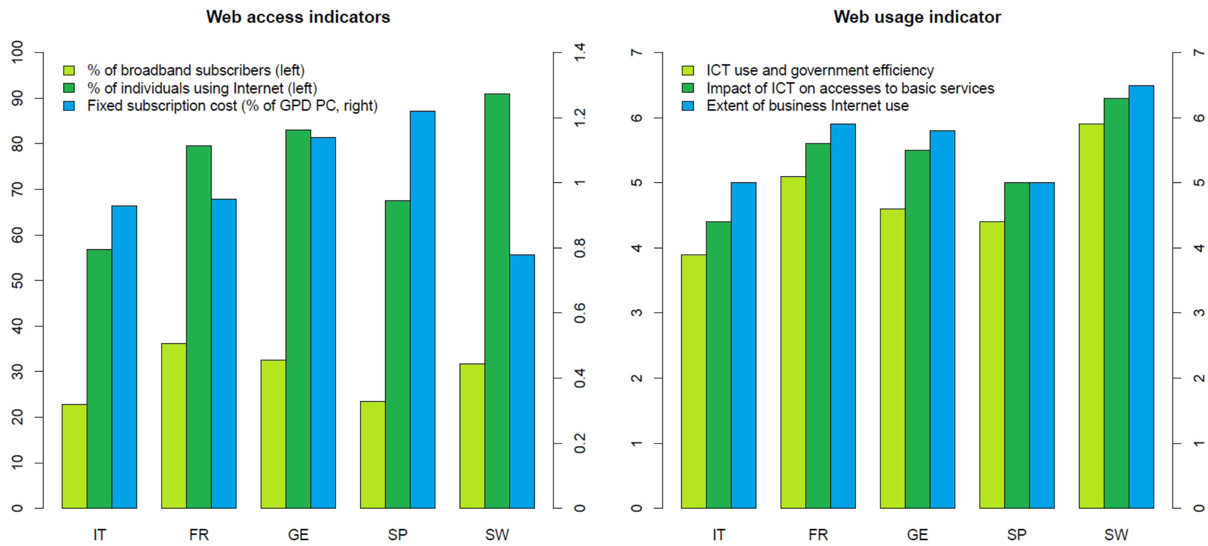
Another issue with innovative activity and Italian graduates though is that the latter are employed a lot less in business enterprises compared to what happens in peer European countries. Taking R&D as a proxy for innovative activity, we can see that it is lagging behind. In the graph, we can see that the issue is in particular with the amount of high skilled workers being employed in Business R&D. The number of graduates employed is comparable in Government and Higher education backed R&D projects, while it is definitely lower for the private sector.



R&D High Skilled Workers
(Benvenuti, Casolaro, & Gennari, 2013)

b. Information and Communication Technology diffusion

ICT investments are a key factor in the innovative output of a country and ultimately its growth potential, as ICT investments have been demonstrated to be linked to the probability of innovation (Spezia, 2011). Indeed, ICT investments facilitate firm networking, accelerating and enhancing the reach of communications, and empower households and public sectors. In order to evaluate the quality of ICT investments in a country, two aspects will be considered. The first is the costs and use of broadband technology, the second is an index which synthesizes the use of ICF in businesses, governments and households. The latter data comes from the 2012 edition of the Web index by the World Wide Web Foundation (Benvenuti, Casolaro, & Gennari, 2013).



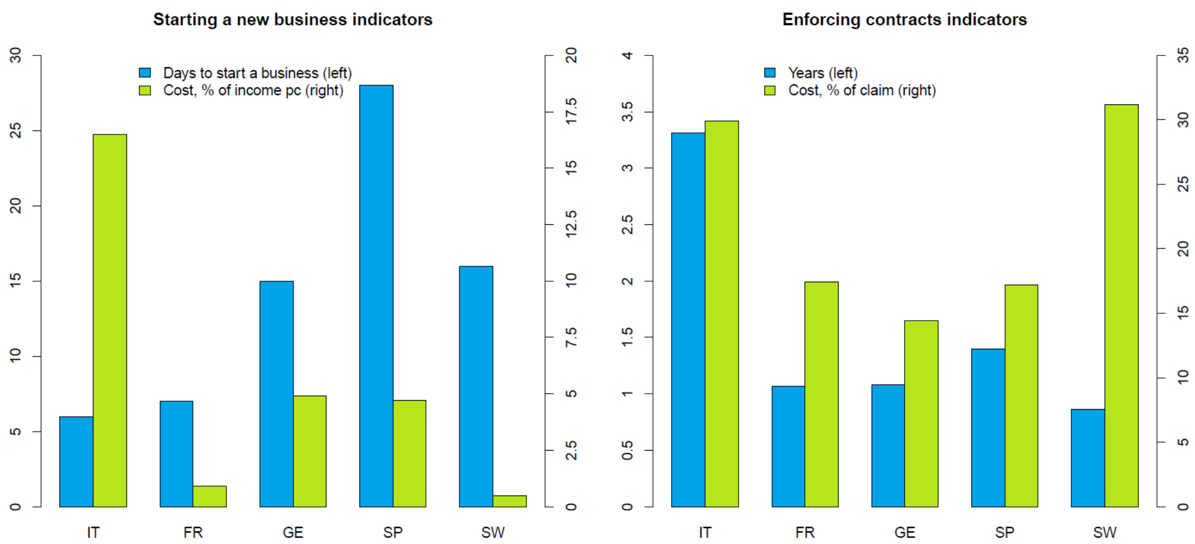
ICT Indexes 2012
(Benvenuti, Casolaro, & Gennari, 2013)

We can see from the above graph that the adoption of ICT has been less intense than what happened in peer countries. Indeed, in 2012 22.8% of population has access to a broadband connection in Italy, the lowest number of the European countries considered in the graph. Internet usage presents an even bigger gap with peer countries, as only 56.8% of Italians use Internet, a number 25-30 percentage points lower. Broadband costs don't seem to be having a big impact on this number, as 0.93% of GDP is in line with most countries with the exception of Sweden. In the second graph, we can see the usage indexes of Internet. It is visually immediate the bad performance of Italy when considering all three indicators, the ICT use in government services, the use of ICT to access basic services for citizens and finally the extent of companies using ICT. The gap in use of ICT with other European countries is both caused by lower adoption rate and its low impact on enterprises, government and households. This is happens due to the demographic distribution of Italian population, which is not concentrated in large towns but more dispersed into small cities. In this scenario, broadband connection may not be available in the smallest towns, and demand for internet services may be depressed by the low average level of education and the lacking incentives to use the technology by the public sector (Benvenuti, Casolaro, & Gennari, 2013).

c. Regulatory framework

Entrepreneurial activity is strictly dependent on the quality of the regulatory framework surrounding it. In order to set up a stimulating environment for entrepreneurs, new ideas should be able to be taken to market fast and with the lowest possible costs. Once a business is stable, in order to not stress too much firms, administrative and fiscal burdens should be kept at a low, sustainable level. Contracts should be able to be enforces, property rights defined and disputes should be able to be resolved in a reasonable time and transparency promoted. In order to evaluate how is the Italian condition on these matters, we will see how Italy is positioned on the Doing business survey by the World Bank. The last results positioned Italy at 73rd place, with a lower performance than its comparable countries in Europe and even lower than the average of OECD high income countries (Benvenuti, Casolaro, & Gennari, 2013).

Some categories in the survey are particularly relevant in relation with innovation. The conditions for starting new businesses is one of them, since, as seen in the second chapter, a large part of innovative ideas is developed by creating new enterprises. The other category is the relative capability to enforce intellectual property contracts within the specific country borders. In both these categories Italy has much worse performance compared to major peer European Countries, as shown by the below graph (Benvenuti, Casolaro, & Gennari, 2013).

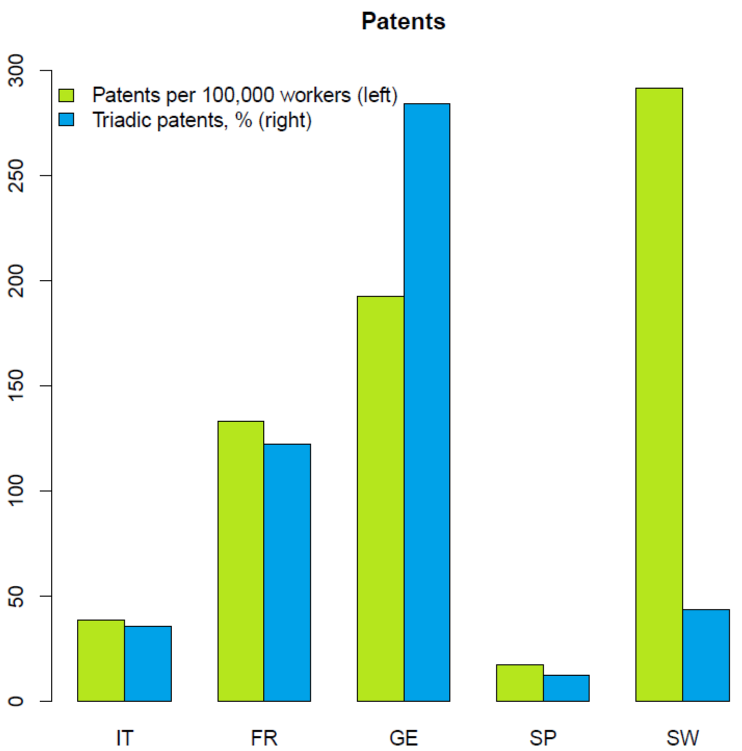


Ease in doing business
(Benvenuti, Casolaro, & Gennari, 2013)

The bad performance in enforcing contracts indicators can be caused by the low efficiency of the judicial system. Indeed, Italian courts take a very long time (3.3 years on average), amount of work and high costs (41 interactions on average and 29,9% of the claim) in order to settle a commercial dispute. In particular the time spent resolving legal conflicts is three times longer than what happens in Germany and France, and it is a big deterrent in starting business in Italy.

Another relevant category of the Doing Business index, especially for new firms, is how easy it is to receive credit. Italy also performs worse than other countries, and this is a consequence of how hard it is to solve a dispute in courts if the debtor doesn't fulfill the obligation. Along with the hardships in getting credit, Italy has also a very high level of taxes, which also isn't encouraging for new firms. Overall, these issues create a bad environment to entrepreneurs wishing to start their ventures (Benvenuti, Casolaro, & Gennari, 2013).

Another important topic is the protection of intellectual property rights. Indeed, if the government isn't creating the right set of rules to protect intellectual property, any firm trying to innovate through research has no incentive in doing so, as the output of their project can easily be diffused to the public and the competition, which would nullify any competitive advantage from innovating. We have already seen in the previous paragraph the trend of patents filed in the last years by Italy, but we haven't compared it to other European countries.



In the below graph, we can see the number of patents filed over working population. The results, especially when compared to Germany and Sweden, can be explained by the low technological content of Italian innovative projects as a consequence of the limited amount invested in them. Furthermore, a high portion of Italian firms are of small and medium size, and this feature makes them less prone to file for patents due to the financial impact of such process. Finally the hardships encountered in enforcing rights in the country are also a deterrent from filing a patent at all.

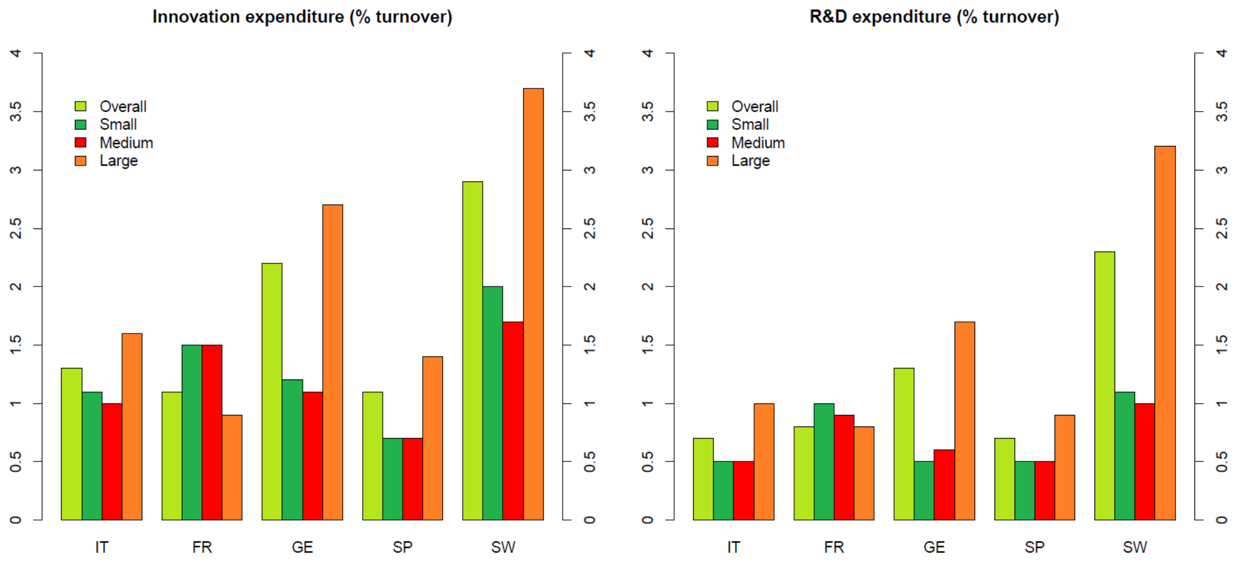
(Benvenuti, Casolaro, & Gennari, 2013)

d. Innovative enterprises

According to CIS data from Eurostat, 56,3% of Italian companies have produced innovation in the 2008 to 2010 period. This value is marginally lower than Sweden, but far away from the results of Germany, where 79.3% of firms produced innovation. These numbers change when we only look for the numbers of technological innovation, or disruptive innovation, where the gap with the other countries is more prominent, as it should be expected given all of the aforementioned limitations of Italy concerning entrepreneurial innovation. Furthermore, innovative firms in Italy account for roughly 80% of total revenue, a level that can be compared to Sweden. Since the value does not change if both technological and non-technological innovative firms are considered, we can infer that innovation is closely related to firm size. Indeed, in Italy innovative firms are mostly large enterprises (80% of large enterprises have innovative projects ongoing), while a way lower number of small and medium enterprises do (56.9%). The problem is though that innovation produced is of low quality, with low chances to create patents (Bugamelli, Cannari, Lotti, & Magri, 2012).

This can be predicted from the public ownership structure of large firms, which impacts the innovative effort of firms, as we have seen in chapter 3. The market pressure on managers may be depressing innovation by putting incentives to more short-term, safer incremental projects.

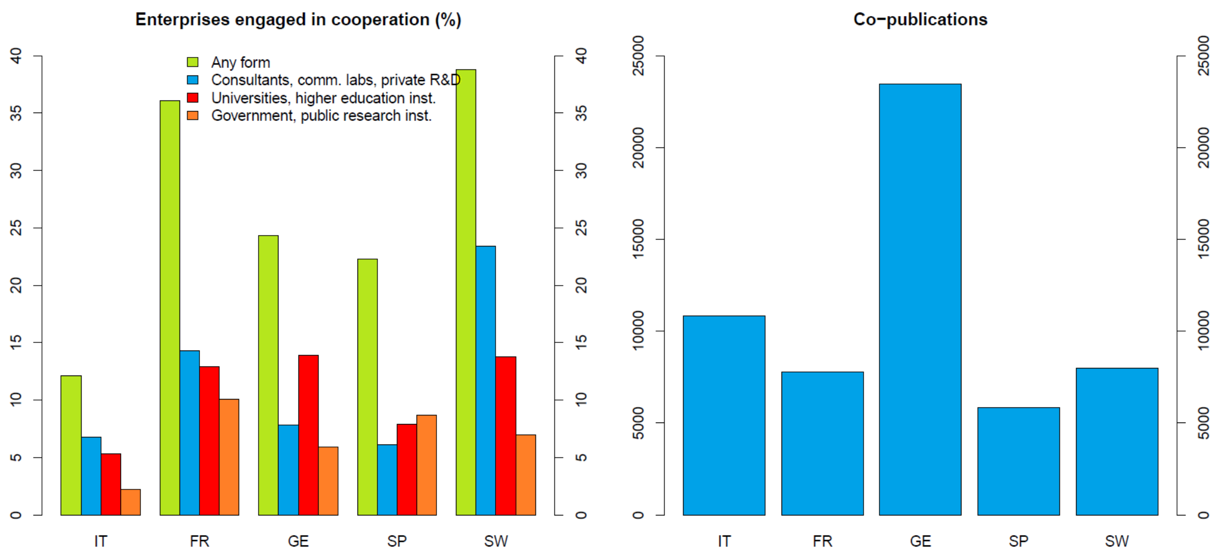
Indeed, we can see from the graph below that only half of innovative expenditure by firms (scaled by turnover) is related to R&D. This is a much lower percentage compared to German or Swedish firms, and is probably due to the composition of Italian industry, with its small firms and low technological sectors. Interestingly, the low propensity to invest in R&D affects all sizes of firms, ultimately worsening their innovative performance (Benvenuti, Casolaro, & Gennari, 2013).



Innovation and R&D expenditure by firm size CIS 2010
(Benvenuti, Casolaro, & Gennari, 2013)

e. Cooperation environment

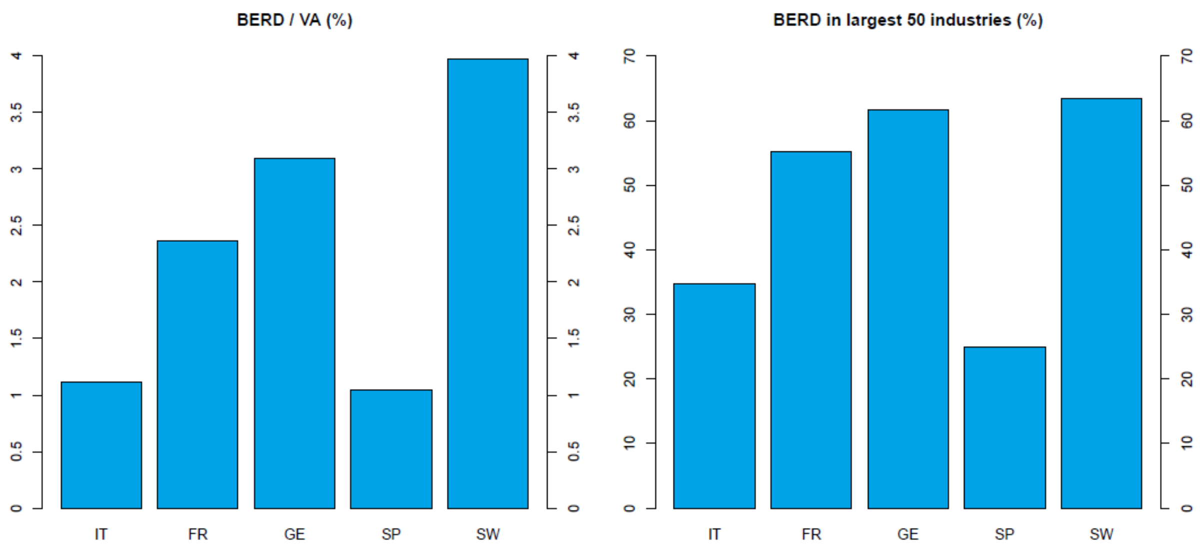
Cooperation between firms and institutions producing knowledge is fundamental in order to create innovative projects. Taking co-publications as a proxy for the quality of innovation spurred by partnerships, we can see that Italy performs better than France, Spain and Sweden, while still lagging behind Germany. On the other hand though, data concerning the collaboration between firms and universities is an issue. Indeed, firms don't finance university R&D as much as in other countries, therefore not exploiting the benefits of the cooperation with knowledge producing institutes which might spill it over to the firm. On the contrary, Italian firms are the less inclined to acquire information from the outside in three of the four categories shown on the graph.



Cooperation data
(Benvenuti, Casolaro, & Gennari, 2013)

f. R&D Expenditure

Having analyzed the other factors of the gap of Italian innovation landscape compared to the European leaders, it shouldn't come as a surprise that it also has some issues concerning the R&D expenditure committed to innovative projects. The ratio between R&D expenditure and value added in the graph outlines once again how Italy is lagging behind in comparison with the top innovating European countries. An indicator with an ambivalent interpretation is the degree of R&D spending concentration among firms in the country. On one side, less concentrated expenditure may be beneficial for the overall innovative effort of a country, since there is less dependence of few large companies and there is more growth ground for small firms with new projects. On the other hand though, dispersed expenditure may not possess the critical mass needed to create a strong innovative landscape.

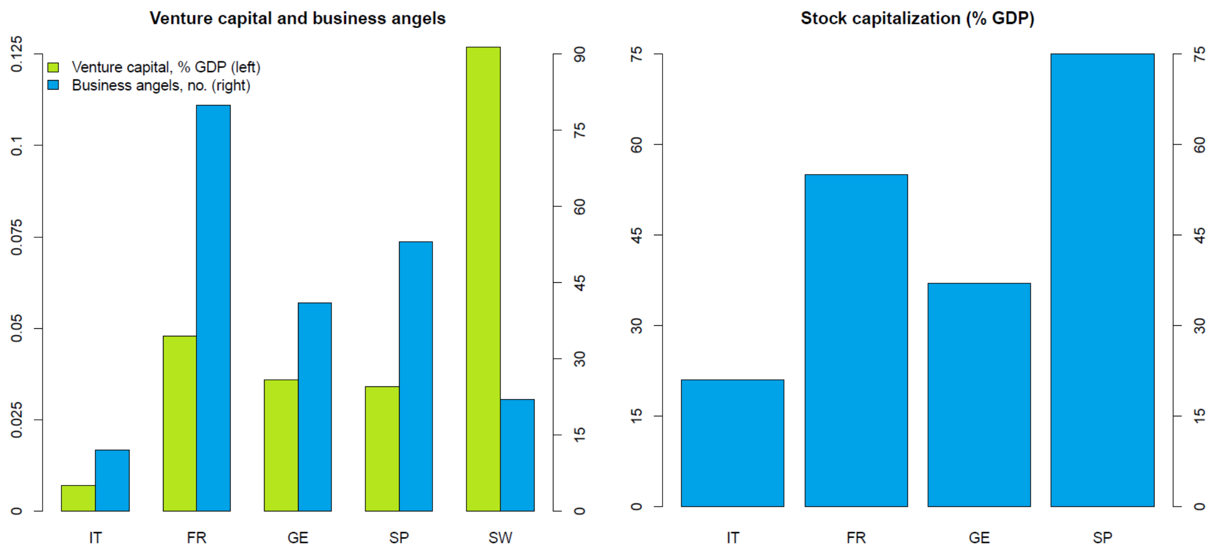


Business enterprises R&D data 2010-2011
(OECD, 2014) (Benvenuti, Casolaro, & Gennari, 2013)

R&D expenditure in Italy looks less concentrated than in peer countries, confirming the aforementioned characteristics of the Italian innovation system, with a widespread R&D expenditure, too small to produce radically innovative results. This evidence is even worse when considering that Italian firms are receiving more widespread public funding compared to Germany and Spain (Benvenuti, Casolaro, & Gennari, 2013).

III. Financing innovation in Italy

As seen from the previous paragraph, obtaining the resources to fund innovative projects is an issue in Italy. As seen in Chapter 2, innovative firms suffer from several characteristics, such as high information asymmetry, the production only of intangibles as output, the possible moral hazard issues connected with the information asymmetry; all of which makes innovative firms themselves very risky in the eyes of investors. Equity being the method of choice for small and technological firms, we can see that both Venture Capital and the stock markets are underperforming.



Innovation Financing
(Benvenuti, Casolaro, & Gennari, 2013)

Indeed, we can see from the above graph that Venture Capital financing was equal to 0.003% of GDP in 2011, the smallest value among peer European Countries, along with Business angels also showing a very low number. Overall, Italy has the lowest amount allocated by private equity investors to small and technological firms.

Stock market figures are also not encouraging, with Italy having the lowest capitalization of peer countries. This, as also mentioned in chapter 2, is discouraging for innovative enterprises because of the role of stock markets as a cash-in exit for investors and a financial resource for entrepreneurs who wish to fund more projects. A stock market capitalization/GDP ratio of 21% makes Italy, again, not very attractive for innovative enterprises, which need to have a liquid and efficient stock market in order to achieve long-term attractiveness for investors and performance (Benvenuti, Casolaro, & Gennari, 2013).

a. Early stage financing in Italy

In order to monitor the early stage investing activities in Italy, we will follow the 2013 report on Early stage financing by IBAN – VEM (Caotorta, et al., 2013) survey. The two associations respectively monitor the Angel Financing process and the venture capital investments activity in Italy.

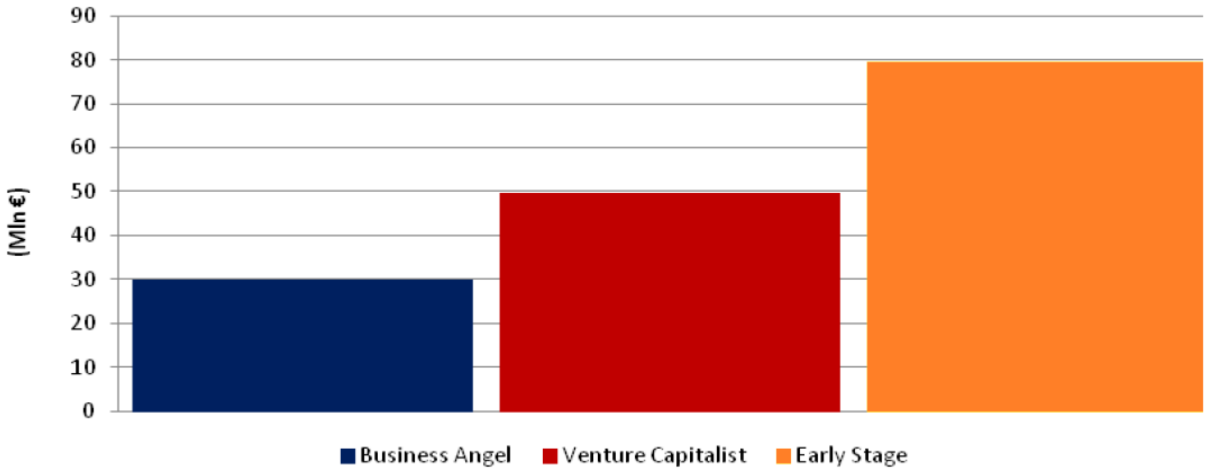
Early stage financing is fundamental to foster innovation in a country. Indeed, as seen in chapter 2, giving access to capital to innovative projects partially solves the credit rationing that may happen if early stage financers like Angel investors or Venture Capitalists are not present. In Chapter 3 we have also seen as these investors have a positive impact on the overall innovative performance of a country.

Concerning Italy, we can see from the aforementioned survey that in 2012, there have been 125 target firms which received resources from early stage investors. This number has decreased from the previous year, when 163 received financing. This reduction has been caused by a 40% collapse in the number of investments Angel Investors have made (only 70 targets in 2012), while Venture Capitalists have increased the number of investments from 45 to 55.

The total number of investments is 186, of which 70 are from Venture Capital Funds and the remaining are attributed to Angel Investors. The overall number has also decreased by 13% from the previous year. On the other hand, the number of participations of multiple investors in the same target has roughly remained stable, two thirds of the Angel-backed firms have had multiple investors, while firms backed by multiple VCs have been a third of the total. There is an ongoing growth of the interaction between Venture Capitalists and Angel investors, with 14 deals characterized by the presence of both forms of financing, when only 4 deals in the previous year had investors from both categories.

The amount of investments in the early stage market has been for year 2012 of roughly 80 million Euros, excluding follow on and public operators. The number hasn't shown a significant increment from the previous year.

Of this 80 million Euros, 50 millions have been invested by institutional investors, venture capitalists, while 30 millions have come from Business Angels, as seen in the following chart:

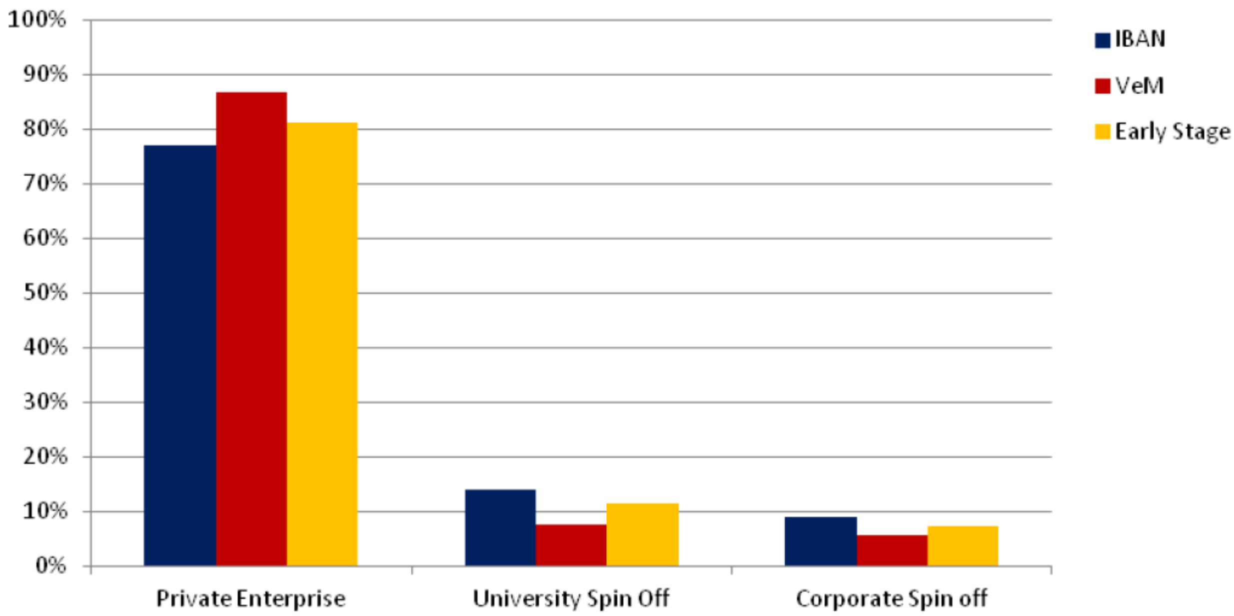


Early stage financing in Italy
(Caotorta, et al., 2013)

A focus on the average amount of invested from Venture capitalists allows us to highlight a reduction of this amount, which has fallen from roughly 1 million Euros in 2011 to 800.000€ in 2012. On the other hand, Angels have nearly doubled the average amount invested from the previous year. Furthermore, Angel cooperative deals are growing and at the same time are growing investments lower than 100.000€ by single angels. In total, the average investment by both Angels and Venture Capitalists is 650.000€. The participation stake acquired by VC investors in the target is also decreasing, passing from a 40% average acquiring stake to an average value of 30% in 2012. Business angels instead have maintained a constant average quota of the target stock, at 25%.

Of all the deals, 67% of them have been seed capital while 33% start-up, with seed recording an increment over the previous year. This increment is only attributed to seed capital deals, because business angels deals remain stable at a 70%/30% repartition.

Of all these deals, private ownership is represented by over 80% of the investment opportunities, getting the preference of both VC and Angels. However, it's interesting to underline how Angels have started to get closer to Academic spin-off phenomena, even though in a residual way like it already happens with VC. Overall, academic spin-offs remain only 10% of the entire market.



Deal Origination (Caotorta, et al., 2013)

On a conclusive note, there haven't been major changing trends in the funding of early stage ventures. Even though there has been a positive signal coming from the rising collaboration between business angels and venture capitalists, there haven't been very encouraging growth numbers in this deal sector.

Business Angels are slowly becoming the “big brothers” of Venture Capital funds, thanks to the bigger average investment which allows better scale economies and lowering the opportunity cost of each deal. This is happening also thanks to the birth of a number of investor clubs who are able to create more structured investments.

VC funds on the other hand have started to get closer to seed capital deals, which previously were consistently targeted by Angels. This has lead to operations with both kinds of investors present, both at seed stage and later financing rounds.

The survey also doesn’t confirm the Business Angels closeness to Corporate spin-offs, which have been marginal. The same can be said about academic spin-offs, with cooperation between investors and University and Corporate spin-offs still being a low point of the Italian system.

As a final note, the survey shows that the amount invested has shown no growth sign and is still not comparable to the early stage markets in Germany, France and UK, making Italy still a difficult environment for the development of innovative projects (Caotorta, et al., 2013).

b. Financial Debt and risk Capital: empirical evidences

As seen in chapter 2, empirical studies have generally shown that recurring to debt to finance innovation may have different characteristics in the different life-cycle stages of a firm. Credit rationing is supported in some cases also for more mature and bigger firms. In the Italian case, several studies have faced the problem of firms financing innovation. Several studies show a general difficulty for new, high-tech firms in accessing bank loans (Giudici & Paleari, 2000) (Colombo, Mastro, & Grilli, 2003) (Colombo & Grilli, Funding gaps? Access to the loan market by high-tech startups, 2004). We have to underline on the other hand that on a larger scale analysis on the matter, including enterprises with large capitalization, a study shows that neither the firms' dimension nor its high-tech characteristics can predict credit rationing (Guiso, 1998). On the other hand though, Scellato observes that in Italy only firms with a larger collateral are able to maintain a constant patenting activity (Scellato, 2003).

In order to observe the behavior of Italian firms pursuing innovation with regards to financial debt, we will follow the findings by Calderini, Oriani and Sobrero (Calderini, Oriani, & Sobrero, Il Finanziamento Privato dell'Innovazione: quali strumenti per quali attività., 2004). Their work highlights that small enterprises have a limited access to credit, and at the same time highly technological firms tend to reduce their bank debit while growing, using alternative means of financing if possible.

This result may suggest that, in Italy, equity is indeed more central than debt when confronting the problem of financing innovation. The latter can't be analyzed without considering at the same time the options that firms have to access external risk capital. Two phenomena need to be brought up when considering external equity financing: after the 2000 crisis and the 2008 one, the investments in R&D have faced a substantial reduction in the whole globe. Secondly, it is possible to observe relevant differences in investment between different countries, as seen in the first paragraph in this chapter. Furthermore, financing innovation implies a shift in time of private equity investments along the life cycle of the firm. Early stage, expansion, replacement and buyout are all different stages in the growth of an innovative venture. In Italy, buyout has increased from 2000 to 2002 at the expense of early stage. This outlines a preference for later stages of the life of a firm for investors, because of the lower risks. At the same time though, as seen in chapter 3, this propensity for the buyout stages comes at the expense of early stage investments, which foster innovation at a higher degree than more mature firms (Calderini, Oriani, & Sobrero, Il Finanziamento Privato dell'Innovazione: quali strumenti per quali attività., 2004).

The Italian industrial structure has lost in the last decade important contributions on R&D by large enterprises, and this has aggravated the situation. In order to achieve growth objectives it is necessary to face what can be done by the different parts involved in the demand for innovative products and financial instruments.

Concerning bank loans to finance innovative projects, we have to acknowledge the limits of the banking system in the absence of specific corrections. Limits that are not only a natural consequence of what bank loans are, but that are also positive if the system wants to avoid putting excessive risks (and costs) on the banking system with long term uncertainty and near absence of tangible collateral.

On the other hand, the idea of the banking system completely ignoring innovative firms is hardly sustainable. Only a system as widespread on the

Italian territory as the banking one can actually affect an industrial system as peculiar as the Italian one, characterized the very small companies with very local scope and managers still largely uncomfortable with the relationships with large national and international capitals. We can then assume that the banking sector could have a big role in the early stages of an innovation-based growth of our industrial system. The latter may system may indeed be helped by the banking system in achieve greater scale and better managerial competences, apt to access other forms of financing, more structurally adequate for the risk profile of innovative activity. Concerning the information asymmetry problems, it is apparent that inadequate accounting standards together with the low attitude towards innovative activities of consultants and accountants are an obstacle in facing the legal problems involved in the innovative process. Thus, information is not communicated clearly to banks that in turn won't finance firms. Furthermore, the absence of technical competences in the banks' management in the evaluation of financing proposals with high-tech content is another issue of the Italian picture (Calderini, Oriani, & Sobrero, Il Finanziamento Privato dell'Innovazione: quali strumenti per quali attività., 2004).

On the other hand the distance between banks and Venture Capital funds should not be interpreted as a signal of short-term mindset or unwillingness to invest, but as a consequence of the high risk profile of the projects in need of financing. The lack of venture capital financing in Italy may be caused by the performance of exit options. We have already seen in chapter 2 that a liquid, developed stock market makes venture capital investments way more attractive in the eyes of investors. The Italian weakness in this sector compared to other realities is, at least in part, explained by the poor development and high volatility of stock markets, in particular for the new markets.

In this perspective concerning equity markets, the majority of the efforts should be concentrated on the development of the latter in order to sustain growth and development of innovative firms. As a consequence, it is in the authors' view, suboptimal that innovation is only sustained with the creation of instruments finalized to the transfer of knowledge and technologies bound strictly to physical structures such as incubators, or virtual structures such as "technological districts". These solutions are unable to create by themselves the conditions for good ideas to become object of entrepreneurial initiative with reasonable growth hopes (Calderini, Oriani, & Sobrero, Il Finanziamento Privato dell'Innovazione: quali strumenti per quali attività., 2004).

5. IPO AND PATENTING ACTIVITY IN ITALY

As seen in the previous chapter, the Italian stock markets, through IPO exits, are one of the key drivers for fostering innovation in industrialized countries. In this last chapter, a research has been conducted in order to answer some questions on the relationship between the innovative performance and the decision to access the stock markets by Italian firms.

I. IPOs in Italy and their impact on patent applications.

After seeing how the Italian landscape is performing in general terms of financing innovation in the previous chapter, we will examine how the transition from private equity to public stock markets impacts the innovativeness of firms. As we have seen in the literature review in Chapter 3, IPOs tend to impact negatively the innovative processes of firms completing the IPO (Bernstein, 2012). In the last chapter though, we have seen that according to recent research on financing innovation in the Italian economic system, only firms with larger capitalization are able to sustain patenting activity (Calderini, Oriani, & Sobrero, Il Finanziamento Privato dell'Innovazione: quali strumenti per quali attività., 2004). In order to evaluate if IPOs as a financial instrument are supporting patenting activity in Italy, we will create a database similar in purpose and spirit to the paper by Bernstein.

We extracted from the Consob website the list of all prospects of companies who filed an IPO from 2002 to 2012 (CONSOB, 2015). Of these companies, we have therefore reported those who ultimately completed the IPO and those that withdrew it. For each firm that either completed or withdrew the IPO, we have then noted the patents filed in the years before the IPO filing and afterwards, using the online available database of the "Ufficio Italiano Brevetti e Marchi" (Ministero Italiano dello Sviluppo Economico, 2015).

We will be testing some hypotheses on the databases in Appendix 2 of this chapter.

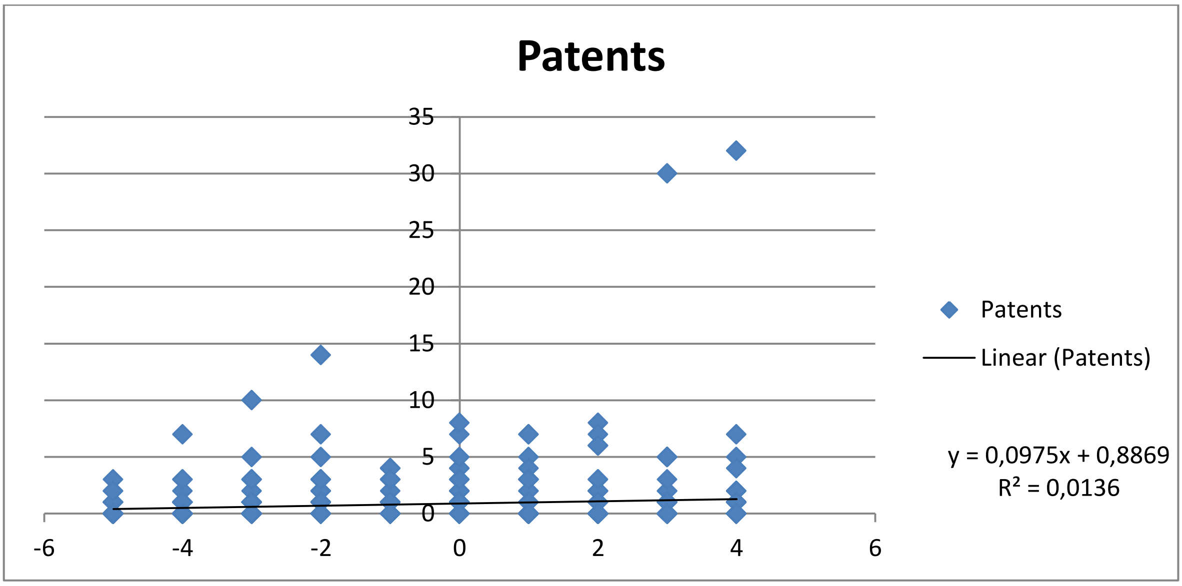
II. The dataset.

Data was gathered from the online database of prospects from the CONSOB website, and organized in separate lists according to the year when the IPO filing occurred in the time period between 2002 and 2011, signaling whether the IPO was completed or not. Afterwards, for each firm applying for an IPO, the patent database from "Ufficio Italiano Brevetti e Marchi" was consulted in order to monitor the patent applications for each firm from 1989 up until 2015.

Assuming that market price fluctuations were not relevant with regards to patenting activity, following the work by Berstein (Bernstein, 2012), the following table was created reporting the number of patents for each firm applying for an IPO in the 5 years before the event, the event year, and 4 years afterwards. The full table can be found in Appendix 2, along with the table with the relative weights.

III. Linear regression of the overall dataset

A linear regression of the dataset was ran in order to evaluate the hypothesis that there is a positive correlation between the IPO event and the yearly patenting activity. The results are the following:



SUMMARY
OUTPUT

Regression Statistics	
Multiple R	0,116407
R Square	0,01355
Adjusted R Square	0,01175
Standard Error	2,394277
Observations	550

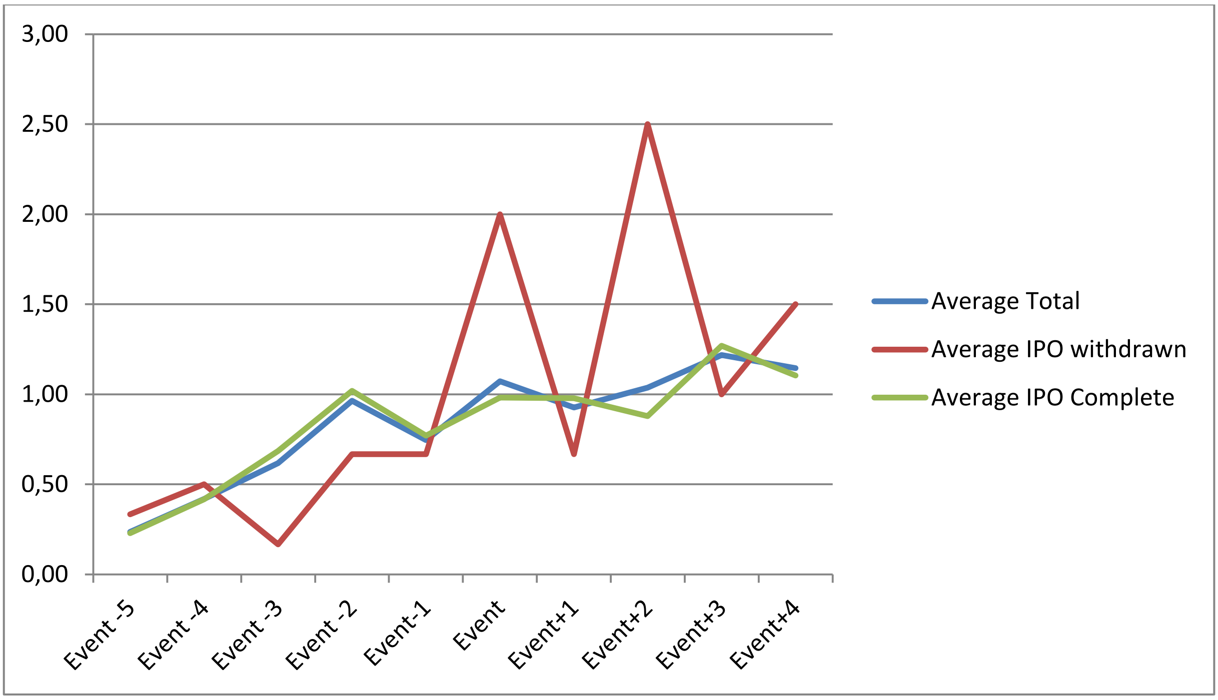
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	43,15289256	43,15289	7,527677	0,0062748
Residual	548	3141,445289	5,732564		
Total	549	3184,598182			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0,886942	0,103627642	8,558934	1,15E-16
Event Year	0,097521	0,035543988	2,743661	0,006275

After running the regression, we can see that at a very high significance level of 0,006, there is indeed a small positive correlation between the independent variable "Event year", which represents the years preceding and following an IPO, and the dependent variable number of patents. On the other hand though, the function variation is only explained in a very small part by the variation of the time approaching and following the IPO, as the squared residuals only explain 1,3% of the total, therefore suggesting that there the IPO filing by itself isn't explaining much of this trend.

In order to have a general view of the variations per each year of patenting activity in correlation with the IPO, we can visualize the following graph.



Patents issued per year around IPO event

(Ministero Italiano dello Sviluppo Economico, 2015)

(CONSOB, 2015)

In here we can see the averages of patent applications in each year approaching the event. The Green line shows the overall trend for all firms which filed for an IPO, whether completed or not. The Blue line is showing the curve relative only to firms who completed the IPO, while the red one is representing the patents filed by companies who withdrew their IPO application.

We can see that the overall trend on average is an increase of patent applications leading up to and in the years following the IPO.

We have to keep in mind that since the number of Italian IPOs is small compared to other markets and the sample is of 55 overall IPO filings, of which 49 completed and only 6 withdrawn. Given this premise, we can try to draw some insights from these numbers. It looks like, from both the regression and the graph above, that firms who file for an IPO do improve their patent activity. This statement would be in agreement with the previous chapter concerning the financing innovation in Italy by Calderini et alia (Calderini, Oriani, & Sobrero, Il Finanziamento Privato dell'Innovazione: quali strumenti per quali attività., 2004). Indeed, it looks like firms reaching a maturity stage financially are the ones that are able to sustain a reliable patenting activity.

The red line sample is very small, and thus cannot be used to draw any meaningful conclusion, but there seems to be a trending larger increase in patenting activity for those firms who didn’t complete the IPO. This trend would be in line with the results by Bernstein concerning the effect of IPOs on innovative activity (Bernstein, 2012).

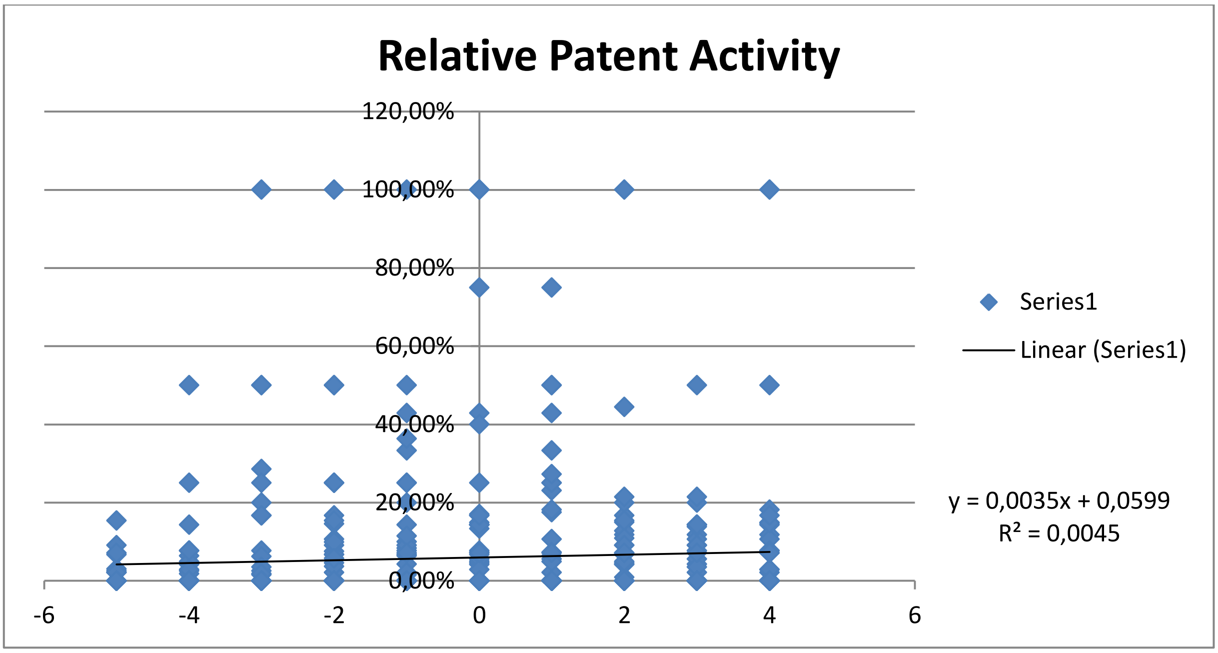
On the other hand though, these results are indeed inflated in the year post IPO by the activity of the top performers with regards to patenting (we can see some clear outliers in the scatter plot), which is several magnitudes higher than the rest of the observations.

IV. Modified Dataset as a percentage of overall patenting

In order to overcome this limitation and look for data more representative of the patenting performance of each single firm prior and post IPO instead of the overall figures, the original database has been modified in order to return instead of the raw number of patents filed per each year, the relative percentage of patents which have been filed in the years around the IPO compared to the firm overall patenting activity from 1989 to 2015.

This was done in order to remove the high impact of the top performers in patenting activity. We can see that the do present some differences.

Again, a regression has been ran on the dataset, setting as the independent variable the event year and the dependent variable the relative percentage of patents filed in each year compared to the overall patenting activity.



SUMMARY
OUTPUT

Regression Statistics	
Multiple R	0,0671
R Square	0,0045
Adjusted R Square	0,0027
Standard Error	0,1497
Observations	550,0000

ANOVA

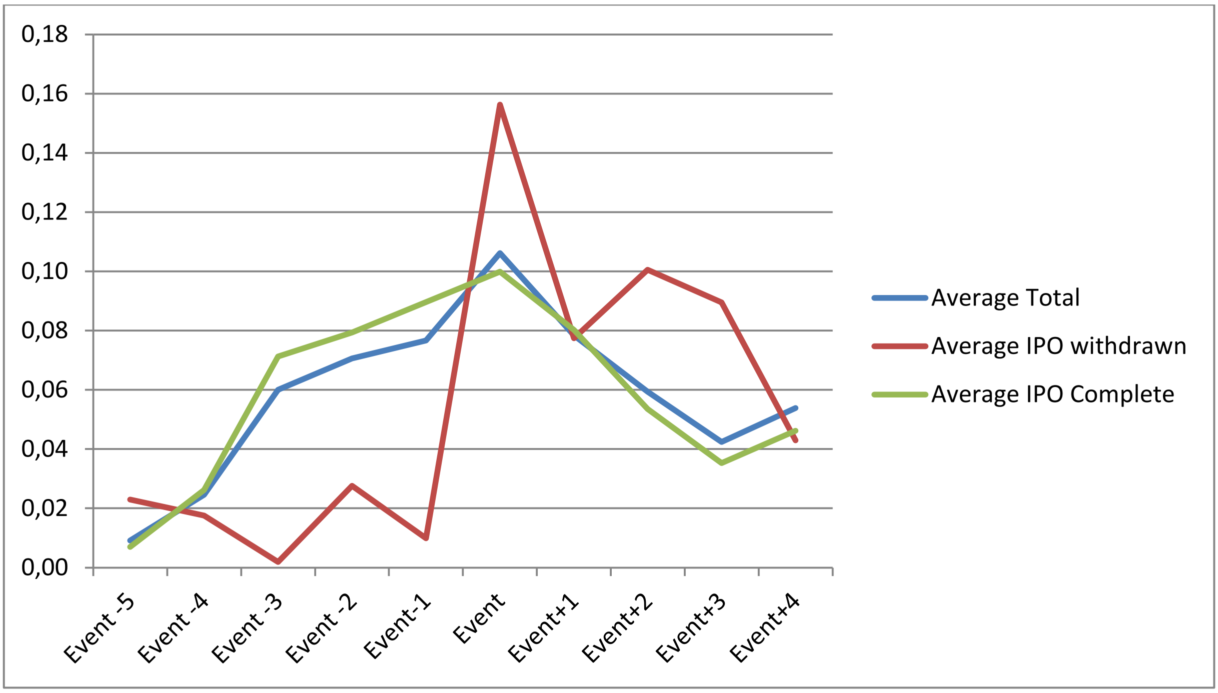
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,055548	0,055548	2,479874592	0,115888558
Residual	548	12,27494	0,0224		
Total	549	12,33049			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0,059853	0,006478	9,239864	5,41192E-19
Event Year	0,003499	0,002222	1,574762	0,115888558

Again, we can estimate a small positive trend between the two, although at a lesser significance level (11,5%).

We can see that, while still positively trending, the slope of the function is flatter, indicating that in the long run the relative effect of the IPO on long term patenting activity has a very small effect.

Again, the R Square is extremely low, hinting that the impact itself of IPOs on patenting activity in Italy is marginal. As we did in the previous instance, we can try to get some small insights from the graphical representation of the average relative patenting activity for each year.



Relative percentage of Total Patents issued per year around IPO event

(Ministero Italiano dello Sviluppo Economico, 2015)

(CONSOB, 2015)

We can immediately see that data relative to each observed firm's total performance returns a peak in activity precisely around the IPO event. For overall IPOs and completed IPOs, the activity afterwards declines at lower values than the pre-IPO ones.

This may indicate a window-dressing phenomenon for firms with patenting activity: in order to maximize the share value of issued IPOs, Italian firms may tend to file as many patent applications as possible in order to look more appealing to the market.

Again, the data relative to withdrawn IPOs composes a very small sample, but it does look like that the peak is even higher at the IPO event for withdrawn IPOs, who, contrary to what happens to IPO completed, do have a reduction on patenting activity following the IPO, but at a higher level compared to the relative patenting activity pre IPO.

V. Conclusions

This chapter tried to empirically find some answers to what is the impact of IPOs on the patenting activity and innovative activity of firms. The problem with this kind of research is indeed the sample: Italian IPO activity is limited, and so is patenting activity compared to other industrialized countries. Therefore it can't be inferred the impact of a public ownership on patenting activity on a general level, but we can get some interesting insights from the data collected.

It definitely seems to be a little stimulus to patenting activity for companies with an already large patenting activity pre-IPO, which consolidates the statement that a large dimension in Italy is indeed the preferable route in order to maintain a stable R&D output.

On the second part of the analysis, we have seen how the IPO event per se is connected with an increase in patent filing, suggesting that firms exploit patent filings as assets to have higher market recognition. Overall, there doesn't seem possible to have definitive answer on whether a public ownership compared to private ownership has any advantage on the innovative performance of Italian firms.

Appendix 1

IPO lists per year with patenting activity

Data/Numero	Operazione	IPO Compl	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	ToT
22/02/2002	Ammissione quotazione azioni ordinarie "Actelios spa"	Yes																		1		1								2
08/11/2002	Ammissione a quotazione di azioni ordinarie e di risparmio di "Italenergia spa" che assumera' la denominazione di "Edison spa"	Yes													1	1				1	1		1			1	1			7
13/11/2002	Ammissione a quotazione azioni ordinarie "Tenaris S.A."	Yes														3	3		1											7
20/11/2002	Offerta pubblica di sottoscrizione e vendita di azioni ordinarie "Socotherm SpA" finalizzata all'ammissione a quotazione	Yes		2				1	1			1	1		1	1	3			1		1								13
			Relative weights																											
		Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0,5	0	0	0	0	0	0	0	
		Yes	0	0	0	0	0	0	0	0	0	0	0	0	0,14	0,14	0	0	0	0,14	0,14	0	0,14	0	0	0,14	0,14	0	0	
		Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0,43	0,43	0	0,14	0	0	0	0	0	0	0	0	0	0	
		Yes	0	0,154	0	0	0	0,08	0,08	0	0	0,08	0,08	0	0,08	0,08	0,23	0	0	0,08	0	0,08	0	0	0	0	0	0	0	

Data/Numero	Operazione	IPO Comp	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	ToT
2003	Ammissione a quotazione e offerta pubblica di vendita e di sottoscrizione di azioni ordinarie "META spa"	Yes								1			1			3	1			1										7
2003	Offerta pubblica di vendita e ammissione quotazione azioni ordinarie "Hera spa"	Yes															1			1		1	1		2	1				7
2003	Ammissione a quotazione azioni ordinarie "New Co28 spa" (che assumera' la denominazione sociale "Autostrade spa")	Yes															1													1
2003	Offerta pubblica di vendita e sottoscrizione e ammissione quotazione delle azioni ordinarie "Isagro spa"	Yes						1	3	4	6	1	2	3	7	4	2	1	2	1	1	3	3	3		1				48
2003	Offerta pubblica di vendita e sottoscrizione e ammissione a quotazione sul mercato telematico azionario - segmento STAR - di azioni ordinarie "Trevisan spa"	Yes												1	1		1	2										1		6
2003	Ammissione quotazione azioni ordinarie "Cell Therapeutics, Inc."	No																3	1			1				1				6
			Relative weights																											
		Yes	0	0	0	0	0	0	0	0,142857	0	0	0,142857	0	0	0,428571	0,142857	0	0	0,142857	0	0	0	0	0	0	0	0	0	
		Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,142857	0	0	0,142857	0	0,142857	0,142857	0	0,285714	0,142857	0	0	0	
		Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
		Yes	0	0	0	0	0	0,020833	0,0625	0,083333	0,125	0,020833	0,041667	0,0625	0,145833	0,083333	0,041667	0,020833	0,041667	0,020833	0,020833	0,0625	0,0625	0,0625	0	0,020833	0	0	0	
		Yes	0	0	0	0	0	0	0	0	0	0	0	0,166667	0,166667	0	0,166667	0,333333	0	0	0	0	0	0	0	0	0	0,166667	0	
		No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0,166667	0	0	0,166667	0	0	0	0,166667	0	0	0	

Data/Numero	Operazione	IPO Completed	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	ToT
18/06/2004	Offerta pubblica di vendita e sottoscrizione e ammissione	Yes		2			4	2	2	4	1	2	2		1	3	1	3		3			2	4	9	7	4	10		66
21/10/2004	Offerta pubblica di vendita e sottoscrizione e ammissione	No												1							1	1	1				8	1		13
05/11/2004	Offerta pubblica di vendita e ammissione quotazione azioni	Yes																		2	2	2	1	5	1			4		17
05/11/2004	Offerta pubblica di sottoscrizione e ammissione quotazione sul	No						2																						2
			Relative weights																											
		Yes	0	0,03	0	0	0,061	0,03	0,03	0,061	0,015	0,03	0,03	0	0,015	0,05	0,02	0,045	0	0,045	0	0	0,03	0,061	0,14	0,106	0,061	0,152	0	
		No	0	0	0	0	0	0	0	0	0	0	0	0,08	0	0	0	0	0	0	0,077	0,0769	0,077	0	0	0	0,615	0,077	0	
		Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,118	0,118	0,1176	0,059	0,294	0,06	0	0	0,235	0	
		No	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

Data/Numero	Operazione		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	ToT
05/05/2005	Offerta pubblica di sottoscrizione e ammissione quotazione azioni ordinarie "Aeroporto di Venezia Marco Polo - Save spa"	Yes																	1											1
15/07/2005	Offerta pubblica di sottoscrizione e vendita finalizzata all'ammissione alle negoziazioni nel mercato Expandi delle azioni ordinarie "Bioera spa"	Yes																1												1
06/10/2005	Offerta di vendita e sottoscrizione finalizzata all'ammissione a quotazione di azioni ordinarie "Anima SGR spa"	No																			1									1
20/10/2005	Offerta pubblica di vendita e sottoscrizione finalizzata all'ammissione alla quotazione delle azioni ordinarie "Caleffi spa"	Yes		5	1		1								3		1	3	7	3	2	2	7		5	5	1	1		47
04/11/2005	Offerta pubblica di vendita e sottoscrizione e ammissione quotazione di azioni ordinazie "Guala Clousures spa"	No									2	4	1	1	1	1	3	4	2	7	6					6		2		40
10/11/2005	Offerta pubblica di sottoscrizione e vendita di azioni ordinarie "Eurotech SpA" finalizzata all'ammissione a quotazione	Yes									1								1	1	8	1		3		1	2			18
16/11/2005	Offerta pubblica di vendita e sottoscrizione e all'ammissione a quotazione di azioni ordinarie della societa' "Safilo Group S.p.A."	Yes		6	5	1																			2	1	4	5		24
07/12/2005	Ammissione alle negoziazioni sul mercato telematico azionario organizzato e gestito da Borsa Italiana S.p.A. delle azioni ordinarie di "NewGames S.p.A." che assumera' la denominazione sociale "LOTTOMATICA S.p.A."	Yes														1														1
			Relative weights																											
		Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
		Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	
		No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
		Yes	0	0,11	0,02	0	0,02	0	0	0	0	0	0	0	0,064	0	0,0213	0,064	0,149	0,064	0,043	0,04	0,149	0	0,11	0,106	0,02	0,021	0	
		No	0	0	0	0	0	0	0	0	0,05	0,1	0,03	0,025	0,025	0,025	0,075	0,1	0,05	0,175	0,15	0	0	0	0	0,15	0	0,05	0	
		Yes	0	0	0	0	0	0	0	0	0,06	0	0	0	0	0	0	0	0,056	0,056	0,444	0,06	0	0,17	0	0,056	0,11	0	0	
		Yes	0	0,25	0,21	0,042	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,08	0,042	0,17	0,208	0	
		Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	

Data/Numero	Operazione	IPO Completed	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	ToT
27/01/2006	Offerta pubblica di vendita e sottoscrizione e ammissione a quotazione di azioni ordinarie di "Marazzi Group S.p.A."	Yes	1	2	3				1			1	1	1				1		1		1			2					15
07/04/2006	Offerta di vendita e sottoscrizione e all'ammissione a quotazione delle azioni ordinarie "EEMS ITALIA S.P.A."	Yes									1	3	1	2	1		3	1	1	2										15
21/04/2006	Offerta di vendita e sottoscrizione e all'ammissione a quotazione delle azioni ordinarie "Saras S.p.A."	Yes																									2	1		3
02/05/2006	Offerta pubblica di sottoscrizione e ammissione alle negoziazioni nel Mercato Expandi di azioni ordinarie "Pierrel S.p.A.	Yes		1	2	2	2	1																						8
03/05/2006	Offerta pubblica di vendita e sottoscrizione e ammissione a quotazione sul MTA Segmento STAR gestito da Borsa Italiana S.p.A. di azioni ordinarie di NICE S.p.A.	Yes											1		1			5	2	8	5	6	5	5	3	4		2		47
03/05/2006	Offerta di sottoscrizione finalizzata all'ammissione a quotazione nel Mercato Expandi delle azioni di "NoemaLife S.p.A."	Yes																								1				1
19/05/2006	Offerta pubblica di sottoscrizione e vendita di azioni ed all'ammissione delle azioni ordinarie "Bolzoni S.p.A."	Yes				1			3					1	1			1	1		2	1								11
16/06/2006	Ammissione a quotazione delle azioni ordinarie di "PIRELLI TYRE SPA"	Yes											4									2	30	32	38	36	39	36		217
16/06/2006	Offerta pubblica di vendita e sottoscrizione e ammissione a quotazione sul Mercato Telematico Azionario gestito da Borsa Italiana S.p.A. di azioni ordinarie di "PIAGGIO & C. S.p.A."	Yes	1	3	4	6	4	4	5	2	6	1	8	2	3	7	5	14	3	4	7	7	5	4	6	1	11	19		142
29/06/2006	Prospetto Informativo di ammissione a quotazione delle azioni ordinarie della "Sirti S.p.a."	No		4	9	5	1	4	2		1	1	1			1	1	2		4	4	6	5		2		2			55

Relative weights

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Yes	0,07	0,13	0,20	0,00	0,00	0,00	0,07	0,00	0,00	0,07	0,07	0,07	0,00	0,00	0,00	0,07	0,00	0,07	0,00	0,07	0,00	0,00	0,13	0,00	0,00	0,00	0,00
Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,07	0,20	0,07	0,13	0,07	0,00	0,20	0,07	0,07	0,13	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,67	0,33	0,00
Yes	0,00	0,13	0,25	0,25	0,25	0,13	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,02	0,00	0,00	0,11	0,04	0,17	0,11	0,13	0,11	0,11	0,06	0,09	0,00	0,04	0,00
Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00
Yes	0,00	0,00	0,00	0,09	0,00	0,00	0,27	0,00	0,00	0,00	0,00	0,09	0,09	0,00	0,00	0,09	0,09	0,00	0,18	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,14	0,15	0,18	0,17	0,18	0,17	0,00
Yes	0,01	0,02	0,03	0,04	0,03	0,03	0,04	0,01	0,04	0,01	0,06	0,01	0,02	0,05	0,04	0,10	0,02	0,03	0,05	0,05	0,04	0,03	0,04	0,01	0,08	0,13	0,00
No	0,00	0,07	0,16	0,09	0,02	0,07	0,04	0,00	0,02	0,02	0,02	0,00	0,00	0,02	0,02	0,04	0,00	0,07	0,07	0,11	0,09	0,00	0,04	0,00	0,04	0,00	0,00

Data	Operazione	IPO Completed	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	ToT
12/10/2007	Offerta pubblica di vendita finalizzata all'ammissione a quotazione sul Mercato Expandi delle azioni Piquadro	Yes																						1				1		2
27/09/2007	Offerta di sottoscrizione e vendita finalizzata all'ammissione a quotazione sul mercato Expandi delle azioni ordinarie Bouty Healthcare spa	Yes																2	1			1								4
12/07/2007	Offeta pubblica di vendita e sottoscrizione finalizzata all'ammissione a quotazione sull'Mta - segmento Star - delle azioni ordinarie della Bialetti Industrie spa	Yes						1		1	1		3				1	10	2	4	5			5	1		1			35
12/07/2007	Ammissione a quotazione sul Mercato Expandi delle azioni ordinarie della B & C Speakers spa	Yes									1								1	1		1								4
29/06/2007	Ammissione a quotazione sull'Mta, segmento Star, delle azioni ordinarie della DiaSorin spa	Yes										1	1							1										3
20/06/2007	Ammissione a quotazione sull'Mta, segmento Star, delle azioni ordinarie della Enìa spa	Yes																	1											1
14/06/2007	Ammissione a quotazione presso il mercato Expandi delle azioni ordinarie della Pramac spa	Yes																		1	2		1	1						5
07/06/2007	Ammissione a quotazione sull'Mta, segmento Star, delle azioni ordinarie della Landi Renzo spa	Yes			1						1	1		2	1	1					2		1		1	1	1	1		14
22/05/2007	Offerta pubblica di vendita e sottoscrizione finalizzata all'ammissione a quotazione sul mercato Expandi delle azioni ordinarie Screen Service Broadcasting Technologies spa	No																							1					1
18/05/2007	Offerta pubblica di vendita finalizzata all'ammissione a quotazione sull'Mta, segmento Star, delle azioni ordinarie della Zignago Vetro spa	Yes				1																1								2

Relative weights

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,00	0,00	0,00	0,50	0,00
Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,25	0,00	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Yes	0,00	0,00	0,00	0,00	0,00	0,03	0,00	0,03	0,03	0,00	0,09	0,00	0,00	0,00	0,03	0,29	0,06	0,11	0,14	0,00	0,00	0,14	0,03	0,00	0,03	0,00	0,00
Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,25	0,25	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,33	0,33	0,00	0,00	0,00	0,00	0,00	0,00	0,33	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,20	0,40	0,00	0,20	0,20	0,00	0,00	0,00	0,00	0,00
Yes	0,00	0,00	0,07	0,00	0,00	0,00	0,00	0,00	0,07	0,07	0,00	0,14	0,07	0,07	0,00	0,00	0,00	0,00	0,14	0,00	0,07	0,00	0,07	0,07	0,07	0,07	0,00
No	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00
Yes	0,00	0,00	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Data	Operazione	IPO Completed	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	ToT
11/07/2008	Ammissione a quotazione sul Mercato Expandi delle azioni ordinarie Enervit spa	Yes								1								1	1			1								4
26/06/2008	Offerta pubblica di vendita e sottoscrizione finalizzata all'ammissione a quotazione sull'Mta, segmento Star, di azioni ordinarie Kedrion spa - Supplemento al prospetto per l'aggiornamento della descrizione del regime fiscale in seguito all'emanazione del decreto-legge n. 112/2008	No																			4		3	1	1	2				11
21/03/2008	Offerta pubblica di sottoscrizione e di vendita finalizzata all'ammissione a quotazione sul mercato Expandi delle azioni ordinarie della Rosss spa	Yes		1	2		1	1									2	1		2				2		1				13
14/01/2008	Ammissione a quotazione sull'Mtax delle azioni ordinarie della Cell Therapeutics	Yes																3	1			1				1				6
02/01/2008	Ammissione a quotazione sull'Mta delle azioni ordinarie della Ciccolella spa	Yes								1	1	1																		3
			Relative weights																											
		Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,25	0,25	0,00	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
		No	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,36	0,00	0,27	0,09	0,09	0,18	0,00	0,00	0,00	
		Yes	0,00	0,08	0,15	0,00	0,08	0,08	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,15	0,08	0,00	0,15	0,00	0,00	0,00	0,15	0,00	0,08	0,00	0,00	0,00	
		Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,17	0,00	0,00	0,17	0,00	0,00	0,00	0,17	0,00	0,00	0,00	
		Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,33	0,33	0,33	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	

Data	Operazione	IPO Completed	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	ToT
11/06/2010	Offerta pubblica di vendita e sottoscrizione, finalizzata alla quotazione sull'Mta, di azioni	Yes						1		1				2	4									1		1	3	1		14
17/06/2010	Offerta in opzione e ammissione a quotazione sull'Mta di azioni ordinarie e di risparmio Kme Group	Yes																				3	3							6
15/10/2010	Offerta pubblica di vendita finalizzata all'ammissione a quotazione sull'Mta di azioni	Yes																					1		3					4
04/11/2010	Offerta in opzione e all'ammissione a quotazione sull'Mta di azioni ordinarie Premuda spa	Yes										1																		1
			Relative weights																											
		Yes	0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,07	0,00	0,00	0,00	0,14	0,29	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,07	0,21	0,07	0,00	
		Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,50	0,00	0,00	0,00	0,00	0,00	0,00	
		Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,25	0,00	0,75	0,00	0,00	0,00	0,00	
		Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	

Data	Operazione	IPO Completed	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	ToT
25/11/2011	Offerta pubblica di vendita e ammissione a quotazione sull'Mta, segmento Star, di azioni ordinarie Cobra Automotive Technologies spa	Yes						1		1				2	4									1		1	3	1		14
10/06/2011	Offerta pubblica di vendita e all'ammissione a quotazione sull'Mta delle azioni ordinarie Salvatore Ferragamo spa	Yes																				3	3							6
17/02/2011	Offerta pubblica di venditae ammissione a quotazione sull'Mta di azioni ordinarie emesse da Giovanni Crespi spa	Yes																					1		3					4
02/02/2011	Offerta pubblica di vendita e sottoscrizione e ammissione a quotazione sull'Mta di azioni ordinarie Philogen spa	Yes										1																		1
			Relative weights																											
		Yes	0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,07	0,00	0,00	0,00	0,14	0,29	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,07	0,21	0,07	0,00	
		Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,50	0,00	0,00	0,00	0,00	0,00	0,00	
		Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,25	0,00	0,75	0,00	0,00	0,00	0,00	
		Yes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	

Appendix 2

Databases,

Patents by IPO filing

Year	Event -5	Event -4	Event -3	Event -2	Event -1	Event	Event t+1	Event t+2	Event t+3	Event t+4	Ipo complete
2002	0	0	0	0	0	0	0	0	0	1	Yes
2002	0	0	0	0	1	1	0	0	0	1	Yes
2002	0	0	0	0	0	3	3	0	1	0	Yes
2002	0	1	1	0	1	1	3	0	0	1	Yes
2003	0	1	0	0	3	1	0	0	1	0	Yes
2003	0	0	0	0	0	1	0	0	1	0	Yes
2003	0	0	0	0	0	1	0	0	0	0	Yes
2003	1	2	3	7	4	2	1	2	1	1	Yes
2003	0	0	1	1	0	1	2	0	0	0	Yes
2003	0	0	0	0	0	0	3	1	0	0	No
2004	2	0	1	3	1	3	0	3	0	0	Yes
2004	0	1	0	0	0	0	0	0	1	1	No
2004	0	0	0	0	0	0	0	2	2	2	Yes
2004	0	0	0	0	0	0	0	0	0	0	No
2005	0	0	0	0	0	1	0	0	0	0	Yes
2005	0	0	0	0	1	0	0	0	0	0	Yes
2005	0	0	0	0	0	0	0	1	0	0	No
2005	0	3	0	1	3	7	3	2	2	7	Yes
2005	1	1	1	3	4	2	7	6	0	0	No
2005	0	0	0	0	0	1	1	8	1	0	Yes
2005	0	0	0	0	0	0	0	0	0	0	Yes
2005	0	0	1	0	0	0	0	0	0	0	Yes
2006	0	0	0	1	0	1	0	1	0	0	Yes
2006	1	0	3	1	1	2	0	0	0	0	Yes
2006	0	0	0	0	0	0	0	0	0	0	Yes
2006	0	0	0	0	0	0	0	0	0	0	Yes
2006	1	0	0	5	2	8	5	6	5	5	Yes
2006	0	0	0	0	0	0	0	0	0	0	Yes
2006	1	0	0	1	1	0	2	1	0	0	Yes
2006	0	0	0	0	0	0	0	2	30	32	Yes
2006	3	7	5	14	3	4	7	7	5	4	Yes
2006	0	1	1	2	0	4	4	6	5	0	No
2007	0	0	0	0	0	0	0	0	1	0	Yes
2007	0	0	2	1	0	0	1	0	0	0	Yes
2007	0	1	10	2	4	5	0	0	5	1	Yes
2007	0	0	0	1	1	0	1	0	0	0	Yes

2007	0	0	0	0	1	0	0	0	0	0	Yes
2007	0	0	0	1	0	0	0	0	0	0	Yes
2007	0	0	0	0	1	2	0	1	1	0	Yes
2007	1	0	0	0	0	2	0	1	0	1	Yes
2007	0	0	0	0	0	0	0	0	0	1	Yes
2007	0	0	0	0	0	0	1	0	0	0	Yes
2008	0	1	1	0	0	1	0	0	0	0	Yes
2008	0	0	0	0	4	0	3	1	1	2	Yes
2008	2	1	0	2	0	0	0	2	0	1	Yes
2008	0	3	1	0	0	1	0	0	0	1	Yes
2008	0	0	0	0	0	0	0	0	0	0	Yes
2010	0	0	0	0	0	1	0	1	3	1	Yes
2010	0	0	0	3	3	0	0	0	0	0	Yes
2010	0	0	0	0	1	0	3	0	0	0	Yes
2010	0	0	0	0	0	0	0	0	0	0	Yes
2011	0	0	0	0	1	0	1	3	1	0	Yes
2011	0	0	3	3	0	0	0	0	0	0	Yes
2011	0	0	0	1	0	3	0	0	0	0	Yes
2011	0	0	0	0	0	0	0	0	0	0	Yes
Average Total	0,24	0,42	0,62	0,96	0,75	1,07	0,93	1,04	1,22	1,15	55
Average IPO withdrawn	0,33	0,50	0,17	0,67	0,67	2,00	0,67	2,50	1,00	1,50	6
Average IPO Complete	0,23	0,42	0,69	1,02	0,77	0,98	0,98	0,88	1,27	1,11	49

Relative Patenting activity by IPO filing.

Year	Event -5	Event -4	Event -3	Event -2	Event-1	Event	Event +1	Event +2	Event +3	Event +4	Ipo complete
2002	0	0	0	0	0	0	0	0	0	0,5	Yes
2002	0	0	0	0	0,142857	0,142857	0	0	0	0,142857	Yes
2002	0	0	0	0	0	0,428571	0,428571	0	0,142857	0	Yes
2002	0	0,076923	0,076923	0	0,076923	0,076923	0,230769	0	0	0,076923	Yes
2003	0	0,142857	0	0	0,428571	0,142857	0	0	0,142857	0	Yes
2003	0	0	0	0	0	0,142857	0	0	0,142857	0	Yes
2003	0	0	0	0	0	1	0	0	0	0	Yes
2003	0,020833	0,041667	0,0625	0,145833	0,083333	0,041667	0,020833	0,041667	0,020833	0,020833	Yes

2003	0	0	0,166667	0,166667	0	0,166667	0,333333	0	0	0	Yes
2003	0	0	0	0	0	0	0,5	0,166667	0	0	No
2004	0,030303	0	0,015152	0,045455	0,015152	0,045455	0	0,045455	0	0	Yes
2004	0	0,076923	0	0	0	0	0	0	0,076923	0,076923	No
2004	0	0	0	0	0	0	0	0,117647	0,117647	0,117647	Yes
2004	0	0	0	0	0	0	0	0	0	0	No
2005	0	0	0	0	0	1	0	0	0	0	Yes
2005	0	0	0	0	1	0	0	0	0	0	Yes
2005	0	0	0	0	0	0	0	1	0	0	No
2005	0	0,06383	0	0,021277	0,06383	0,148936	0,06383	0,042553	0,042553	0,148936	Yes
2005	0,025	0,025	0,025	0,075	0,1	0,05	0,175	0,15	0	0	No
2005	0	0	0	0	0	0,055556	0,055556	0,444444	0,055556	0	Yes
2005	0	0	0	0	0	0	0	0	0	0	Yes
2005	0	0	1	0	0	0	0	0	0	0	Yes
2006	0	0	0	0,066667	0	0,066667	0	0,066667	0	0	Yes
2006	0,066667	0	0,2	0,066667	0,066667	0,133333	0	0	0	0	Yes
2006	0	0	0	0	0	0	0	0	0	0	Yes
2006	0	0	0	0	0	0	0	0	0	0	Yes
2006	0,021277	0	0	0,106383	0,042553	0,170213	0,106383	0,12766	0,106383	0,106383	Yes
2006	0	0	0	0	0	0	0	0	0	0	Yes
2006	0,090909	0	0	0,090909	0,090909	0	0,181818	0,090909	0	0	Yes
2006	0	0	0	0	0	0	0	0,009217	0,138249	0,147465	Yes
2006	0,021127	0,049296	0,035211	0,098592	0,021127	0,028169	0,049296	0,049296	0,035211	0,028169	Yes
2006	0	0,018182	0,018182	0,036364	0	0,072727	0,072727	0,109091	0,090909	0	No
2007	0	0	0	0	0	0	0	0	0,5	0	Yes
20	0	0	0,5	0,25	0	0	0,25	0	0	0	Yes

07											
2007	0	0,028571	0,285714	0,057143	0,114286	0,142857	0	0	0,142857	0,028571	Yes
2007	0	0	0	0,25	0,25	0	0,25	0	0	0	Yes
2007	0	0	0	0	0,333333	0	0	0	0	0	Yes
2007	0	0	0	1	0	0	0	0	0	0	Yes
2007	0	0	0	0	0,2	0,4	0	0,2	0,2	0	Yes
2007	0,071429	0	0	0	0	0,142857	0	0,071429	0	0,071429	Yes
2007	0	0	0	0	0	0	0	0	0	1	No
2007	0	0	0	0	0	0	0,5	0	0	0	Yes
2008	0	0,25	0,25	0	0	0,25	0	0	0	0	Yes

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