POLITECNICO DI MILANO
Facoltà di Ingegneria dei Sistemi
Corso di Laurea Specialistica in Ingegneria Gestionale

INTELLECTUAL PROPERTY PROTECTION AND OPENNESS TO OPEN SOURCE IN HYBRID SOFTWARE START-UPS

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Anno accademico 2012/2013

a Mamma e Papà

“ Iterum Alte Volat ”

Abstract

The aim of this paper is to analyze the effects that the human capital of founders exerts on the NTBFs' performance in the software industry. In particular, the study was limited to companies characterized by hybrid business models, dedicated to activities for the realization of purely proprietary products and open source products or projects, and to two main corporate performances: the degree of intellectual property protection and the degree of openness to the Open Source characterizing different companies. This work focused on the aforementioned topic to fill the existing theoretical literature gap. So far a wide investigation has been devoted to the analysis of the relationship between the characteristics of the human capital of the founders and the growth and survival performance of NTBFs without a specific distinction between those with proprietary business models and those with hybrid ones. Furthermore in the theoretical literature the relationship between the venture capitalists and the means of intellectual property protection such as patents and the characteristics of the human capital of founders, respectively, has been deepened extensively.

Therefore, after a broad review of the theoretical literature and after a description of the direction of investigation of the work, the main hypothesis to be empirically tested have been identified. To achieve this goal the data have been personally collected, creating a dataset unique in its kind, used then to carry out various statistical analyzes needed to verify the hypotheses of the conceived research question.

The independent variables selected to represent the characteristics of the human capital of founders are: education, the specific experience in the software industry and entrepreneurial experience. Their impact on patents and trademarks endowments as well as on the holdings of open source software products among the different companies has been investigated.

The empirical verification seems to confirm the existence of a negative impact of the education and industry or entrepreneurial experience on the endowments of patents and trademarks of the companies. This has highlighted the fact that the instruments of intellectual property protection act, for young and inexperienced entrepreneurs, as a confidence booster to capture the potential value of the products and the business ideas they realized and conceived, even despite the security arising from possible alliances with reliable partners for the commercialization of their technologies.

Moreover the performed empirical analysis did not reveal interesting findings regarding the relationship between the levels of education as well as the experience of the founders and the

probability that a firm is more or less geared to the creation of open source products. A possible explanation for this results is that in this analysis the traditional determinants of the degree of openness to Open Source indicated by the theoretical literature have been excluded and it has not been possible to consider the previous specific Open Source experience of the founders. The only interesting but countertrend result relative to this behavior is the finding of a positive impact of the high-level managerial experience of the founders on the amounts of OS products in the various companies. This, against the expectations, can be interpreted as an important indicator of new trends and business policies devoted to facilitate an increase of the rate of OS projects integrated with the corporate strategies and to promote mutual collaboration with the OS developers' communities.

Abstract (italiano)

L'obiettivo dello studio condotto in questo paper è quello di analizzare gli effetti che le caratteristiche del capitale umano dei fondatori di NTBFs nel settore del software e con modelli di business ibridi (ovvero caratterizzati da attività volte alla realizzazione congiunta di prodotti puramente proprietari e di prodotti o progetti open source) esercitano sulle prestazioni delle imprese stesse. In particolare l'analisi è stata circoscritta a due principali performance aziendali: il grado di protezione della proprietà intellettuale e il grado di apertura all' Open Source caratterizzanti le diverse imprese del campione analizzato. Il motivo per cui lo studio è stato focalizzato sull'argomento appena descritto è quello di colmare la lacuna presente nella letteratura teorica inerente a questi temi, dal momento che ampio spazio di approfondimento è stato devoluto all'analisi delle relazioni esistenti tra le caratteristiche del capitale umano dei fondatori e le performance di crescita e sopravvivenza delle NTBFs senza una precisa distinzione tra quelle con modelli proprietari e quelle con modelli ibridi. Inoltre nella letteratura teorica è stata ampiamente approfondita la relazione esistente tra i principali finanziatori delle NTBFs: i Venture Capitalists e, rispettivamente, alcuni mezzi di protezione della proprietà intellettuale come i brevetti e le caratteristiche del capitale umano dei fondatori.

Dopo aver quindi effettuato un'ampia rassegna della letteratura teorica sugli argomenti sopracitati ed aver individuato la direzione di indagine del lavoro sono state concepite le principali ipotesi da andare a verificare empiricamente.

Per realizzare questo obiettivo sono stati raccolti personalmente i dati necessari per creare il dataset, unico nel suo genere, che è stato utilizzato per effettuare le diverse analisi statistiche necessarie ai fini di verificare le ipotesi delle research question concepite.

Sono state considerate come principali variabili indipendenti, rappresentative delle caratteristiche del capitale umano dei fondatori, l'educazione, l'esperienza specifica nel settore del software e l'esperienza imprenditoriale; sono stati analizzati gli impatti esercitati da queste ultime sulle dotazioni di brevetti e trademark e sulle dotazioni di prodotti software di tipo open source delle diverse aziende.

La verifica empirica ha confermato l'esistenza di un impatto negativo da parte dell' educazione e dell'esperienza specifica di settore o in generale imprenditoriale sulle dotazioni di brevetti e trademark delle aziende. Ciò ha evidenziato il fatto che gli strumenti di protezione della proprietà intellettuale agiscano per gli imprenditori più giovani e inesperti

come iniezioni di fiducia nel tentativo di appropriarsi del valore potenziale dei prodotti e delle idee di business da essi realizzati e concepite.

Dall'analisi empirica svolta invece non sono emersi riscontri interessanti riguardanti il rapporto esistente tra i gradi di educazione e esperienza dei fondatori e la probabilità che un'azienda sia più o meno orientata alla realizzazione di prodotti open source. Questo potrebbe essere dovuto al fatto che nella realizzazione di questa analisi siano state escluse le classiche determinanti del grado di apertura all' Open Source indicate dalla letteratura teorica e non sia stato possibile considerare l'esperienza specifica pregressa dei fondatori nell'ambito Open Source. L'unico risultato interessante, anche se controtendenza, relativo a questa performance è derivato dal riscontro dell'esistenza di un impatto positivo tra l'esperienza manageriale di alto livello dei fondatori e le quantità di prodotti OS presenti nelle diverse aziende. Questo, contro le aspettative, può essere interpretato come un importante indicatore delle nuove tendenze e politiche aziendali volte a favorire l'aumento del tasso di progetti OS integrati con le strategie corporate e a favorire una collaborazione reciproca con le comunità di sviluppatori.

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1. Theoretical Framework

1.1 Overwiew

The purpose of the literature review section of this thesis is to provide an overview of what is the open source software realm. In the literature it has been extensively treated by many scholars which, however, have generally depth specific aspects and phenomena. The study, thus, covers what are the main issues relating to the open source software realm trying to provide a fairly full picture of what are the main problems related to it. The fact of taking into consideration several aspects has allowed us to draw several reflection and interesting research questions. Starting from a general description of the OS phenomenon, to better understand what are the determinants of the commercial evolution of the same, has been dealt a literature review concerning hybrid business models that are born from the coexistence of the OS movement and the proprietary software firms, to then take into consideration the wide part of the literature concerning the relationship between the OSS and IPRs (intellectual property rights). Particularly in the last section is dedicated space to the discussion of those which are the relationships between the methods of financing through VC (Venture Capital), other topic extensively treated in the literature, and the principal means of intellectual property protection taken into account in this study, namely trademarks and patents, as well as the analysis of those which are the relationships between the characteristics of the founders' human capital and the VC funding.

To perform the drafting of the literature review was first carried out an extensive study and research of the main works on the treated topics to then assemble and link the main interesting extracted information following a personally identified line of argumentation.

The literature review has, therefore, been structured as follows:

1. The first chapter is a brief historical overview of the different phases that have characterized the evolution of the open source phenomenon over time; it has been carried out going to highlight the major discoveries and innovations that have gradually laid the affirmation of open source software worldwide.

2. The second chapter provides the necessary information to understand the reasons why it has spread The Open Source Movement particularly in the software industry. The chapter exactly sheds light on those which have been and continue to be the main

reasons that led those who have started and give a continuum to the OSS movement, because, since they are the real protagonists and creators of this huge success, it was considered appropriate to begin the analysis of the theoretical literature showing exactly the basic stimulation that they have received and which have turned into constant dedication to the cause.

3. The third chapter was dedicated to those which are the ways in which starting from the open source community has gradually created the framework for making the OS phenomenon a profitable reality for many firms in the software industry. It was undertaken a description of those which are the different stages that allowed the gradual approach of the companies that produce proprietary software to the communities that develop open software. The focus of the whole argumentation is the OSS hybrid business model whose study has been extensively treated in the theoretical studies carried out until now. This was done in order to understand the reasons why business models as the latter have developed, especially with what degree of openness to OS, on what basis of commercial readiness of the OSS products have spread, and with what future development prospects can be brought forward.
   In the concluding section of the chapter is investigated one of the most characteristic aspects of the OSS movement seen from the point of view of the architecture in the broad sense of both the community and the companies that adopt hybrid models of business, i.e. modularity. Starting from the concept of appropriability discussed earlier in the chapter, light is thrown on what is the problem of complementarity whitin the development of OSS projects and on what are the solutions developed within the movement with a specific focus on the "object-oriented programming "and on its characteristics of the reusability and flexibility. Particular attention has been paid to what are the conditions of open-source collaboration, precisely from the viewpoint of the type of intellectual division of labor, which allow within the various "hybrid" companies and within the OSS communities to easily get those that are the advantages deriving from the structural characteristics mentioned above.

4. In the fourth chapter, entitled "Intellectual Property Rights into OSS", after an historical overview on the emergence and spread of different modes of intellectual property protection has been addressed a thorough investigation of what is the role of two particular means of protection, Namely trademarks and patents, inside the 'OSS.

among this relation Have been analyzed jointly two main aspects. The first is the influence that portfolios of intellectual property protection consisting of patents and trademarks are able to get on the transition from a business model aimed at more "proprietary" structures to a more open to the OSS. While the second is focused on the ability of the endowments of these portfolios to allow companies engaged in the development of open source software to generate value and to appropriate of the latter.

5. In conclusion, it was chosen for the sake of completeness on the OSS sphere to introduce a chapter that would allow to have an overview of what has been and continues to be the predominant financing mode for firms that decide to take this route, i.e. Venture Capital funding. Exactly the chapter, after an introduction of the reasons why this method of financing combines well with those which are the intrinsic needs of start-up firms in the software industry, is divided into two blocks designated to analyze, with purpose aimed at following the one that is the line of investigation chosen for this thesis, those that are the relations and mutual effects existing between the VC and respectively the forms of patent protection and the characteristics of the founders of the various star-ups.

1.2 Historical Overview

In their study Garzarelli and Langlois (2008) take as an example to introduce what is the concept of OSS, the case of Gaspard Riche de Prony, french engineer who in the late eighteenth century was commissioned by the revolutionary government to construct the largest and most accurate set of trigonometric and logarithmic tables ever produced. Beginning with the recruitment of a few brilliant mathematicians employed to devise formulas well suited for numerical calculation, went so far as to lead a group of 80 people involved in the transformation of these formulas in simpler algorithms. Excluding aspects such as the non-voluntary nature of insiders and the "Fordist" rather than collegial nature of the internal processes, it is possible to consider the “project Prony” as one of the first famous examples of intellectual division of labor in order to share out a complex creative task very close to what is today the conception of OSS project.

In the last years the open source movement has gradually become a topic of great importance in the software industry (Fitzgerard, 2006) but, before introducing the issues of main interest for our study, it is appropriate to provide a brief historical overview of the phenomenon evolution and this will be done by describing six stages.

Benussi (2006) refers to the first stage (1945-1969) as the “new thinking” period summarizing in this expression what were the activities of scientific and technological cooperation in order to obtain greater military innovation. In this manner ever more increased the awareness of need for new ways of data communication and management that led to the use of this new way of developing technology by different universities. The second stage (1963-1975) has been called "the big MAC" because it has seen the development and birth of projects such as the Mac and MIT. Concerning the first, it refers to the creation of an online community of information, capable of storing data and programs for all programmers (Fano & Corbato, 1966). At MIT instead were studied techniques to solve the problem of running one program at a time, the solution was the creation of a time-sharing system capable of operating on multiple problems simultaneously. Such ideas based on the sharing of processing power then lie behind the development of the OS software. The third phase from 1971 to 1982 is the one that saw the development of one of the most important features of the Open Source model, namely modularity, of which will be provided later in this chapter a brief argumentation. In particular, this feature is the basis of the diffusion in this third phase of UNIX, the first open source operating system which is based on the idea that advanced complex functionalities depends on the way simple components of a project interact with

each other. The fourth Stage (1977-1991) covers the time span ranging from the birth of Apple Computer to the publication of the World Wide Web project from the CERN Laboratories. At this stage, the emergence of more and more proprietary software led to a growth of the Open Source movement in response to the monopolization of the sector led by big companies like Microsoft. The fifth step concerns the creation of a project created in 1983 in response to the commercialization of UNIX: the GNU project. The latter was an operating system based on UNIX, but obviously free and prevented from becoming proprietary thanks to the GNU General Public License associated with it. During the same period also were born two non-profit foundations: the Free Software Foundation and the Open Source Initiative (OSI) in order to protect the free software users and promote initiatives to spread the phenomenon. In particular OSI in 1997 conceived the Open Source Definition that incorporates the notion that anyone should be able to use software code, modify it and diffuse such modifications without having to pay anything. The definition required compliance with the following criteria:

1. Free Redistribution

The license shall not restrict any party from selling or giving away the software as a component of an aggregate software distribution containing programs from several different sources. The license shall not require a royalty or other fee for such sale.

1. Source Code

The program must include source code, and must allow distribution in source code as well as compiled form. Where some form of a product is not distributed with source code, there must be a well-publicized means of obtaining the source code for no more than a reasonable reproduction cost preferably, downloading via the Internet without charge. The source code must be the preferred form in which a programmer would modify the program. Deliberately obfuscated source code is not allowed. Intermediate forms such as the output of a pre-processor or translator are not allowed.

2. *Derived Works*

The license must allow modifications and derived works, and must allow them to be distributed under the same terms as the license of the original software.

3. *Integrity of The Author's Source Code*

The license may restrict source-code from being distributed in modified form only if the license allows the distribution of "patch files" with the source code for the purpose of modifying the program at build time. The license must explicitly permit distribution of

software built from modified source code. The licence may require derived works to carry a different name or version number from the original software.

4. *No Discrimination Against Persons or Groups*

The license must not discriminate against any person or group of persons.

5. *No Discrimination Against Fields of Endeavor*

The license must not restrict anyone from making use of the program in a specific field of endeavour.

6. *Distribution of License*

The rights attached to the program must apply to all to whom the program is redistributed without the need for execution of an additional license by those parties.

7. *License Must Not Be Specific to a Product*

The rights attached to the program must not depend on the program's being part of a particular software distribution.

8. *License Must Not Restrict Other Software*

The license must not place restrictions on other software that is distributed along with the licensed software.

9. *License Must Be Technology-Neutral*

No provision of the license may be predicated on any individual technology or style of interface.

(Source: *http://opensource.org*/docs/osd)

The last stage (1991-2001) of this historical digression was characterized by the emergence of the Web 2.0 and of Linux in response to problems that arose with the GNU project and the need to connect programmers around the world using the Web; which is why it was developed the first kernel (the core of an operating system: software having the task to provide to processes running on the computer a secure and controlled hardware access) for the GNU / Linux operating system.

1.3 The Open Source Movement

To explain the main reasons that underlie the diffusion of OSS one can start from the definition of Varian and Shapiro (1999), according to which "everything that can be digitalized, that is represented by bit sequences, is information ", then the same is true for software. Bonaccorsi and Rossi's work (2003) shows that the peculiarity of the Open Source movement can be explained using recent developments in the theories of collective action, of co-ordination in the absence of a central authority and of the diffusion of technologies in the presence of network externality. There are several factors that may explain the distribution of informational goods such as increasing returns from the production or supply side, and network externality effects, or increasing returns from the demand side (Bonaccorsi and Rossi, 2003).

In the case of software programmers the importance of sharing a particular type of software (the operating system which runs the whole file system of the computer) is a typical direct positive externality, while having increasing initial returns can trigger a virtuous circle that starting from a small initial advantage culminate in the spread of that type of standard across the market. Indeed that's what happens when a piece of software is able to gain a significant market share that will encourage consumers to use it and the suppliers and producers to adopt more and more products complementary to the standard establishing the effective market dominance. The choice of an operating system, such as the Linux system in place of Windows NT, according to Dalle and Jullien (1999) does not depend on how many people use this system but rather how many use it within the same network of reference of the individual.

Regarding this theory is worth highlighting the diffusion, during the development of the OS movement, of a phenomenon called "advocacy" which consisted in the fact that the leading members of the OS movement invited the users of OS programmers to convince other members of their network to abandon the commercial sector. In view of these and other phenomena, it is easier to explain the significant and rapid growth of the OS phenomenon.

In this context, however, some theories (Olson, 1965) support the existence of adverse effects positively correlated to the increase of the number of members: "as the size of the group increases there is a progressive reduction in the probability of being detected and a corresponding increase in the incentive to benefit from the good without contributing to its production ". Other theories (Hardin, 1982), however, discredit the latter as highlight the fact

that, the presence in the initial core of subjects with great interest in programming and animated by the desire to be the first to give a contribution to the resolution of a new problem or a specific goal, allowed to initially create virtuous circles likely to produce the collective good and to discourage opportunistic behavior in the rest of the group. The efficacy of the subgroups consist of the best hackers; their best resource is the incomparable know-how in computer science that is sufficient to supply the good without the co-operation of others.

It is worth noting that the presence of hackers behind many OSS projects as well as the whole movement, not only is necessary to explain the reason of the movement itself, but also is a reason for its rapid expansion. The latter claim is supported by the theory of Hurberman and Loch (1999) who show that the presence of a few individuals with very strong propensity to innovation allows the critical mass to be reached almost immediately. Reaching the critical mass involves moving from a state of equilibrium to a new technological one characterized by an incoming technology, which occurs when some variables (in technology diffusion models are represented by the number of people who adopt the new technology) characterizing a process rise above a given threshold.

A positive effect of network externalities in OSS is that who adopts these standards is entitled to have access to a greater benefit the greater the number of tools designed and developed within the same network of OSS users. Remains worthy of note the fact that while the OSS movement is characterized by a community of free developers, companies producing proprietary software in order to compete must resort to huge investments in R&D, and this certainly is a factor not to be overlooked in the economies of the game played between the two opposing forces.

Successful open source software projects tend to be characterized by highly distributed teams of volunteer developers who contribute new features, fix defects in existing code, and write documentation for the product (Raymond 2001, Von Hippel and Von Krogh 2003). These developers (which can be numbered in hundreds) are located around the globe and hence may never meet face to face. Among the most popular examples of products developed in this manner are the Linux operating system and the Apache Web server (Alan MacCormack, John Rusnak, Carliss Y. Baldwin, 2001). When programmers are allowed to work freely on the source code of a program, this will inevitably be improved because collaboration helps to correct errors and enables adaptation to different needs and hardware platforms (Bonaccorsi & Rossi, 2003). This happens because facilitated by one of the leading hallmark of many present-day open-source efforts, namely the fact that the bottom-up coordination is more often unplanned rather than planned (Langlois and Garzarelli, 2008).

One of the reasons that may explain the reason of OSS programmers free working is, according to Bonaccorsi and Rossi (2003), their heterogeneity and the presence of different groups in terms of know-how, interests and user needs, forming a number of sub-groups with quite different profiles. Surely the fact that many programmers look at certain activities like hobbies is not enough to justify the enormous outcome obtained from the OS movement. Another reason is the fact that producing OSS is seen by many as a form of intellectual gratification similarly to that of scientific research. The sharing of the same code, and of the results is not only useful for the purposes of feedback which may go by other developers with the intention of facilitating the final refinement, but also to the same authors of the code that take advantage from the point of view of personal prestige. Some also consider OS programming a way to freely express their creativity, and as a form of art in the commercial world dictated by well-articulated guidelines of the work. Among other reasons, however, what remains the most widely accepted is the fact that working for the OS movement and thus increasing its visibility in the sector is also seen as a good business card from companies looking for programmers who enjoy a certain prestige that is acknowledged to them from the network. Of course, the fact that sometimes software solutions that meet the needs of programmers are not present in the market, can push them to provide these weaknesses by themselves. Bonaccorsi and Rossi (2003) point out that a good OS project, to be such that, can't exclude two factors: a widely accepted leadership setting the project guidelines and driving the process decisions, and an effective co-ordination mechanism among the developers based on shared communication protocols (in particular, the latter factor, linked to modularity, will be faced in the end of the chapter). It is noteworthy that also for OSS projects one may encounter internal hierarchical structures. The difference with the case of proprietary software is that the roles are not assigned from the beginning, but as the project grows and community expands accepting new developers, is natural the outlining of project leader figures within it. Often the latter coincide or are constituted largely by those who are the first original developers or founders of the project. It deserves to be clarified that, more than an official investiture, this "election of leaders" should be seen as a continuous maturing over time recognition to those who theoretically have lavished more efforts and contributions to the project.

After this digression, which attempts to provide an explanation to the original soul of the open source movement and to such a great "free production" among its developers, we can proceed analyzing the way for-profit firms manage the commercialization of OSS product .

1.4 The Open Source Hybrid Models

1.4.1 OSS Communities and OSS Commercialization

After the transformation of OSS into a commercially viable form, a new stream on OSS commercialization has begun to expand focusing on for-profit firms, on their collaborations with OSS communities, on the IPR mechanisms used to appropriate returns from such an open business model, and on the competitive dynamics introduced by OSS.
As clarified by Askoy, Fosfuri and Giarratana (2011), what each company has to pay close attention to when deciding whether taking the path of the OS, is the degree of openness. This choice will involve others very important decisions that are closely related to that, such as the levels of protection that each firms wants to confer to the developing software, but more particularly to the strategic issues that are evoked by this choice. From literature emerges that the most common ways to ensure a good level of intellectual property protection in the software industry are trademarks and patents, but are not ruled out also the various methods of software licensing. These tools of protection and their degree of adoption are fundamental for the purpose of not losing the competitive advantage that, as will be explained subsequently, the OSS is able to provide firms over competitors.

Bonaccorsi et al. (2006) examine the determinants of the degree of openness toward OS and discusses the stability of hybrid models in the evolution of the industry by exploring the entry strategies of software firms in the OS field. The authors show that OSS firms which enter the market with exclusively OS products are a limited number, since the vast majority combines OS and proprietary solutions thus giving space to a remarkable heterogeneity of business models consisting of different degrees of openness to OS. The study leads to the conclusion that among the main factors that negatively influence firms' choices to take the path of openness to the OS, there are switching costs on the supply side and externality network effects on the demand side. In addition, the authors also wonder about the nature of hybrid models from the point of view of the "mutation" trying to figure out if one is facing a transition "from a pure proprietary model toward a pure OS model or vice versa, or rather a steady organizational-state equilibrium ". Supposing to being faced with a trend of companies in the sector characterized by a shift from the proprietary model to the OS one, the authors show that it is not found any empirical data demonstrating that with the passage of time there is a metamorphosis oriented to a higher degree of openness to OS.

Various factors on the demand side, as the higher risk perceived by customers in buying OSS products developed and marketed by new entrants, force companies to decide whether to combine different types of licensing schemes offering both OS and proprietary solutions, or whether to follow a pure model based entirely on OS software. Even if one opts for the latter alternative then the issue lies with the definition of the degree of openness to OS more suited to business goals and then with the suitable management strategy to achieve it.

In the software industry one of the main sources of switching costs is the compatibility between successive generations of software or more generally between hardware and software products (Shy, 2001). As mentioned above, the phenomenon must be analyzed from both the supply and the demand side. This because customers holding proprietary software may find economically disadvantageous a switching to OS specially if it requires extra training or the conversion of files and archives and specially if the companies, that have developed and commercialized proprietary software using license, benefit from a wide portfolio of products that may still not be compatible with the new OS ones. For this reason Bonaccorsi et al.(2006) argue that "the more experience a firm has of proprietary software, the more it will be restrained by inertia from adopting OS". It is important to note at this point that the goal of the study discussed by the authors, is not to investigate what determines the adoption of OS by firms that previously used exclusively proprietary software; this aspect is treated by some studies that disagree in part (also in the light of some specific conditions) the previously highlighted conclusion that defines the experience of proprietary software firms as a repellent to the shift to the OS standard. As described in greater detail in the next chapter, Fosfuri et al. (2008) argue that the likelihood of a firm to open its business model to OS may be higher or lower depending on the presence of certain types of portfolios of intellectual property protection which have been "assembled" gradually during the "purely proprietary firm phase" of its life.

Another factor that impacts the degree of openness to OS, considered by Bonaccorsi et al. is the size effect which "depends on the fact that the expected value of a process innovation is a function of the actual volume of production and hence of the size or turnover level". While the fact that the utility of a software program increases with the current and expected size of the user network, causing a spiral of path-dependent behavior, can be identified in the case of network externalities among the direct externalities (Katz & C. Shapiro, 1989). Theories of indirect externalities show that the larger the diffusion of a given software package the stronger the incentives for companies and individual programmers to develop compatible applications (indirect externalities; Farrell and Saloner 1985). Practitioners in the community

admit that OS users still perceive the two systems as incompatible and can be seen that prejudice is held not only by unskilled end users but also by professionals (Stam, 2009). Therefore Bonaccorsi et al. (2006) expect "proprietary software benefits from larger network externality effects and assume that this reduces the openness of firms toward OS". Furthermore as result of their study, the authors expect the degree of openness to OS to be a positive function of the size of the software firm and a negative function of the length of experience with proprietary software, the date of adoption of OS, and the perceived importance of compatibility problems on the demand side.

Another considerable aspect when it comes to move from a business model focused exclusively on proprietary software, to an hybrid model with a certain degree of openness to OS, is also the addressing and, above all, the effort in adapting to new ways of approaching customers, of managing open code available on the Internet and of learning how to manage the interaction and access to the Community of programmers. Obviously this adaptation phase requires a transition period such that, according to Bonaccorsi et al. (2006), will cause a low level of openness to OS the shorter the time needed for adaptation.

Chesbrough (2003), argues that firms should make the same use of both internal and extraneous ideas, and of internal and external paths to market, thus trying to take advantage of all possible opportunities for technological development. For instance Dahlander and Magnusson (2008) claim that innovation stems not only from a firm's internal investments in R&D, but also relies on important inputs from a variety of external sources, including competitors, consumers, public research institutions, universities and other types of organizations. The fact of undertaking the change to a more oriented OS business model can also mean taking part in OS projects in various communities such as FOSS, which allow the free software and open source code to be constantly improved, modified and distributed (Bonaccorsi & Rossi, 2006 , Dahlander & Magnusson, 2008).

Early studies on OSS centered on the motives driving the contribution of users and developers to OSS projects, the functioning of innovation processes, and the governing issues in OSS communities (Bonaccorsi & Rossi, 2003; Lakhani & von Hippel, 2003; Lerner & Tirole, 2005; O'Mahony & Ferraro, 2007).

Arguably, the idea of companies to undertake OS community relations in order to introduce innovations to their indoor products is very appealing, but may not be considered as a stroll since this choice involves the construction of a sustainable business model. Dahlander & Magnusson (2008) examine how firms make use of communities and how this use is associated with the firms' business models. They start arguing this from the premise that

firms benefit from the creative ideas of individuals outside the company but the inflow of such ideas does not happen spontaneously.

The authors structure the evolution of the relationship between community and propietary firms in three key stages. The first one in the access to the OS community and the different ways to gain it. Companies mainly use two tactics: establishing new communities or identifying and using the existing ones. The first one consists in creating a platform on an area of interest for the company, able to attract not only hobbyists but also employees at other companies. This tactic also derives from the belief that it is better to aim to create a niche still not widespread to grow through the enlargement of the community in which one can become leaders rather than jumping into established mass-markets. The real problem, however, in this specific case lies in the fact that for the company is very complicated to attract enough outsider to reach the critical mass for the development of the created community. Certainly, the greater is the software code's contribute to the customization of the products the greater the chance of attracting programmers. Also having a niche that does not focus on only one specific product is very important in order to grow. Another reason to prefer this tactic is the possibility that establishing a new community, can function as a marketing tool that can raise the awareness of the brand; of course, in terms of disadvantages, this tactic requires high up-front costs.

As firms and community participants are driven by different motives that differ mainly in the fact that the former seek the protection of software in order to maintain competitive advantages unlike the latter, once a firm has access to a community the next step is to align its strategies to those of the community. This is one of the most studied and interesting issue if one considers that the concept of extracting financial benefits from jointly developed software contradicts the core values of OSS movement, in which the code is protected from being appropriated for commercial purposes through the use of legal and normative mechanisms (O'Mahony, 2003). Firms, who aim to utilize the advantageous attributes of OSS in order to create and appropriate value, have to overcome the challenge of adjusting their respective resources and core competencies in a manner that comply with the core values of OSS (West, 2003). This can be done in this case through two main tactics. The first is to adopt licensing practices that clarifies that ownership is to develop practices about copyright issues for firm's own products and integrated source code developed by other communities. The advantages of this tactic remains the purpose of establishing a basis for collaboration between the firm and the community and of avoiding direct conflicts with community participants. Regarding the disadvantages instead: it's difficult to impose practices that are too much proprietary because

they upset community participants; even if it's necessary to experiment, too many changes may create uncertainty for community participants; it's time consuming to analyze legal consequences of licensing practices. The second tactic to align business and community strategies is to influence the direction of development by creating incentive structures for individuals working in the community in order to push them to reach tasks that are of relevance for the firm. The main advantages are a pace technological development by providing different means of subtle control of community participants and the opportunity to receive feedback and tests from individuals that have used the product. The main disadvantages however are that the interference with the work of community participants can disrupt the community's organization and that is still hard to motivate individuals to work on uninteresting tasks. Worth noting that community participants try to avoid the appropriation of their joint work by commercial companies through the use of normative mechanisms such as punishing those who do not behave in accordance with the norms and values (O'Mahony, 2002).

Once the companies have had access to the community and have aligned their strategies the work done in the community remains to be assimilated. One of the tactics used is devoting resources to evaluate and select source code from communities. This because the collaboration with the latter puts the company facing a number of resources that one must carefully select before they can be integrated into the firm's internal processes. The pros associated with this tactic are the increase in the acceptance of employees within the organization and the fact that community participants can work on intellectual challenges and employees on less stimulating tasks, such as bug hunting and efficiency tests. Many difficulties such as the issue to know where to specialize and the fact that evaluating the source code is time consuming, however, remain. A second tactic is to return non-strategic source code to communities. It means selectively share the source code developed by the firm back to communities because not all code they produced was going to be of strategic importance to the firms. The main advantage of this approach is in gaining legitimacy in the community, but revealing source code brings about a number of potential issues. The main disadvantage is that competitors benefit by using source code developed by the firm, but as mentioned above, since the code is not considered strategic for the company, this is a limited risk.

From the just made analysis in which have been described what are the stages that characterize the relationship between firm and an OS development community there are two main findings: using communities is a way for firms to increase the total amount of resources they can draw upon in the innovation processes; there is at the same time the need to

appropriate the potential value of an innovation by limiting other firms' access to the same resources and information.

Bonaccorsi & Rossi (2006) argue that, since many firms are entrepreneurial ventures created by individual programmers that, within the OS community have gained experience and have invested contributions and therefore have strong personal beliefs and values in relation to the OS movement, is likely that these entrepreneurs could transmit to their companies the same values they believe in, shaping their business models towards the openness to OS.
As instead regards the doubts about the transactional nature of the hybrid models, reference can be made to two main currents of thought . A large part of the literature argues that the limit equilibrium will be characterized by a single standard, and the dynamics will be of a winner-takes-all type also relying on theories showing that an initial advantage of a technology will lead to its dominance in the long run. Conversely other studies (Bonaccorsi & Rossi 2003, Dalle & Julien 2003) point to the coexistence of competing technologies in equilibrium maybe in the hybrid model that, as reported by Business Wire (2009) "is likely to end up as the most prevalent business model".

West (2003) suggests that under some conditions hybrid strategies might be preferable to either purely open source or purely proprietary alternatives. Bonaccorsi et al. (2009) in their study find out that firms whose OSS turnover is above 50% between 2000 and 2003 inform remarkable increase in OSS turnovers while those who work with OSS without generating revenues out of it have a notable decrease suggesting the sustainability of a mixed business model.
The following is a more detailed brief overview of what are the modes of income resulting from the commercialization of OSS in companies that adopt hybrid models of business.
Ljungberg (2000) argues that firms gain from OSS developments through the distribution of OSS support material under a trusted brand name. This strategy is also the one behind the Red Hat business model; the company generates revenues selling contracts to support the software that is freely available and downloadable from the website. The second way to gain is by adding value to OSS with additional features or extensions in the form of proprietary software (eg Sendmail), and the third is through the creation of relationships between open source software and other farm products in different ways, such as the bundling (eg IBM).
Conversely Hawkins (2004) identifies four possible sources of revenue for companies focused on the development of OSS. The first of these, also shared by Ljungberg (2000), is the support

that, with the second resource identified, namely sales, remains a source of direct gain. The third mode detected by Hawkins is the one adopted by companies that historically have in their core business the production of hardware but which have supported, always or at a later stage, also the development of complementary software able to enhance the hardware development and commercialization. Even if the developed software was not able to generate a palpable increase of the value of the final product and therefore an increase of turnover, the economic benefit that firms would indirectly have by the use of OSS internally developed products, would be that of lowering the production costs.

The last resource of revenue identified by Hawkins is the internal use of open source software. This mode, more than from a strategy, arises from conditions in which firms are in needing for inexistent software or special customization for an existing one. In this situation according to Samuelson (2006) is much more convenient for firms sourcing through OSS, rather than doing it through proprietary software because it is obviously a lower cost solution and also because it allows to exploit the modular factor in other OSS projects (as shown in detail in the next chapter).

Teece (1986) in his study shows that in a market characterized by easy imitability there is a high risk that the profits from the development of innovative software may accrue to the owners of certain complementary assets rather than to the owners of intellectual property. Furthermore for innovators would be much more expensive, because of high transaction costs, negotiating with the owners of complementary assets. For these reasons Teece marks his study on the need for highly innovative companies to avoid the risk of market failure and thus frustrate all the deployed research efforts; thus suggests that they must first find a correct position in these complementary activities. This thesis supports and is supported in turn by the claims of Fosfuri et al. (2008) and Askoy et al. (2011). They claim that, in case of a company which is dealing with proprietary software and which is also taking the road of OSS, the presence of complementary assets and of resources of intellectual property protection can really generate value for the firm making indirectly profitable the innovative development of OSS. Also Askoy et al. (2011) suggest that forms of intellectual property protection such as patents, even if do not directly protect OSS may indirectly do so when they are designed to protect the appropriability of the value of OSS products' complementary activities.

In Teece's analysis (1986), returns from innovation not only depends on the nature of complementary assets but also on the appropriability regime and on the stage in the evolutionary development of technological knowledge. Appropriability regimes are a mix

between intellectual property rights and secrecy. While the latter is a way to protect internal knowledge, IPRs are designed and used in order to prevent unauthorized use by competitors (excludability). In OSS however we witness a use of IPRs in the form of licenses that do not discourage or prohibit any access to information and it is precisely starting from this aspect that Bonaccorsi et al. (2006) seek to provide evidence that: "Open Source can be a sustainable business model for the software industry also in absence of any appropriability; within the OSS paradigm, complementary assets are distributed collectively, without a concentrated ownership structure; in the OSS paradigm the strength of the network externalities shapes the emergence of a de facto dominant design, stemming from a community of users/producers independently even of the powerful precence of large companies". Teece contrarily argues that innovators need to weld the appropriability conditions of innovation in order to prevent the imitability because in absence of this factor would be discouraging for them to continue to invest in R&D. Innovation without appropriability is not sustainable in the long run (Granstrand, 1999; Towse and Holzhauer, 2002). The OSS movement on the other hand has come up with an alternative IPRs management thanks to brilliant legal inventions. In absence of appropriability indeed what has likewise allowed to make profits were the OS licenses and more particularly the copyleft licenses. In this regard it is appropiate to open a little digression on the importance of OS licenses to assure the correct effectiveness of open source software models and to explain the meaning of the term "copyleft". The 'OSI's (Open Source Initiative) definition seeks to clarify as much as possible what are the main issues regarding domain, use and redistribution modality of OSS. To that end, one of the key points to be highlighted is the difference between OSS and Public software. this difference lies in the fact that the OSS code as well as being accessible to everyone gives also the possibility to have access to the source code and the ability to change and redistribute it. The General Public Licence (GPL) is one of the most popular and adopted licenses within OSS and its author, Richard Stallman, through this licence has tried to preserve the free nature of the software code rather than giving a way of making easier cutting its privatization; from this concept was born the use of the word "copyleft" as opposed to "copiright." Copyleft Licences boost imitation behaviours, but force the ones who customise a copyleft software to release the modifications under the same copyleft license so to forbid to take private advantages from code written by others (Bonaccorsi et al., 2008).

1.4.2 Modularity in the OSS realm

The problem of appropriability and OSS licenses allow us to introduce the issue of complementarity. Within the OSS paradigm in fact, complementary assets are distributed collectively and it's the community that owns these assets in a democratic way (Von Hippel, 2005). Once respected the rules defined by OSS licensing schemes, firms do not have to negotiate other contractual arrangements to gain access to complementary assets. To that end it should be noted that the Internet nowadays is as a potential distribution channel that enables new entrants in the software industry to distribute programs and to render assistance at very low costs. Of course the focus of the question lies in the fact that complementarity becomes a crucial aspect when OSS innovators, for the purpose of being able to benefit from innovation itself, are forced to integrate it into assets owned by others. To overcome this problem, the OSS movement has managed to find a solution in the introduction of the concept of reusability and in the "object-oriented programming". More generally, the development of software in OSS projects depends on a coordination mechanism based on a bottom-up approach that finds its adequate definition precisely in the latter expression. This approach is a winning process innovation since it allows to cope with both the natural complexity that characterizes the software and the complexity deriving from the possibility to combine the different features of the software in various ways (Franck and Jungwirth, 2001).
One of the main characteristics of object-oriented framework is the modularity of developed programs that therefore legitimate the project of the characteristic of reusability. More precisely, theoretical literature (O'Reilly 1999, Raymond 2001, MacCormack and all. 2001) argue that, in open source, modularity is one of the more developed features unlike what happens in the proprietary software field. When it comes to modular systems one can refer to nearly decomposable systems that preserve the possibility of cooperation by adopting a common interface enabling, governing and disciplining the communication among subsystems. The modular concept fits well what are the characteristics of the Open Source production process because it allows the modules to be developed independently from each other avoiding problems of inefficiency and bottlenecks and to be assembled once completed (Garzarelli & Langlois, 2008).
Baldwin and Clark (2000) argue that the modularization of a system can generate tremendous value in an industry, given that this strategy creates valuable options for module improvement. In this way has been increased the degree of modularisation or decomposibility of software products. At the same time the fact of focusing on the design of the core and most

innovative aspects of the new applications instead of designing the whole architecture from scratch each time, has been possible. Shapiro and Varian (1999) point out that this metamorphosis of the technological processes has had a much wider impact going to significantly change the structure of the costs of OSS firms. Even in MacCormack's (2001) work about the management of software projects, the importance of a modular architecture that "facilitates process flexibility" is emphasized. In fact, modularity is a feature that allows firms' costs that previously were considerable as fixed costs to turn in variable costs and also allows the breakeven point and the associated risk to decrease (Piscitello, Bonaccorsi, Merito & Rossi, 2006). Arora and Merges (2004) argue that, if the optimal structure for complex cumulative innovation expected small companies to develop software components integrated in large companies products, then the ability of the various instruments of intellectual property protection such as patents to foster that structure is an important benefit. The theoretical validity of this statement will be better understood thanks to the arguments contained in the following chapter.

Langlois and Garzarelli (2008) suggest that open-source software projects are neither bazaars nor cathedrals (using the first as a comparison to indicate structures decentralized, flat and with varying degrees of freedom in planning, and therefore very close to the reality of the FOSS community; the second term on the contrary indicates structures much more similar to proprietary firms: rigid and centralized), but hybrids manifesting both voluntary production and conscious planning. They point out that it is the nature and intensity of demand and the extent to which demand is quality or time sensitive, that can shift the margin between modularity and integrality. More precisely the authors argue that open-source collaboration is a type of intellectual division of labor that exchanges effort, where the nature of this exchange is possible if there is uppermost willingness of the developers and then labor division's planning.

In 1975 Brooks sheds light on what he considers the main handicap of the intellectual division of labor among a large number of workers. He argues that in an operating system, which may be seen as a very complex tangle of interconnections, the problem that arises is that of coordination between the different programmers and the cost associated with it. In the same period (1972), instead, Parnas laid the foundations for object-oriented programming arguing that one attempts to design systems in which not only the parts don't need to communicate extensively with another but are actually forbidden from communicating with it. This approach also known as "information hiding or encapsulation" is not intended to promote,

between the different operators, the sharing of the parts of the system that may change, unlike those which are unlikely to be changed and therefore should appear in the interfaces between modules.

In an OSS project every programmer may deliberately choose to deal with the development of an aspect of the project, and then a specific "fraction" of code; this is consistent with the fact that each of them should feel free to act and produce what best suited to his knowledge and his abilities. In case there is a pending job, the strategy that is commonly adopted lies in waiting for someone that volunteers his contribution; if no one is willing to do so, unless it is of fundamental importance for the continuation of the overall work, is usually removed. Alternatively one will try to remedy finding time and resources to develop it also jointly between several programmers, because often several alternative solutions lead to new winning solutions. This suggests that a winning property in this area of development is selective capability (Bonaccorsi and Rossi, 2003).

1.5 Intellectual Property Rights and OSS

In the software industry and more recently in the OSS, the problem of IPRs is an issue that has been widely discussed in the theoretical literature. When it comes to IPRs in software one refers to the object of protection which is information. One of the basic features of information is that once produced it is theoretically accessible to all but, pragmatically, it is very difficult to exclude others from using it and for this reason the information can be seen approximately like any other public product with problems related to the production and especially to their consumption. Once produced, the information can be used at a marginal cost tending to zero (Brenner, 1985) and therefore, for all those who are not able to cope with the costs associated with its production, the imitation become the easiest alternative to implementation . This behavior is a very close example of the so-called phenomenon of "free riding". This latter takes place when, within a group of individuals, there is a member who avoids giving its contribution to the common good because he believes that the group can work equally despite its abstention. In our specific case study, the open source code is the common good, while uncooperative individuals represent companies that do not comply with the basic principles of the OSS movement, taking possession of the code and privatizing the later versions that will be developed from it. As recalled by Smith (2006): the higher the potential value of information, the greater the interest in gaining from copying it. The phenomenon has the main effect of increasing the degree of information asymmetry within the industry, since other operators will emulate the behavior of the identified free rider offloading the cost of information onto fewer and fewer operators, till reducing them to zero. Therefore in theory requests for information will be missing and its offer will be also stopped.
According to the foregoing considerations, it could be argued that, in absence of appropriate instruments of intellectual property protection, the software industry and in particular the OS would be destined to gradually decrease its innovative rate due to market imperfections related to the mode of accessing information. The presence of such opportunistic behavior may in fact be the cause of a deadlock under optimal levels of the sector production. Then from these reasons follows the need to use IPRs in order to avoid these opportunistic behavior and to ensure legal protection for creators of innovation. However, there is a good slice of literature that lingers on the actual usefulness of IPRs going to investigate the non-positive effects that their introduction may have had on the innovative growth. IPRs are instruments that allow owners to expand their veto beyond what is innovation itself. The

possession of an IPR allows to extend this right of ownership to all the ideas of development that are based on the original innovation. For instance, IPRs could limit innovation, since they draw a line to the cumulativeness process in treating information, which require instead a free access and use of knowledge formerly generated (Besen & Raskind, 1991)

There are different modalities that allow to guarantee protection of intellectual software. Some of them stem from recordings such as trademarks and patents, and others may be classified as copyright or trade secret. Analyzing the theoretical literature will be exclusively given support to the investigation of issues related to the first two typologies mentioned since the issues and arguments related to other types of intellectual property protection go beyond the central object of this work; for this reason, the main informations concerning them were confined to the following definitions:

- *The copyright* is the exclusive and assignable legal right, given to the originator for a fixed number of years, to print, publish, perform, film, or record literary, artistic, or musical material. The copyright ensures the protection of the innovative work immediately from the moment in which it is created; protection is ensured in an automatic way, without there being any need of a recording or official publication, although it may still be useful since in case of imitation represent an unequivocal proof of authorship. The copyright gives the author the right to: claim authorship of the work, oppose any use of the work that could damage its reputation, economically and exclusively exploit the work
- *Trade secrets* are information that companies keep secret to give them an advantage over their competitors. They are established on the concept of confidentiality, which protect a process, method, plan, formula or other information unique to a manufacturer (such as the software code) from being divulged among not authorized individuals

As regards trademarks, these are combinations of "words, phrases, symbols, or designs that identify and distinguish the source of the goods or services" (USPTO Documentation) which secure legal protection of marketing investments and reputation for quality, brand names, and distribution channels. Even if trademarks do not protect against the imitation of the product *per se*, they do help to boost appropriability by securing control of these complementary assets. Firms can register as a trademark a new name, a jingle or a slogan, a new image, or a logo and also promotions. Trademark owners pay different types of fees for each class of goods or services for which a trademark is registered, and they have to prove

periodically that they are using the trademark in the relevant market; even if the owner is willing to pay the fees, a trademark is cancelled if it is not commercially used for five consecutive years after registration. Whereas patents have received great attention in both management and economics literature, academic interest in trademarks has only recently emerged. Some studies show that trademarks represent a good proxy for the products and markets in which a firm operates, and that they are correlated with sales and stock market value (Seethamraju 2003, Smith and Parr 2000). Mendonça, Pereira & Godinho (2004) test trademarks as a complementary indicator of innovative activity, which is generally proxied by R&D expenditures and patents. For instance Linux, Apache and Debian have trademarked their names for both differentiation purposes and for preventing proprietary appropriation of the OSS code (O'Mahony, 2003).

The oldest registered trademark is the Bass Brewery's Red Triangle for ale was the first trademark to be registered in the United Kingdom under the Trade Mark Registration Act 1875. In 1980, there were fewer than ten thousand registered high-tech trademarks in the United States while in 2012, there were more than 300,000. The two symbols associated with U.S. trademarks ™ (the trademark symbol) and ® (the registered trademark symbol) represent the status of a mark and accordingly its level of protection. While ™ can be used with any common law usage of a mark, ® may only be used by the owner of a mark following registration with the relevant national authority, such as the U.S. Patent and Trademark Office (USPTO or PTO). The proper manner to display either symbol is immediately following the mark in superscript style.

However, as regard patents one can start from the mid-1960s when the Copyright Office formally decided to permit registration of computer programs through the late 1980s and copyright provided relatively strong protection for software. In the following decade, a series of appellate decisions narrowed the scope of copyright for broader structural features of computer programs. However, major firms in the industry by that time had already begun turning to patent protection. Then, beginning in the 1980s and coming to fruition by the mid-1990s, judicial opinions and administrative actions began to adopt a more expansive approach to the breadth and strength of software patents. Although software patents were granted in the United States before 1994, only after that date, thanks to a court decision, software inventions become patentable per se and not only in conjunction with hardware inventions, so that any real difference between the treatment of software and that of other inventions was essentially eliminated by the U.S. Patent and Trademark Office (USPTO). The number of software patent applications increased dramatically after 1994. Bronwyn &

MacGarvie (2010) find evidence that following the expansion of software patentability, in the mid-1990s, software patents have been highly valued in the market compared to ordinary patents. Wagner and Cockburn (2010) show that Internet companies filing patents were more likely to survive the collapse of the dot-com bubble after 2001.

The spread of patents and the cost and frequency of litigation have raised concerns, not only in the United States, but also in the European Union and Japan (Mann & Sager, 2006) and this has generated an intense debate between detractors and advocates of software patentability (Hall & MacGarvie 2006).

Precisely patents are legal titles granting owners, for a limited time period, the exclusive right to make commercial use of their innovation and the enforcement power to prevent others from using it or to set the terms on which it can be exploited. In the software industry, a patent usually protects an algorithm, that is, a series of step-by-step procedures that are necessary to perform a task. If there are mathematical procedures beyond the algorithm, they are protected, too.

Firms file patents to secure legal protection of their inventions although patents also serve other purposes such as blocking rivals' research, preventing suits, reinforcing bargaining power in cross-licensing negotiations, sustaining technology transactions, etc. (Cohen et al. 2000, Ziedonis 2004).

Mann & Sager (2006) argue that even among software firms there are differences in the use of patents. Beyond the impact on the innovativeness, which can be positive or negative depending on the circumstances as we will see later, some research suggests that patents are primarily used for strategic purposes, such as for use in cross negotiations to deter-licensing or litigation (Cohen et al. 2000), rather than directly for preventing imitation. Indeed, the increased use of patents may lead to greater innovation and competition in the software (Smith and Mann, 2004), since arise also mechanisms related to the appropriability of returns from research and development. From the point of view of the competition between the incumbent/entrant, Porter (1980) offers the vision of patents as a barrier to entry and a source of competitive advantage for incumbents but does not quantify this effect. Nevertheless survey research reporting the experience of practicing managers has shown that the power of patents to block imitation by competitors is generally perceived as imperfect and is surprisingly weak in many industries (Mansfield et al. 1981, Levin et al. 1987, Cohen et al. 2000).

Concerning this issue, Cockburn and MacGravie (2011) argue that potential entrants with patent applications relevant in a market are more likely to enter it and that patents appear such as substitute for complementary assets in the entry process, because patents have both greater entry-deterring and entry-promoting effects for firms without prior experience in other markets. They suggests that the strengthening of IP rights in software and therefore the fact that it has become more patentable, led to a more substantial intensification of the entry-deterring effect of patents for young, specialized firms than for established businesses companies, as opposed to the entry-promoting effect, and led to the fact that the deterrent effect of patents is substantially less negative when entrants arrive in the market with their own patents.

1.5.1 The role of Patents and Trademark in the OSS industry

For the purpose of better understanding which is the existing link between OSS industry and patents and trademarks, many theoretical studies in literature tried to explain how firms preexisting I.P. protection endowments are able to impact more or less favorably the development and commercialization of OSS products among this firms and what the main effort or what obstacles have to deal with, depending on the composition of their portfolios of intellectual property protection. This kind of analysis should further be useful to better understand the reasons why for-profit firms engage in the commercialization of OSS products. The OSS characteristics sharply contrast with the standard model for proprietary software, whereby innovative firms conceal their source code and use licenses to deprive users of the ability to share and modify the original software (Dam, 1995). The biggest issue when it comes to OSS product is to boost the appropriability of these products and to identify the different mechanisms capable to permit this. Unlike some approaches, such as the Hall and MacGarvie's one (2010), which find that legal decisions expanding software patentability were viewed negatively by the stock market and that the marginal software patent makes little contribution to market value, others, such as Askoy et al. (2011), claim that it's a matter of fact that the adequacy of a firm's appropriation mechanism to its business model is crucial in order to capture the value created. Merges (2006) finds evidence that, for firms, adjusting to the presence of patents and putting effort into acquiring them, correlates with indicators of market success. When it comes to a regime of appropriability reference is made to those that are environmental conditions, excluding firm and market structure, such as to allow an innovator to seize the benefit of what is the value of innovation recognized by the market, and

then to gain the profits derived from its commercialization. According to Teece (1986) the most important dimensions of such a regime are the nature of the technology, and the efficacy of legal mechanisms of protection. As regards patents, it is known that the degree of perfect appropriability that are expected to be able to confer at a theoretical level, rarely, if we exclude cases such as new chemical products and simple mechanical inventions, corresponds to the actual degree of appropriability detectable in reality. Patents sometimes provide little protection because the legal requirements for upholding their validity or for proving their infringement are high.

For instance, they can combine an OSS with a proprietary license (Hecker 1999, Henkel 2006). Alternatively, they can use traditional protection mechanisms such as legal rights and secrecy on at least part of the software, or even build an exclusive relationship with a committed developer community (Dahlander and Magnusson 2005). In some industries, particularly where the innovation is embedded in processes, trade secrets are a viable alternative to patents because the latter are ineffective at protecting process innovations (Teece, 1986).

Mann (2006) analyzes the role of property rights in the open source development model, focusing on appropriation mechanisms that are necessary for firms to profit from OSS commercialization and his work's results suggest that, without the intellectual property protection mechanisms, OSS cannot continue to grow in commercial importance and that the proprietary firms who extract the largest benefits out of OSS commercialization will be large firms. Therefore if the opening to OSS can mean an increase in the value of the company, must be investigated the conditions of intellectual property protection that facilitate this process.

In that regard Fosfuri, Giarratana and Luzzi (2008) "argue that firms can profit from their investment in OSS by relying on the control of complementary resources, and that the heterogeneity in the distribution of such resources explains why some firms take more OSS commercial actions than others". The autors orientate their study on the calculation of the probability of a firm to release OSS products starting from the analysis of the different types of portfolios of intellectual property protection and distinguishing the study in four separate cases according to the distinction between hardware and software products and the type of protection used for the same: patent or trademark. Such a research arise from and is justified by the empirical evidence provided by recent studies (Henkel 2006, Gruber and Henkel 2006, Bonaccorsi et al. 2006) that claim that the OSS can speed the spread of a certain standard, thereby permitting companies to benefit from the development and sale of complementary products to the same standard. In fact, companies must be able to count on the control of complementary goods in order to be able to gain from the efforts infused in the development

of products innovation, especially when the legal protection of intellectual property is weak. This means that even if the new product is easy to imitate, the set consisting of the new product and its complementary activities should not be.

Therefore to answer the question of how preexisting stocks of patents and trademarks affect the efforts devolved in the development of OSS products, Fosfuri et al. (2008) proceed in the study starting from the analysis of the case of a company with a large portfolio of software patents, the first of the four types considered. They identify three main reasons to justify why a portfolio with these characteristics offers and acts as a good complementary asset for the commercialization of OSS products. Firstly, as shown by Arora (1995) and (Teece 1986), firms can exploit the OSS code in the event that they are endowed with a large set of patented software algorithms that guarantee to them the ability to extract gains from the use of the OSS code in close relationship with the complementary assets. Second, firms with software patents can direct the evolution of an OSS project to their own advantage in two ways: exercising enforcement rights in order to make it prohibitively difficult for new contributors to obtain patents that write onto related knowledge and discouraging those contributions that pursue a deployment of the project that is too distant from the aims of the firm. The third reason why it is convenient holding a broad portfolio of software patents is summarized in the opportunity to enjoy a strong bargaining power and an important ability to deter accusations of imitation. Therefore lawsuits and litigations, in the event that the release of a OSS product has dented already existing contributions or in the case it is ambiguous to establish whether or not it violates existing patents, can be avoided. The result is that the more a company will have a large portfolio the easier it will succeed in finding compromises or solutions with potential litigators.

The second case study, regarding firms that have a large software trademarks portfolio, is analyzed starting from the consideration of the industrial organization tradition that predicts that an incumbent is generally directed not to introduce new products be sure that these could not be cause of market cannibalization eroding profits in existing lines of business. While patents protect the underlying technology, trademarks serve more as a differentiation mechanism that aims at distinguishing the brand of a service or a product by leveraging the holder's reputation. It is also important to emphasize that a firm that has established and protected a reputation in proprietary software has done so to increase the consumer's willingness to pay a premium for quality, reliability, and brand name. The firm therefore has an interest in emphasizing the costs for customers of switching brands (Fosfuri, Giarratana, Luzzi 2008). The release of OSS products from a firm that can boast software trademarks in

its portfolio means offering products with a different positioning under the same brand and this for the reasons mentioned above may prove to be a disadvantage. This is supported by the fact that normally many customers/consumers of OSS products are cost conscious (Von Hippel and Von Krogh 2003) and that OSS products tend to be priced much lower than equivalent proprietary products.

Trademarks are used primarily to convince the customer that a product is better than those of competitors despite having very similar performances. Under these circumstances, entering OSS might be harmful because it might suggest to the consumer that competing products are nearly identical. Thus, firms with large software trademark portfolios will be more likely to adopt wait-and-see strategies.

After analyzing the case study on software it is interesting to focus on the impact that hardware patents and trademarks have on the development of OSS products since the hardware is the complementary component on which both the proprietary software and the OS one run and since many companies are involved in developing and commercializing both the types of product. In this case the analysis can be performed jointly both for companies with a large hardware patents portfolio and for those with large hardware trademarks portfolio since the effects found in the literature are basically the same. In fact, when a company invests massively in patents aimed to protect their hardware products and aimed at creating a strong image and reputation of quality has any interest in developing OSS products when they reduce the production costs of the software or minimize hold-up from software suppliers if the firm typically outsources software production. Firms with large stocks of hardware trademarks and patents therefore have an incentive for backing OSS initiatives from which they will eventually benefit as a result of complementarity (Fosfuri, Giarratana, Luzzi 2008). This is possible because firms, in the production phase of OSS, can often reuse and combine numerous software chunks belonging to other OSS projects thus having a considerable advantage in assembly costs of the new OSS products.

Finally, it is worth noting that firms with strong hardware trademarks and a broad hardware patents portfolio are essentially uninterested in the protection of their software and therefore more prone to OSS. That because, when software is designed to be used to make the machines operational, it is advantageous for the reasons mentioned above, that the company let the several operations be updated and serviced freely. Second, when the OSS solution is customized to the machine, the imitation of the software program becomes more difficult because the process of customization entails a great deal of tacit and unobservable knowledge; whereas when the software is specifically designed for the machine, it becomes

much more difficult to imitate because imitators can't have access to the tacit and unobservable knowledge that are linked to the project.
Therefore in conclusion the result of this theoretical framework's analysis is that:

- firms with large stocks of software patents are more likely to release OSS products
- firms with large stocks of software trademarks are less likely to release OSS products
- firms with large stocks of hardware trademarks or patents are more likely to release OSS products

Once spelled out those which are the various configurations of endowments of intellectual property protection that best promote and encourage the openness of software and hardware firms to OSS, it's appropriate to take a further step of analysis in order to fully understand the conditions under which these protection instruments confer high appropriability for the developed innovation. In the event of companies with hybrid business models, the presence of portfolios of intellectual property protection with greater or lesser density of trademarks or patents may therefore have a different impact on what are the capabilities of appropriability of the business innovation's value and then may impact more or less positively on generating value for these firms. Inter alia Askoy, Fosfuri & Giarratana (2011) in their work examine the conditions under which OSS might be most beneficial for a firm in terms of value enhancement; then they try to give an explanation the modalities used by firms to advance their capabilities to retain the value they have created through the instrumentality of appropriability regimes in which legal mechanisms of protection are utilized (Teece, 1986). For instance Mann and Sager (2006) focuse on the question whether patents are valuable to the firms that have them, namely trying to find out if they help firms attract financing or if they allow firms to exploit the value of internal research and development investments. This because if patents do not have a positive value for the firms that acquire them, then it is unlikely that the net effects of the patent system are positive.
According to the authors, software trademarks, and similarly software patents, positively influence the relationship between a firm's software product portfolio and its value. This is possible, according to them, since these protection endowments allow company to have much more strengthened brand name and reputation. In particular their findings suggest that, firms taking more commercial actions in OSS paradigm achieve higher firm value through complementary appropriation mechanisms, especially, in the form of trademarks, while firms commercializing proprietary software products benefit more from software patent stocks in

line with what also supported by Bronwyn & MacGarvie (2010) about the value creation associated with software patents in the United States.

The authors, instead, found negative effect of trademark stocks on the relation between proprietary software portfolio and the generation of firm value. This is because, according to them, companies that have in the past taken the road of proprietary software, mainly have adopted the use of software patents for the intellectual protection also because trademarks only recently found a place in this field with this specific functionality. Therefore for these companies would be unbecoming, also because of temporal as well as monetary costliness reasons, implementing a conversion of the instruments of intellectual property protection adopted for their proprietary software portfolios. The results of the study are consistent with the argument of Mann (2006), who suggests that the success of firms which aim at profiting from OSS commercialization, can only be achieved with an emphasis on the property rights that are necessary in order to make profits from other points of the value chain.

OSS transformation to a commercial form requires adjustments in corporate strategy and then managers should be aware of how much the adequateness of intellectual property protection mechanism to their business model matters for incrementing firm value. Trademarks might be investigated in-depth as an alternative approach for appropriating returns under new circumstances of competitive dynamics introduced by OSS (Askoy et al., 2011) and although software patents may not provide a direct protection for OSS products, they may be utilized to capture the value created from OSS releases by providing protection for their complementary assets in the form of proprietary products.

1.6 The Venture Capital in the OSS realm

The development of a software is a process that can take years of economic efforts. Small firms are expected to succeed in this endeavor without the funding from third parties. If, however, the cash flow is not enough here that come into play VCs that are intermediaries that draw on those which are institutional investors funds and reinvest them in small startups in the technology field (Mann, 2005). The typology of VC is for this reason, among the different types of investors that allow to reward the efforts of many developers of OSS projects, one of those that particularly stands out.

In particular investors such as VCs are of fundamental importance to allow the development of projects in the longer period to be completed. These projects require a greater time to market and therefore more resources during the period in which they are developed because of their greater complexity. For high-tech firms, new equity finance has several potential advantages over more than other forms of financing such as bank loans. This financing founds space in the field of OSS entrepreneurship due to the nature of this movement and the economic possibilities of its main promoters, often constrained by the lack of reliable true collaterals to exploit. The approaching of VCs to software industry is also due to an increased interest in sectors with very high growth potential and in particular, many companies in OSS are trying to persuade venture capitalists to fund them pointing just on this factor. But, one must remember the fact that an industry such as software is very prone to market imperfections and along with it the high-tech investments. Colombo and Grilli (2005) point out that, in the presence of information asymmetries between founders and investors one may be faced with problems of adverse selection and moral hazard. This can be solved taking into account different factors such as the presence of valuable human capital that can be a good parameter to be attracted by the project funding possibility (Colombo & Grilli, 2005).

According to Carpenter and Petersen (2002) venture capital is the form of equity financing that is currently best suited to address the capital market imperfections pertaining to the financing of young high-tech companies also because they typically adopt the policy of closely monitoring the founded firms and have partially effective tools to overcome information and agency problems. In the specific case of high-tech investments there is a greater propensity for capital market imperfection. Carpenter and Petersen (2002) find three reasons to justify this last statement. First of all, considering that high-tech investments are difficult to evaluate

and since they embody new knowledge, the existence of substantial information asymmetries between firms and potential investor increases the likelihood that the prospects of the firm's investments are better known to insiders than to outsiders. Second, high-tech investments often have limited collateral value because even if one looks at R&D investment, which is the predominant part of salary payments, we become aware that the salvage value in the event of failure is very low. Lastly, always inherently to R&D, must be highlighted the high level of risk and uncertainty that characterizes this activity from the point of view of the results and the outcomes on which the company and investors relies for its success and for their returns, respectively.

Hubbard (1998) discuss in his work about financing constraints motivating these through the link between collaterisable net worth and the cost of debt. In fact there are several reasons why the extensive use of debt finance may be inappropriate for high-tech firms and why their shadow cost of financial debt may increase rapidly with greater leverage. The following figure representing the trend of the supply curve of debt financing. shows that when the need for external financing exceeds the availability of internal (IF, proxied by cash flow), the greater the excess the higher the marginal cost to be faced in accessing these funds. This is because the cost of borrowed money increases as increases the risk associated with investment from the point of view of the guarantees offered to investors (which, as seen before, in the case of young high-tech companies are few) and it is because of the quantity of cash flow available internally with respect to the amount of corporate debt.

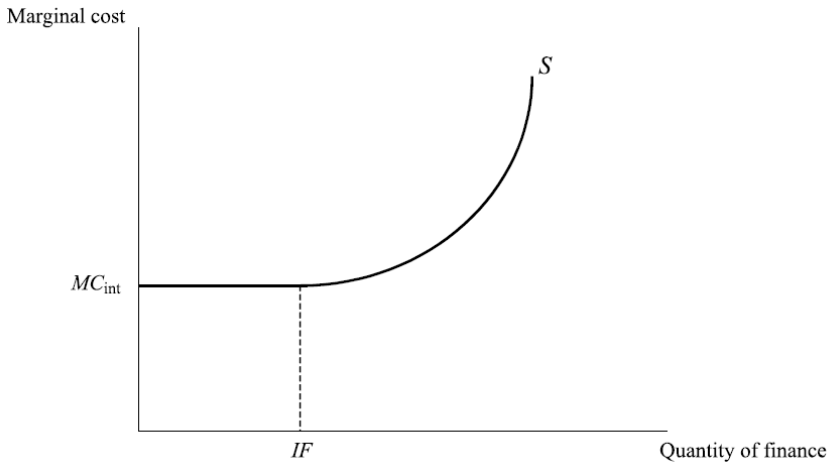

Figure 1: Supply of finance with debt (Carpenter & Petersen, 2002)

Summarizing, for high-tech firms, the limited collateral value of assets, as well as adverse selection, moral hazard, and financial distress, should cause the marginal cost of debt to increase rapidly with leverage and, therefore, the venture capital has emerged as an important intermediary in financial markets, providing capital to these firms that might have otherwise gone unfunded (Gompers, 2004).

There is a wide range of public policies that may improve high-tech firms' access to equity financing, including venture capital. Jeng and Wells (2000) indicates that the institutional and legal environment, including tax policy, can play an important role in encouraging the expansion of equity finance. Governments can also actively encourage the development of stock markets for small high-tech companies, including the reduction of regulatory barriers to listing. In the United States low barriers to listing on the NASDAQ and the NASDAQ Small Cap enhance the ability of a young high-tech firm to obtain new equity finance. As a matter of fact, in the stars and stripes market the majority of venture capital is invested in the high tech sector, where monitoring and information evaluation are important (Gompers and Lerner, 1999). Financial obstacles to entrepreneurship and to the growth of the high-tech sector have been the focus of much public policy discussion in Europe and have been identified as potential weaknesses of the European Union (Bank of England, 1996; European Commission, 1998, 1999). Carpenter and Petersen (2002) in their study argue that, at the same time is needed to promote the growth of small high-tech firms and the development of markets for public finance and private equity venture capital because the institutional factors that affect the availability and cost of equity financing may be an important determinant of the comparative advantage of nations in the production of high-tech goods.

1.6.1 Intellectual Property Rights and VCs

After this overview on VC financing it is interesting to analyze how the theoretical literature takes into account the relationship between IPRs and VCs. In particular, studies conducted have mainly shed light on what is the influence of patents on VC funding and vice versa, inside high-tech companies and in particular inside software.

Mann & Sager (2006) explain that for firms in the pre-revenue stage, patents have little or no value that their role should become increasingly important as firms advance through the venture financing cycle (Mann, 2005). This is due to the fact that in the early stages investors

generally point to product market experience and management acumen as being more pertinent to initial investment decisions. More precisely they turn to a quantitative analysis of the first two stages finding that patent acquisition (or application) at the time of initial investment is largely irrelevant to the firm's subsequent progress through the venture capital cycle.

They also assert that patent acquisition is significantly correlated with any of the several variables that are indicators of the firm's progress through the venture capital cycle such as total investment, longevity and number of rounds. In particular Gompers and Lerner (2001) argue that the number of rounds is a good proxy for performance because the structure of venture capital financing gives venture capitalists a realistic opportunity to terminate firms after each round, and makes each additional round a substantial indicator of progress.

But, still according to Mann (2005), academics generally see an industry burdened by an intellectual property system which grants so many software patents that small companies cannot effectively innovate, so to consider the traditional protection of intellectual property as inappropriate in the context of innovation in the software industry.

There are several difficulties that make it particularly hard to use effectively patents in the pre-revenue stages for the small-firm. Firstly the risk of litigation: one of the biggest problems that puts a small company in serious trouble trying to defend itself in a lawsuit from one of his competitors is the lack of resources to deal with the cause itself. Secondly, the divergence of tasks is a problem that very often comes up for firms adopting an expensive policy aimed to patent at all costs the innovations on which the company is working, without worrying about or remembering that investing in a policy aimed at the protection of intellectual property means at the same time to not use those same investments for what should be the real business target, namely the product commercialization. Finally, being able to exclude competitors ensuring the protection of the intellectual property of their technology, without the certainty to market it and therefore of revenues, is useless. Only reaching the stage of actual and long-term revenues from the sale of their product it will be possible to profit from the benefits of achieved patents.

Once reached the stage of maturity marking the first substantial gains, according to the author, it begins to be possible for firms to benefit from those which are the advantages of patents owned resulting from direct and indirect effects. The patent system guarantees for small firm an automatic stay of competitive activity that remains in force long enough for the firm to attempt to develop its technology. Many small businesses succeed and still have survived not because of their strength to face a lawsuit for patent infringement, but rather

thanks to perceived threat from the incumbent to find themselves involved in a legal illicit copying technology. Definitely one of the most important direct benefits arising from obtaining a software patent is to be able to exclude competitors from the innovation that is covered by the patent. In this area therefore the company can sweep deliberately in research without warning or suffering threats from the market and can therefore benefit from the revenues derived from the licensing of these patents usage to competitors who need the patented technology to be embedded in their products.
Among the indirect effects of the advantages of patenting instead we find more examples. The first is the fact that patents are useful as "barter" in cross-licensing agreements that the firm enters if it reaches a sufficiently mature stage to be a significant player in the industry. The main benefit that cross-licensing agreements provide is freedom from patent litigation; they do not involve the disclosure of any transfer of technology or knowledge beyond material on the face of existing patents. The last set of effects relates to information generated through a firm's participation in the patent system. Moving along the course of a firm's development, these effects fall into three classes: the ability of patents to facilitate the firm's efforts to codify tacit knowledge, the firm's subsequent ability to signal the discipline and technical expertise that allowed it to codify that knowledge, and the use of the patent as a signal of the underlying technology (Mann, 2005).

One the most interesting aspects that several studies have attempted to go back to is the impact that patents have on the actual commercialization of a software product or service featured by the new technology that the patent should protect and guarantee. For instance Mann (2005) tries to identify and decouple what are the economic effects brought by the introduction or the presence of a patent that guarantees the protection of intellectual property, from the economic effects associated with the recognition by customers of value towards the innovation embedded in the products or services offered. In his analysis, the autor takes as reference companies that are usually small firms supported by venture capitalists since many of the technological innovations in the software industry come from small firms and since, performing the same type of analysis on realities much more complex as in case of large public companies, would make more difficult to analyze the relationship between the owned patents and the cash flows of the company. Another reason that leads the author to choose small firms is that, according to him, it is less common at a large firm to find a person with full hands-on responsibility for both the financing arrangements and the IP development and protection policies.

Venture financing contributes to the ability of startup firms to apply for patents in several ways; the venture capitalist facilitates patenting both by providing funds and by providing management expertise to assist the portfolio firm in the development process. On the other hand patents can solve one of the most difficult problems for a startup: convincing the venture capitalist that the startup can sustainably differentiate itself from its competitors (Mann & Sager, 2006).

As part of the patenting process, applicants also are required to disclose details regarding the underlying invention, thus codifying information about the new inventions works into written document (Hsu & Ziedonis, 2008). Then the patenting process is one of the few ways that allows investors to become aware of those that are the information about technological discoveries and their potential value and, therefore, to be able to evaluate the investment based on the perceived quality of innovation (Heeley et al., 2007). Information about the patent portfolio of a firm also enables to pick up knowledge about the lines of research a firm is conducting and how quickly the research is proceeding (Long, 2002: 646). With regard to this last statement, however, Jaffe and Lerner (2004) point out that, excluding other mechanisms for signaling quality as in the case in which a start-up went public, the information revealed through patents is notoriously "noisy" and can be costly to verify. This problem is in addition to the fact that the threshold for patentability, being quite low in countries such as the United States, dramatically increases the likelihood that processes or products with low quality and / or little innovative content, especially in the IT sector, obtain patenting.

Hsu and Ziedonis (2008) seek to demonstrate four main hypotheses. The first one, statistically confirmed, is that, in a start-up's stock, the increases of successful patent applications will trigger an upward adjustment in investor estimates of the start-up's future value, beyond what would otherwise be predicted. The second, which supports the fact that the signaling value of patents will be greater for entrepreneurially inexperienced founders unlike their more experienced counterparts, is however contradicted by the analysis. The third hypotheses says that the signaling value of patents will be greater for ventures during their earlier funding rounds unlike to later rounds because the early funding stages for start-ups are characterized by greater technical and demand uncertainty in product development. Obviously the greater the experience of the venture capitalists in previous interactions within the enterprise network, the more likely they are to identify the companies with the best filed

available patents. Lastly, as fourth hypotheses authors point out another typical example of the attractiveness of patents again referring to the more experienced VCs. The latter may value start-up patents more highly than their less experienced counterparts because of potential complementarity between start-up and experienced venture capitalists' resources due to the easy access to superior resources such as specialized legal counsel (Suchman and Cahill, 1996) and collaborative commercialization partners (Hsu, 2006). Furthermore prominent VC investors in start-ups may help professionalize their internal and external practices across a range of business functions, which can act in complementary ways to raise the value of entrepreneurial patenting. Both the last two hypotheses are statistically confirmed thus providing new evidence that patenting can positively affect investors' perceptions of start-up quality across multiple stages of the entrepreneurial life cycle.

1.6.2 NTBFs' Founders and VCs

Is widely recognized, as mentioned above, that new technology-based firms greatly contribute to the static and dynamic efficiency of the economic system (Audretsch, 1995). These companies are characterized especially in the early stages of their lives by few tangible assets and their future is mainly embedded in new technologies that they will succeed to develop. Therefore, from these issues, arose many studies that have tried to identify other determinants for the growth and success of these companies. One of the many paths of analysis focused on the investigation of the liability of the founders of these companies for their success in terms of the positive effect that their age, education, and work experience may have had on the likelihood that this success will materialize. According to Colombo and Grilli (2005) " it is the "capability effect" of founders' human capital that explains its positive impact on the performances of NTBFs" referring to those that are their unique capabilities. However in the theoretical literature are also presented works that do not attach only to the "capability effect" the positive association between the growth of NTBFs and the human capital of their founding teams. Indeed, there is another factor taken into account in other studies (Xu, 1998; Astebro and Bernhardt, 1999) which is the "wealth effect". This latter refers to the possibility of the founders of having the private funding needed to develop the business activity. Some scholars, including Colombo and Grilli (2005), have attempted to try to attach proper weight to the "funding gap" and the "knowledge gap" in relation to the growth of NTBFs and their human capital.

In literature, carrying out a description of the possible human capital characteristics of founders, reference may be made to the difference between generic and specific human capital of new firms' founders. The first refers to the educational achievements as degrees, Ph.D. degrees or years of work experience in general before the foundation of the firm, while the second one tends to distinguish what are the experiences that the founders had in same industry of the founded company as a proxy of industry-specific human capital (Br¨uderl et al., 1992). Focusing on the impact that education has on business growth, there are numerous studies that show that actually a good level of education of the founders is positively correlated with the probability of survival of businesses, but less strongly with the degree of growth and business development (Bates, 1990; Brüderl et al., 1992; Gimeno et al., 1997). Cooper et al. (1994) for U.S. and Westhead and Cowling new ventures (1995) for UK NTBFs have found instead a positive impact of the educational factor, on the likelihood that the founded firms receive a high growth footprint. Conversely in the literature emerge much stronger results about what is the positive impact of the founders' industry-specific human capital on the growth of firms. Still Cooper et al. (1994) argues that this factor has a positive impact not only on the probability of growth but also of survival of sample's firms. Others as Siegel et al. (1993) in their study argue that the specific human capital is the only discriminating factor between high-growth and low-growth firms.

Different studies therefore suggest that, in general, there is a positive correlation between the human capital and the NTBFs' performances. Nevertheless, as more fully set out in the following pages, the specific human capital characteristics of founders that are directly associated with firm growth partially differ from those that positively influence access to VC (Colombo & Grilli, 2010). Some studies explode this issue invading the problem of new companies' financing, paying particular attention to what mainly results from the literature, namely that there is a very strong correlation between human capital of individuals and their wealth. Most particularly in this case, one must speak of generic human capital since a good level of education often derives also from strong bases of household income (Astebro and Bernhardt, 1999) and that often therefore the possibility of being able to make use of advantages such as the self-financing is not a negligible factor in determining the success to which can point a new society.

Another similar factor considered in the literature, which positively influences the ability of companies to survive and grow, is the inheritance factor. Many scholars (Lindh and Ohlsson, 2006, Holtz-Eakin et al., 2004a / b) found that large inherited amounts of money often increases the likelihood that the beneficiaries could venture in founding new companies, in

addition to increasing the likelihood that these can survive and grow without the usual financial constrains that meet all other enterprises, especially in the high-tech industry.

The outcome of these studies face us with the existence of a virtuous circle for certain categories of NTBFs. Indeed, assuming that factors such as the high generic human capital are positively influenced by the private wealth of the founders, one concludes that firms founded by this category of individuals will enjoy higher growth. This because, despite being characterized by intangible or firm-specific investments, and thus equipped with little inside collateral value, these firms owing to the fact that their founders are wealthy, are in a good position to access both guarantees and additional external funding (Bester, 1985, 1987) and not only equity financing such as the VCs' one. Here then explained the positive "wealth effect" of founders' human capital on firms' growth (Colombo and Grilli, 2005).

In the difficult and uncertain environmental context of business related to new technologies, in order to be able to have business opportunities, it is not only important to have possibilities in terms of absence of financial constraints, but mostly being able to combine the personal distinctive knowledge and intuitions with the available resources so as to generate value.

Surely individuals with greater human capital are likely to have better entrepreneurial judgment (Colombo and Grilli 2005), this mainly because managerial experience or previous business or simply a wide sector knowledge allow them to develop cumulative skills which make individuals more mature and predisposed to manage the business. Furthermore, a new business opportunity, to be successful, generally requires the integration of complementary context-specific knowledge as technological, marketing, and managerial knowledge. This knowledge can be more efficiently coordinated and protected if specialists are members of the founding team rather than they were hired after the foundation (Colombo & Piva, 2008). It would be much more beneficial for future performance of a company to create a functionally balanced founding team composed of individuals with heterogeneous but complementary capabilities because the possession of firm's stakes should be a guarantee of full commitment.

Then according to these studies also the "capability effect" of founders' human capital explains the positive effect of growth of NTBFs. But since, as postulated by "wealth effect", those who have received a better education can have greater access to capital, one must understand if this statement is valid regardless of the type of educational cognitive contents of the founders, namely if it is irrelevant the fact that they are more geared to a technical-scientific field or more to an economic-managerial one.

Colombo and Grilli (2005) therefore come to the following conclusions: years of education of founders in technical-scientific and economic-managerial fields differently influence the growth of NTBFs. In particular they found out that founders' years of university education in economic and managerial fields and to a lesser extent in scientific and technical fields positively affect growth while education in other fields does not.

The same effect on the growth of NTBFs does not occurs in case of founders' years of prior work experience in the same industry of the new firm rather than in other industries. To be more specific, since industry-specific experience may relate to different functional activities, the results of the study showed that it is the technical work experience of founders as opposed to their commercial work experience that determines growth. The first type of experience refers to the skills and knowledge matured by the founders in R&D, process design, engineering and production, while the latter refers to marketing, sale, and customer care activities.

Concerning the managerial and entrepreneurial experiences, the study showed that the managerial competencies of founders do not seem to significantly influence the performance of firms although it has been demonstrated that the presence in a firm of one or more founders with a prior management position in a company with more than 100 employees positively affects recourse to external private equity financing and that this has a large positive effect on growth. By contrast the authors find confirmation of the fact that firms established by "serial entrepreneurs", namely firms with one or more founders with a previous self-employment experience, turn out to enjoy superior growth and moreover are more likely to receive private equity financing.

As regards the founding team's competences factor in many studies, the heterogeneity of this set of skills and knowledge is approximated by the number of founders. In a sense, this approximation is not entirely harbinger of what the true composition of the team is, since it depends on factors such as the same wealth owned by the founders that impacts on various dimensions of the company including the density of the employees. This is why Colombo and Grilli (2005) face an analysis marked on the discovery of the degree of heterogeneity, not looking at the number of founders, but at the true nature of the skills they are equipped with and at their combination among the various funding teams of the sample's firms. Thereby they provide evidence that the presence of synergistic effects of founders' capabilities is limited to some specific entrepreneurs' knowledge dimensions (technical plus economic education and technical plus commercial industry-specificwork experience) but it does not

apply a priori to all the domains of founders' human capital characteristics such as the economic and scientific-technical-managerial education.

In their theoretical framework's analysis: "On growth drivers of high-tech start-ups: Exploring the role of founders' human capital and venture capital" (2010), Colombo and Grilli, considering growth as an indicator of the business success of a sample composed of 439 Italian NTBFs, seek to obtain a better understanding of the roles played by NTBFs' founders and VC investors and of the way they contribute to the success of these firms.

They start by saying that if the effect that human capital has on the growth of NTBFs lies mainly in facilitating the attraction of VC then it means that their indirect effect on companies' growth, mediated by the presence of VC, will be negligible . On the contrary, assuming that there is also a direct effect on growth due to the presence of human capital value, then the heterogeneity of human capital at all NTBFs becomes an important element to define and motivate the heterogeneity of the whole success of NTBFs analyzed in the sample. This is because, since it is known that VC-backed company has less financial obstacles to deal with, the ability to attract VC by the human capital will thus have a second beneficial effect on growth. Contrary instead, the authors support that in the case the role of VC was to "coach" with possibility to transform resources into play, then the effect of human capital of the founders of companies would be less beneficial since this type of VCs' behavior would tend to weaken the link between the basic capabilities of founders and those of the company.

"As is illustrated by Fig. 2, founders' human capital has both a direct positive effect on firm growth and an indirect one, mediated by the attraction of VC" (Colombo & Grilli, 2010).

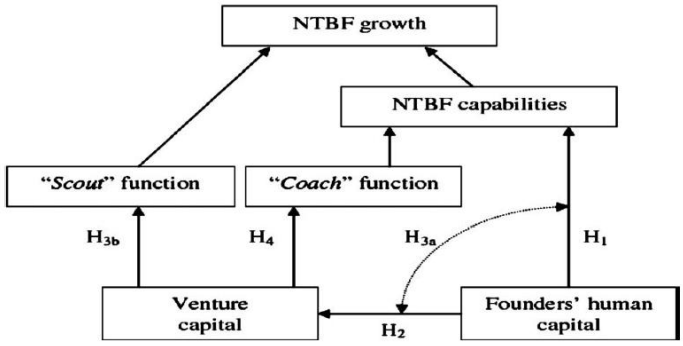

Figure 2: Conceptual model on the relationship between founders' human capital, VC financing and the growth of NTBFs. Legend: H1: The human capital of founders has a direct positive effect on the growth of NTBFs; H2: The human capital of founders has an indirect positive effect on the growth of NTBFs, mediated by the attracting of VC investments; H3a: The characteristics of the human capital of founders that are positively associated with the

growth of NTBFs are also positively associated with the likelihood of obtaining VC; H3b: The characteristics of the human capital of founders that are positively associated with the growth of NTBFs are more so for VC-backed than for non-VC-backed firms (i.e. VC investors as a "scout"); H4: The characteristics of founders' human capital that are positively associated with the growth of non-VC-backed NTBFs have a smaller effect on the growth of VC-backed NTBFs (i.e. VC investors as a "coach") (Colombo & Grilli, 2010).

To justify the fact that there is actually a direct positive impact of the human capital on the growth of the NTBFs, reference may be made to the fact that among the founders, individuals with a background and work experience in the same field of enterprise, such as to allow those to boast a considerable familiarity and mastery of the problems in the company, "are likely to have better entrepreneurial judgment and more specialized knowledge than other individuals. So, they are in a better position to seize neglected business opportunities and take effective strategic decisions crucial for the success of the new firm. "(Colombo, Grilli 2010). On the contrary, to understand the dynamics of the indirect beneficial effect of human capital of the founders due to attraction of VC, is necessary to take as a given assumption the fact that VC investors are more capable than others to identify and distinguish, among all potential new firms with an innovative idea and in need of funding, the companies endowed with the grater human capital among the founders. Founders must be distinguished both from the point of view of management skills and knowledge necessary for the smooth implementation of the starting idea, both in terms of moral integrity in order to avoid the occurrence of opportunistic behavior once obtained the required funding. Theory shows that a way to overcome these problems of adverse selection and moral hazard could be the use of guarantees as suggested by Berger and Udell (1998). But in the case of NTBFs we generally speak of companies with few tangible assets and therefore it is difficult to use guarantees to facilitate financing and down the margin of risk for investors. In innovative contexts such as those treated, and thus by definition characterized by uncertain revenues, the abovementioned risk can't be restrained with certainty as far as the business idea is perceived as successful by all parties involved. Hence, to the extent that VC investors are able to recognize this potential, NTBFs with entrepreneurial teams composed of individuals with greater human capital will be more likely than other NTBFs to attract VC investments.

Figure 2 shows, in addition to these first two direct and indirect effects explained above, also other categories that are mainly linked to the possibility of the existence, in the context of NBTBs, of two main types of role that VC can play in the development process of new businesses. "VC investors may act as a "scout"; they are able to identify NTBFs with great prospect and to provide them with adequate financing. They may also act as a "coach"; they

help NTBFs portfolios to extend their set of resources and capabilities and allow them to achieve growth performances that would be impossible without this support (Colombo and Grilli, 2020).

Regarding the effects on business growth in the case of financing by "scout" VC, the human capital characteristics of founders will attract VC investments as a result of two main assumptions. The first one, as mentioned above, is that : founders' human capital positively affects the growth of the new firm; the second one states that "VC investors generally focus on specific industries and develop context-specific screening that capabilities allow them to judge the hidden quality of entrepreneurial projects and the entrepreneurial talent of the proponents better than other investors" (Chan, 1983; Amit et al., 1998). This explains because in presence of "scout" VC there is a good margin for company growth mediated by the presence of human capital in the company and explains why this growth is not screeching with the fact that the VC "with an active and ongoing involvement in the running of portfolio firms and a presence on its board of directors, actively monitor the behavior of entrepreneurs "(Colombo & Grilli, 2010).

Moreover if firms obtain VC financing, the human capital characteristics of founders that enhance growth should have a greater positive effect because the financial constraints that hinder growth are removed, but the results of the study indicate that only some of the human capital characteristics of founders that have a direct positive effect on NTBF growth, increase firms' likelihood of obtaining VC. On the contrary VC investments are attracted by the management experience of the founding team, which does not seem to play any direct role in favoring growth suggesting that the main role performed by Italian VC investors is not "scouting".

When funding comes from so-called "coach" VC, the latter tend to facilitate what might be considered a reconfiguration of the distinctive ability of the company and its management processes. In this way these companies will gain both a greater professionalization and greater openness to the access to external resources so to take advantage from the new network of potential customers, suppliers, and alliance partners of VC investors' portfolio companies. The results of the study confirm that the human capital characteristics of founders that have a direct positive effect on the growth of non-VC-backed NTBFs exhibit no relation with growth for firms that receive VC financing. This evidence is consistent with the view that once NTBFs obtain access to VC, they can rely on external resources and competencies that are out of the reach of their non-VC-backed counterparts, because of the consultancy, gatekeeping, and signaling functions performed by the VC investor. Consequently, the close

relation between the knowledge and skills of founders and firms' distinctive capabilities that is typical of non-VC-backed companies largely vanishes (Colombo & Grilli, 2010). Therefore the valuable human capital of founders would be less weak than in the case of VC-backing.

1.7 The OSS phenomenon: Anecdotal Evidence

This chapter provides some data concerning the diffusion of the Open Source phenomenon in order to close the information outline started with the previous literature review.

The first figures show what is the global spread of the phenomenon. In particular, looking at the open source activity map published by Red Hat in 2009 after a globally conducted survey, can be seen that among the regions of central importance from the point of view of the OSS development emerge the U.S., China, Brazil, Japan, South Africa, Australia and many countries of the European Union, which appears to be the area with the highest number of countries in terms of development density. The activity results to be rather almost totally absent in the African continent for reasons linked to the economic and social development of the same. Interestingly, beyond historically developed and advanced countries and regions such as the U.S. and the same Western Europe, the countries of BRICS (Brazil, Russia, India, China, South Africa), term used in international economics to refer jointly to developing or newly industrialized countries, although with a slight exception for Russia, are very open to this phenomenon. This therefore confirms the fact that the OSS realm, being a reality closely linked to everything that is related to innovation, will always have more growth margin in fast-growing economies.

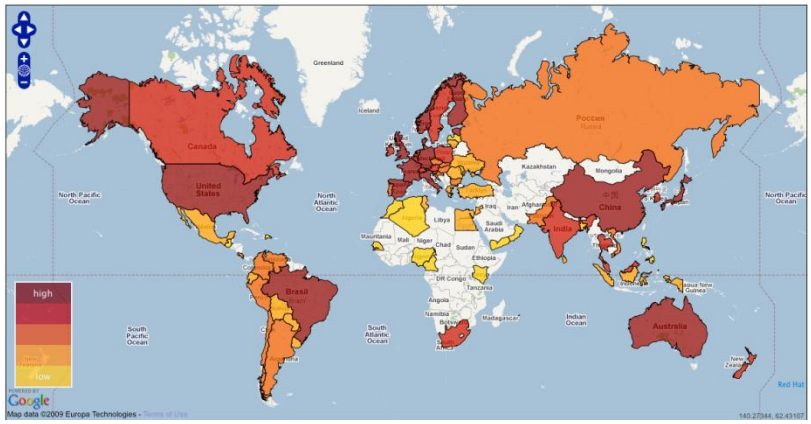

Figure 3: Worldwide OSS development
Source: http://www.openlogic.com/wazi/bid/188004/A-Primer-on-Europe-for-US-Based-Open-Source-Communities-and-Vendors

The following figure is an example of utilization of one of the world's most popular open source browser, i.e. Firefox, whose breakdown of market share by country shows that European countries are comparable to the US in terms of open source software adoption. Firefox serves as a good benchmark because its actual distribution can be measured quite reliably by tracking access to web sites through Firefox itself. On the other hand, the use of the same approximation e.g. for an open source software such as Open Office is not correct since

the number of downloads does not directly translate into the number of installations because one could download Open Office once and install it on many desktops.

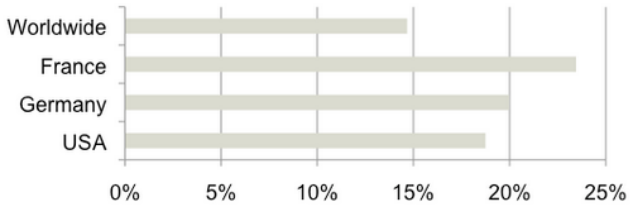

Figure 4: ***Average of Firefox market share (Nov 08-Mar 09)***
Source: http://www.openlogic.com/wazi/bid/188004/A-Primer-on-Europe-for-US-Based-Open-Source-Communities-and-Vendors

The following figures show the competitiveness of the most successful open source products, compared to their main proprietary nature competitors, in those that are two of the most widespread markets within software industry, namely that of browsers and that of operating systems, both as regards the mobile and the desktop industry.

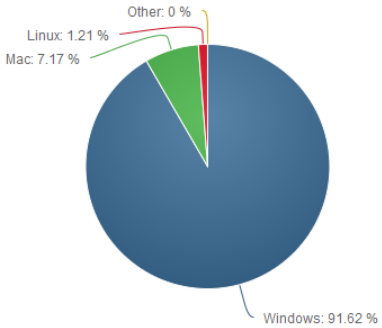

Figure 5: Desktop operating system shares
Source: http://www.netmarketshare.com/

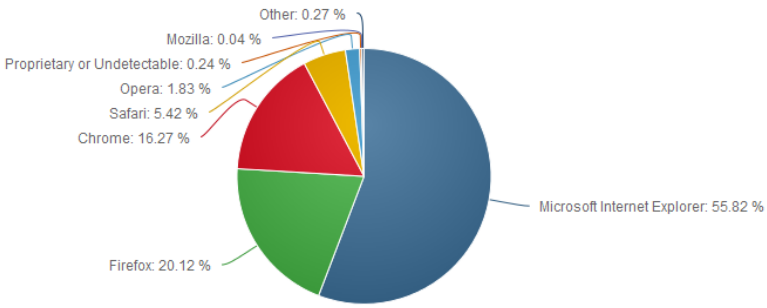

Figure 6: Desktop browser shares
Source: http://www.netmarketshare.com/

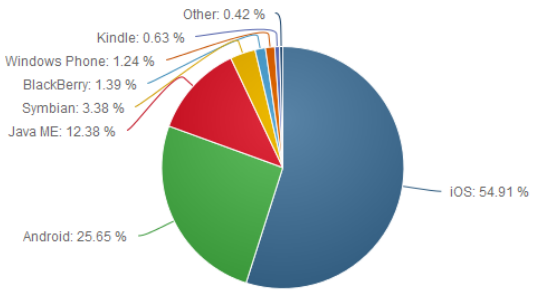

Figure 7: Mobile operating system shares
Source: http://www.netmarketshare.com/

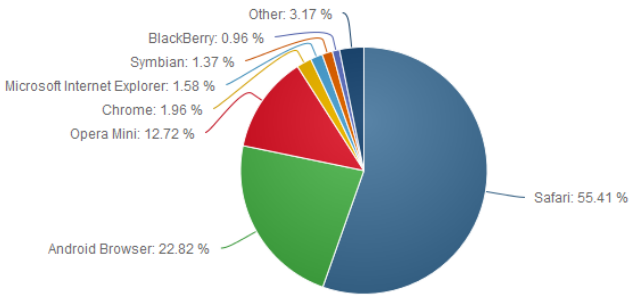

Figure 8: Mobile browser shares
Source: http://www.netmarketshare.com/

It was deemed appropriate to report market data related to the mobile industry since the mobile devices nowadays are among the most developed ones and are among the software on which the high-tech industry is more focusing in terms of investment in R&D. This is also due to the success that mobile devices are having in recent years. This data, of course, considered in the light of those represented in the four previous figures, in which emerges a clear success of open source mobile operating systems and browsers such as Android (Google) over all other competitors (except the Apple's iOS and Safari), is an indicator of the fact that open source software goes along with the needs of consumers and therefore is able to meet their technological development expectations.

As shown in Figure 5, only in the context of desktop operating systems the dominance of proprietary software such as Windows does not leave much room for the competition but nevertheless in second place stabilizes the open source Linux.

The situation is reversed, however, if we look at the following figures showing the data about the distribution and use of web servers. From a survey carried out in the current year by Security Space emerges that the leader in this area remains the open source Apache far ahead of Microsoft, the first direct competitor.

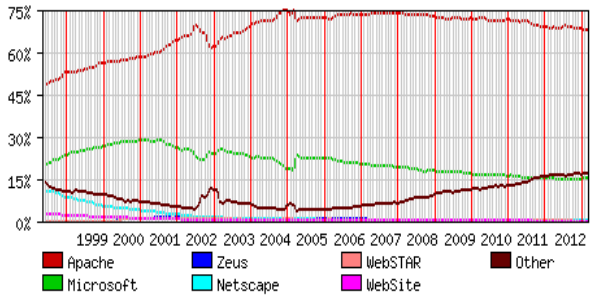

Figure 9: Historical web server market share across all domains.
Source: www.securityspace.com

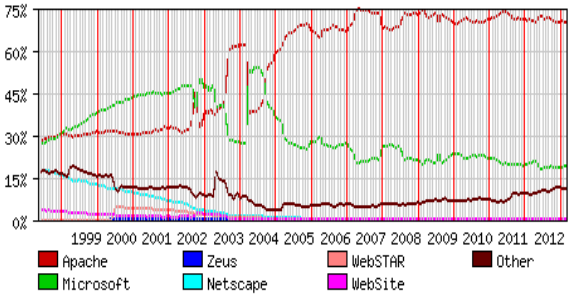

Figure 10: Historical web server market share in the U.S. domain.
Source: www.securityspace.com

From the figures also emerges the comparison between the diffusion of the two different web servers across all the domains and in U.S. single domain. It is noticeable that spanning the years 2002-2004 the competition between Apache and Microsoft has tightened up, designating however at the end the undisputed statement of the former.

After having offered a description of what are the distinguishing characteristics of programmers and developers of the OSS communities in the theoretical literature, we have decided to provide additional data also regarding the communities themselves. To do this we referred to the information gathered in the last survey (2012) that Eclipse (a community for

individuals and organizations which collaborate on commercial open source software) collected by submitting it to 732 members of its community.

First of all, the results showed that 52% of people involved in the survey have from 2 to 10 years experience writing code. In Figure 7, which shows the distribution over the last four years of the most used operating systems for software development, can be observed that 55% of the developers continue to use Windows despite a decline of about 8% from 2011. However, excluding this market giant, one can see that the remainder of the open source developers prefers to use an open source operating system like Linux rather than using a proprietary one with an established and strong brand such as Mac OSX. In fact there was an increase in the Linux usage of 4.5 percentage points bringing its total amount to 32.5%, on the contrary to what concerns the Mac usage that, with a lower growth (3.5%), touches the 12% of the overall enjoyment. This is an unquestionable indication that those who constitute and become part of the community recognize that open source is a high-quality and, above all, a functional product, even more true if one considers that the adequacy and performance of an operating system must be very high in the case of a complex activity such as those carried out by software developers.

Figure 8 shows instead the categorization of the industries closest to that in which, individuals who took part in the survey, OS develop code. From the figure emerges a significant representation from software and hardware vendors creating high-tech products and noteworthy there is also the 20% represented by students, thus suggesting again that the phenomenon is positively correlated with not very high age ranges where the right stimulation to develop, as we will see later, does not arise from any kind of remuneration.

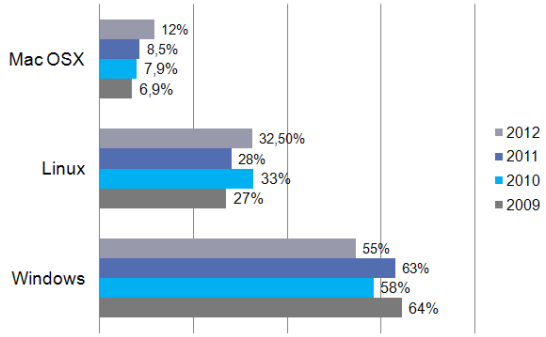

Figure 11: Primary operating systems for software development
Source: www.eclipse.org

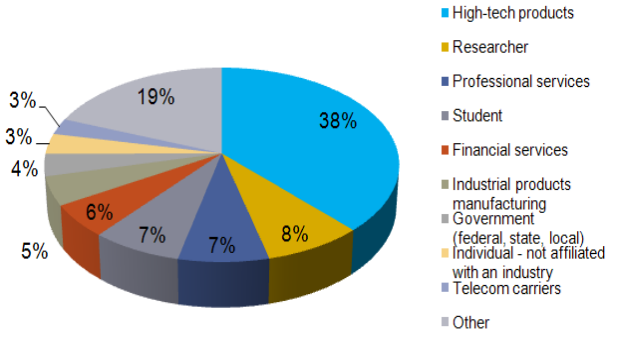

Figure 12: Programmers' main OS development industries
Source: www.eclipse.org

From the above mentioned survey also has emerged that the most widely used language among developers is Java, which became open source under the GPL in 2006, with more than 76% of the vote, ahead of the more obsolete C / C + +.

As regards instead strategies adopted when using open source software by the companies in which the survey's submitted developers work, has emerged that corporate policies gradually become more positive towards open source participation. In particular, the survey shows that over the last three years the trend depicting the use of open source software, followed by a contribution on the results obtained in at least one community, is growing unlike the usage of the code in business in a purely opportunistic way that in same period shows a decreasing trend. This can be considered as an important signal that globally the phenomenon is on the rise since also private companies, starting to work more closely with the various open source community, give importance and visibility to this type of activity.

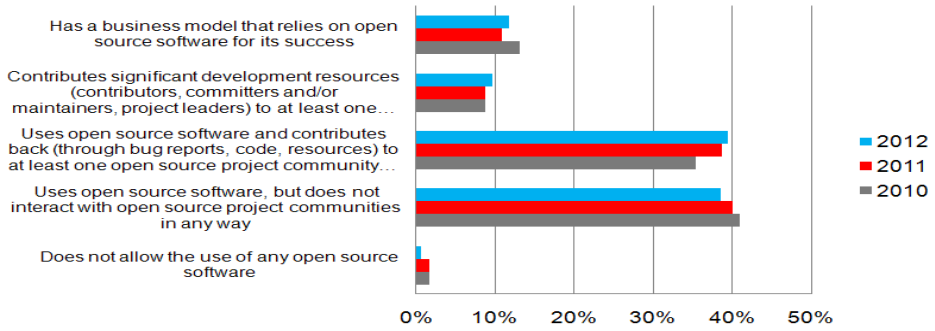

Figure 13: Firm's policy towards the use of open source software
Source: www.eclipse.org

We conclude the statistic digression concerning the habits of open source developers bringing in Figure 10 those that are the main reasons that push and encourage them to cultivate continuously over time interest in the phenomenon and to actively contribute in open source projects. As mentioned earlier in this chapter and once again took the contentions in the theoretical literature, the most shared reason, which we consider to be the driving force that distinguishes the huge worldwide success of the phenomenon, is the passion that developers feel in being able to contribute to the growth and improvement of the software code and also in sharing what are the values that govern the whole philosophy of FOSS communities. The strong passion as often happens in those fields is therefore synonymous with quality, a typical feature of open source products.

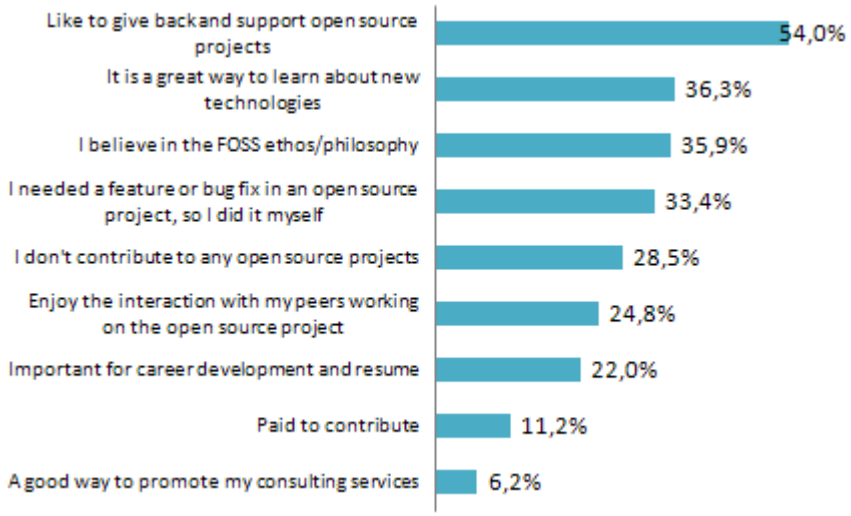

Figure 14: Main reasons of contribution in an open source project
Source: www.eclipse.org

As mentioned in the analysis of the theoretical literature business models based on the OS are increasing more and more the attention of both the customers and the companies that properly do not undertake business with it. This is because the open source has gradually increased its credibility from a point of view of the possibility of indirectly monetize from its products and therefore the ability to be a sustainable model for the generation of value if opportunely combined with closed development business models. Therefore the last figure reported in this chapter refers to the division of revenues resulting from the OSS activities among the various opportunities and categories of usage of the open software. From the figure emerges as most revenues for OSS vendors descend from the sale of "Closed source licenses", term used in open source to refer to proprietary software licensing. Revenues from open source software instead are zero, while a slice is earned by support services through both "subscription" (annual service and support agreement) or via regular or special contacts for assistance. "Software services" constitute 10% of total revenue and refer to customers who use the software via hosted or cloud. Of lesser importance are revenues from the activities of additional functionalities offered as a service through annual agreement of support, the revenues from activities involving the customization of specific software developments and the revenues from activities of advertising exposure associated with free software (The 451 Group, 2010).

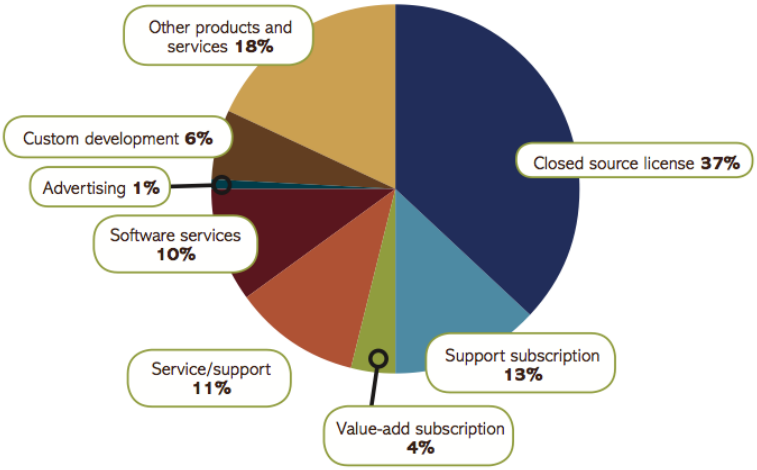

Figure 15: Open Source revenue generator – vendor usage
Source: © 2010 THE 451 GROUP, LLC, TIER1 RESEARCH, LLC

2. Research Questions and Arguments

In this chapter we will briefly summarize the arguments allowing us to introduce the research questions identified after the analysis of the theoretical literature and on which the whole thesis is based.

It is worth remembering that this thesis gives continuity to a previously started project focused on the OSS realm. It also required as first step the collection of the necessary data to carry out the scientific research of the project. The obtained dataset was not appropriate for another possible research question, suggested by the analysis of the theoretical literature and generating particular interest from the point of view of the possibility of deepening the general topic. For completeness in the section "Limitation and Future Endeavors" an attempted explanation of this further possible area of investigation is presented.

Therefore, after the data collection and a careful review of the existing literature (excluding the aspects to which this particular dataset is not sensitive), a clear direction of investigation pointed towards three research questions closely related to each other.

2.1 Line of reasoning

In the analysis of the theoretical literature the topic of the NTBFs' founders has been explored. This was primarily done to provide a general idea of the studies on the founders of high-tech companies and their relations with other agents of these firms' realm, particularly focusing on their relationship with the VCs, whose relevance is widely shared and recognized in terms of the role played in high-tech industry and specifically in the OS industry. The literature provides a wealth of information and feedback about how the relationship structured over time and about the main variables impacting on this tie. We have seen how factors such as the "capability effect" of founders' human capital and the "wealth effect" (Colombo & Grilli, 2005) favorably impact on the performance of NTBFs. We also argued how in particular the human capital characteristics, breaking down into the types of generic and specific human capital, positively impact on the growth of firms especially when it comes to founders' industry-specific human capital. It is worth recalling that the first type relates to the general knowledge acquired by entrepreneurs both through formal education and professional experience. On the other side, specific human capital includes knowledge of the industry in which the new firm operates, and so industry-specific human capital obtained by founders through prior

work experience in the same industry, and also entrepreneur-specific human capital (management skills) that is developed by founders through "leadership experience" (Bruderl et al., 1992).

According to another research (Colombo & Grilli, 2010) the specific human capital characteristics of founders that are directly associated with firm's growth partially differ from those that positively influence access to VC. Other research studies have gone instead to deepen the topic of the founders of NTBFs focusing on what are the effects of the genetic characteristics of the companies among academic and non-academic high-tech start-ups (i.e. Colombo & Piva, 2011).
On the other hand in the literature it is widely argued about the determinants of the degree of openness of the companies with hybrids business models. Bonaccorsi et al. (2006), for example, support the idea that the degree of openness to OS is positively affected by the size of the software firm and negatively by the length of experience with proprietary software, the date of adoption of OS, and the perceived importance of compatibility problems on the demand side. It was finally extensively treated in the literature the theme of the means of intellectual property protection and how they relate to these different business models of NTBFs and with the procedures of VC financing of the firms. In general, from the literature we can draw the following conclusions : without the intellectual property protection mechanisms, OSS cannot continue to grow in commercial importance; companies strategies for acquiring patents, or trademarks, correlate with indicators of market success (Mann, 2006; Merges, 2006); patents and trademarks are fundamental instruments for the appropriability of the value of their product objects as well as the quality of the developed technology, they impede rivals research and adverse litigation, and strengthen the bargaining power of the owners (Cohen et al. 2000; Ziedonis, 2004).

Relying on the above mentioned literature results, we set out to investigate more thoroughly than what can be found in the theoretical literature to date the relationship between the human capital characteristics of the founders of companies with hybrid business models in the software industry and the detected performances: the degree of endowment of the intellectual property protection and that of OS products compared to proprietary products, namely the degree of openness to OS.
Such reasoning translates into the following main research question:

What are the effects that the human capital of the founders of software firms whit hybrid business model exerts on the degree of intellectual property protection and on the degree of openness to OS?

This inquiry in general indicates the path chosen for this work. To test it carefully and to give a general answer it was necessary to divide the question into three sub-questions, which characterized the statistical analysis of this research paper. The analysis of the impact of human capital of the founders of the "hybrid" sample on business performances was carried out separately for the two different features that we have selected as elements of dependence: the degree of openness to OS and the degree of intellectual property protection. In detail, the two analyses explored the different effects that the identified heterogeneous components of the human capital of founders have on the above-cited business performances. The reason for this, as clear from the literature, is the effect of two types of human capital of founders: general and specific human capital, that may differ because of the different nature of the factors that they should represent.
The three research questions that we are going to check are listed below:

2.2 Research Question 1

What is the effect of the characteristics of generic human capital of the founders of firms with hybrid business model on their degree of openness to OS and on their degree of intellectual property protection?

This first research question raises the doubt about whether factors, such as the education of several founders of companies combining business development of proprietary products and OS product, may affect positively two aspects of great importance when it comes to young companies in the software industry. More specifically, the analysis seeks to demonstrate whether educational factors are able to impact positively on the determination of a broad portfolio of patents and trademarks or only one of the two, as well as on the determination of a greater degree of openness to OS. To verify the foregoing statement we have chosen two indicators: an index relative to an excellent level of education among the various founders and the years of education of the founders. At this point one could argue that the two indicator are correlated since generally in order to achieve an excellent level of education more years of education are required. The response is in an interesting reflection present in the theoretical

literature (Colombo & Grilli, 2005; Eisenhardt & Schoonhoven, 1990). It emerges that the combination of complementary capabilities (for instance: technical and economic education or technical and commercial work experience) within the founding team of NTBFs leads to synergistics effects and more rapid growth. Therefore we can study if these synergies, which in fact appear if the team has heterogeneous competences, may actually have a positive effect on the two dimensions of performance that we have chosen, and not only on the growth. When we then refer to the excellence of the founding team we actually think about heterogeneity of certifications and the prestige of the same. In particular, the second indicator, namely the years of education, was selected because the theoretical literature argues that generally it does not affect the firm's growth. Our investigation, then, rises in order to close the gap on the possibility that, despite the growth of NTBFs, the degree of openness to OS and intellectual property protection may be influenced by years of education of the founders.

The next research questions instead focus on the effects of the specific characteristics of the human capital of founders, allowing us to ultimately have a full overview of what are the general effects on the above mentioned business performances.
In this case we have identified three types of indicators of specific human capital.
To be specific, one of them measures the industry-specific human capital characteristics obtained by founders, while the other two measure the entrepreneur-specific characteristics. They are respectively: the type including the variable of working experience in the same field of the company, the type representing the managerial experience of the founders and the type indicating the entrepreneurial experience accumulated in the field.

2.3 Research Question 2

What is the effect of the industry-specific human capital of the founders of firms with hybrid business model on their degree of openness to the OS and on their degree of intellectual property protection?

As previously mentioned the characteristics of industry-specific human capital positively influence the performance of the company from a point of view of NTBFs' speed of growth (Brüderl and Preisendörfer, 2000; Siegel et al., 1993) or likelihood of survival (Brüderl et al., 1992; Cooper et al., 1994). The transversal purpose of our research questions is to restrict the

action field of the effects of human capital only to companies with hybrid business model; then, trying to understand whether the industry-specific characteristics also act positively in the direction of openness and protection of these companies we can provide information and assessments on an aspect of this topic not yet very detailed in the literature.

To perform this analysis we will use as indicator of industry-specific human capital the number of years of experience in the field of the company (one of the indicators most commonly used in the literature). We expect that the increasing experience in the sector of the company decreases the propensity to create a greater degree of openness; mainly because it is believed that more experience in terms of years also generates a kind of ambition that inhibits the preference for business models focused on open source in favor of proprietary models giving benefit by practicing the acquired experiences.

There is, instead, no a priori knowledge on the relation between the years of experience and the degree of intellectual property protection.

2.4 Research Question 3

What is the effect of the entrepreneur-specific human capital of the founders of firms with hybrid business model on their degree of openness to OS and on their degree of intellectual property protection?

This research question focuses on the effects that the entrepreneurial or managerial experience accumulated over time by the founders exert on the degree of IPP (intellectual property protection) and openness to OS.

In the first case the theoretical literature argues that NTBFs established by individuals with prior entrepreneurial experiences exhibit higher growth than other NTBFs (Colombo & Grilli, 2005) and attract more easily private equity financing. In addition, several studies (Mann & Sager, 2006; Heeley et al., 2007; Long, 2002: 646) show that processes such as patenting are among the few means that VCs have at their disposal in order to get more or less objective and reliable feedbacks about the quality and the potential of success of the various companies, of course depending on the ability of perception and analysis (experience) of more experienced investors (Hsu and Ziedonis, 2008).

We also want to check whether a relationship between entrepreneurial experience of the founders and the endowments of intellectual property protection exists, specifically if

entrepreneurial experience of the founders also has the ability to impact the size of trademarks and patents portfolios of the considered companies.

After verifying this hypothesis, we can assert that the effect exerted by the entrepreneurial experience of the founders on the degree of IPP impact through the latter on generation of a greater degree of openness to OS. This statement comes from what is claimed in the theoretical literature (Fosfuri et al., 2008), namely that large equipments of patents and trademarks allow a company to focus more easily on the production and development of OSS products due to the fact that these means of protection act as complementary assets for developed products. We recall that the indicator used to measure the level of entrepreneurial experience of the founders was the average number of companies established by the founding team of any company.

As instead regards the type of entrepreneur-specific human capital characteristics of managerial type, we selected as indicator the number of working experiences in the industry with high-profile positions and therefore mainly the positions which have allowed the founders to improve their management skills. The theoretical literature (Colombo & Grilli, 2005) does not reject completely the possibility that a greater degree of managerial experience exercises greater positive influence on the growth of NTBFs more than in case of a lesser degree of experience. It is however shown that this factor is able to increase the attractiveness of VC investments with consequent benefits for the firm's performances. The aim is therefore to investigate whether the beneficial effects arising from this factor include also that of increasing the degree of IPP and openness to OS for the considered companies.

3. Data Description

3.1 Sources of Data

The empirical analysis carried out afterwards is rooted in the large dataset that was created by extracting the required data from different databases; below has been therefore provided the list and the description of the different data sources that were used.

PROMT and ASAP

The Gale Group's PROMT (Predicast Overview of Markets and Technology), recognized internationally as the leading database for applied research in the field of business, is known for its comprehensive, reliable, and international coverage of companies, products, markets and technologies and its wide and varied collection of magazines, newsletters and newspapers. The database allows the search and consultation of the articles (or abstracts) of over 1000 periodicals and magazines of an economic and financial business. The articles covering the international events and activities of public and private companies in the whole world are classified by companies involved, products, event type and nations involved.

The same type of extraction and collection of data was performed with ASAP database, which is also developed and provided by Gale Group, and which contains roughly the same kind of information provided by PROMT, with the difference that the dataset extends over a broader time period and that the search engine allows conducting most advanced and detailed research.

The initial goal was to identify, from an initial set of companies operating in the software industry, the subset of those with business models addressed to OS, to then select and classify all the software products developed by these subset's firms, distinguishing the OS products from the proprietary ones.

USPTO and EPO

The United States Patent and Trademark Office (PTO or USPTO) is an agency in the United States Department of Commerce that issues patents to inventors and businesses for their inventions, and trademark registration for product and intellectual property identification.

The USPTO cooperates with the European Patent Office (EPO) and the Japan Patent Office (JPO) as one of the Trilateral Patent Offices. The mission of the PTO is

- promoting "industrial and technological progress in the United States and strengthen the national economy" by:
- administering the laws relating to patents and trademarks;
- advising the Secretary of Commerce, the President of the United States, and the administration on patent, trademark, and copyright protection; and
- providing advice on the trade-related aspects of intellectual property.

The EPO provides users with high-quality online patent data from more than 80 different countries and legal status data from more than 40 patent authorities. It monitors the three main patent data streams (bibliographic, facsimile images and full text) at key stages in their life cycles to ensure that they are complete, consistent, accurate and up to date.
For the purpose of expanding the information about the OSS firms found through the use of PROMT and ASAP, have been used the two on line available databases of USPTO and EPO to extract and classify respectively all trademarks and patents acquired by the companies taken into consideration. In particular USPTO's database of registered trademarks is Trademark Electronic Search System (TESS) a search engine that contains the records of active and inactive trademark registrations and applications while EPO's database is Espacenet which offers free access to more than 70 million patent documents worldwide, containing information about inventions and technical developments from 1836 to today.

BusinessWeek, CrunchBase, LinkedIn and LexisNexis®

Bloomberg's BusinessWeek.com is a site dedicated to the constant information on what are the developments and news about global economics, the companies and industries, the politics and the policy, the technology, the markets and finance, innovation and design and other areas dedicated to the world of business. In particular, the site offers an extensive database of information on business news, trends and profiles of successful business people. Crunchbase is a free database of technology companies, people, and investors. The site contains statistical data on more than 200,000 between companies, people, financial organizations, service providers, funding rounds and acquisitions.
LinkedIn Corporation is a social networking website for people in professional occupations and has more than 200 million members in over 200 countries and territories. The site as well

as allowing users to research companies with which they may be interested in working mainly allows to make contact with professionals who work in these companies and allows users to endorse each others' skills such as information regarding their professional career and educational.

LexisNexis ® Academic is a database of over 10.000 Provides access to full-text news, business, and legal publications, using a variety of flexible search options. It is one of the most heavily used databases in higher education and is available at over 1.500 libraries serving over 8 million students and faculty. It also provides company profiles for both public and private companies as well as information about professionals in the world of business.

Access to these four sites and their databases has allowed us to take the third substantial part of the construction of our dataset, namely that consisting of the collection of information about the founders of the OS companies previously found. If the information sought were not available on these sites in order to compose a dataset as complete as possible were also used web research or it was decided to collect this information by contacting the founders of which there was a lack of all or part of the searched data through theirs Linkedin profiles.

3.2 The Data Set

The creation of the dataset of this work was carried out from a previous dataset that has allowed us to investigate some aspects related to the OSS realm and to focus better on the research of the necessary information in order to carry out the different evaluations and decisions about the research questions chosen for this work.

In particular the creation of different hand collect dataset, from which then have been gathered the different types of data that are going to compose the final dataset used for the analysis of the work, has been structured in four precise steps: one dedicated to data collection and information about companies and their products; one dedicated to the collection of information and data relating to trademarks and patents of the various companies; and finally the phase dedicated to collecting information about the founders of each company. The first step was then to go to build the product portfolio on which are based the analyzes conducted to answer the research questions of this work. To do so we proceeded accessing the database PROMT and ASAP in order to search for all the products required. The way in which the research was carried out in terms of research query was the following:

Your search ((Keyword="Product/Service Evaluation" OR "Product Announcement" OR "Software Review") AND (SIC Code=7372)) returned the following results in Business Index ASAP, PROMT, and Newsletters.
Results limited to (Date=01/01/1999-12/31/2010; Fulltext).

All full-text articles taken from ASAP and PROMT and which referred to "Product / Service Evaluation" OR "Product Announcement" OR "Software Review" AND "7372 SIC Code" (which refers to computer software) have been investigated by the query with a result of 1421 articles and document. To facilitate the use of this large database the 1421 documents were divided by year in different folders. Once distinguished the proprietary companies from the open source companies mentioned in the artiche, it was possible to proceed with the creation of firms' product portfolio. The full bodied phase of work then was to search manually in articles all the main necessary information to have a comprehensive product portfolio for both proprietary companies and for the open source companies previously identified.
Since sometimes the downloaded articles do not evaded the disclosure requirements for all categories sought for each type of product, in such cases has been reported in the related information field the expression "n.a." as an indicator of unavailability of the same. This was done only after that the use of alternative sources of information such as the websites of the companies or any other form of information available on the web had given negative results to the research. The research carried out in the previously described modes, however, has led to the collection of approximately 190 proprietary products and of about a dozen OS products. This finding obviously not sufficient to have a reliable database, do not allow any type of statistical analysis, which is why it was decided to "clean" the name of the firms used in the search query to avoid problems such as the fact that in the articles the names of some companies were shortened or were not even presenting legal form indication.
The operations generated for the purpose "to clean" the data have been the following:

- The punctuation cleaning of firm's name which consisted of the removal of punctuation characters such as ",", "." and "-"
- The legal form cleaning of the search field which consisted of the removal of legal forms indications such as "Inc." or "Ltd"
- The legal form indications such as "Company" and "Corporation" have been removed (unless it would lead to a distinction of companies with the same first part of the name)

- Have been considered cases in which it had been referred to companies by abbreviations or by other types of reduced references to their full name.

For instance, a company previously sought in the form "Black Duck Software, Inc." after this cleaning step has been sought in the form "Black Duck" but, in spite of this new methodology, the results however have been unsatisfactory since it was reached the number of 23 OS products, which was still not enough for the requirements of a good dataset on which structuring our empirical analysis.

Thanks to an external contribution consisted in the collection of additional information on the companies in question carried out on the LexisNexis®Academic database, ultimately it has been possible to obtain 127 hybrid firms and have been identified 423 OS products.

After collecting a comprehensive portfolio of hybrid firms, so we proceeded with the manual collection of patents and trademarks on the two databases mentioned above, and then completed the dataset with the research of the members of each founding team and of the relevant information about them which, as will be shown later, have been used as independent variables in our analysis.

In the end therefore has been possible to integrate the partial external contributions with the various types of hand collected data reported obtaining the following dataset:

COMPANY CODE	Unique ID code assigned to each company.
COMPANY NAME	Name of the company of which have been collected open source and proprietary products, patents, trademarks and founders' information.
OTHER NAME	If a company is “formerly known” with another name, it is inserted in this field.
FOUNDATION YEAR	In this field is reported the foundation year of the company.
NUM_PATENTS	In this field is reported the total number of patents identified for the company.
NUM_TRADEMARKS	In this field is reported the total number of trademarks identified for the company.
TOT_PATENTS&TRADEMARKS	In this field is reported the sum of the total number of patents and of the total number of trademarks identified for the company.
NUM_PROPR_PROD	In this field is reported the total number of products of the company if licensed as proprietary.
NUM_OS_PROD	In this field is reported the total number of products of the company if licensed as

	open source.
TOT_PROD	In this field is reported the sum of the total number of products of the company regardless of whether they are proprietary or open source.
OPEN RATIO	The value given by the ratio of the number of open source products and the number of total products (proprietary and open source) of each company. The value may vary between 1 and 0.
MORE OPEN	If the open ratio of the company is greater than the average value of the open ratios identified for all companies, namely 0.706, this dummy variable takes value 1, 0 Otherwise.
LESS OPEN	If the open ratio of the company is less than the average value of the open ratios identified for all companies, namely 0.706, this dummy variable takes value 1, 0 Otherwise.
NUM_FOUNDERS	In this field is reported the number of all the founders of the company.
SUM_YEARSofEXPERIENCE	In this field is reported the sum of years of experience in the same industy of the company of all the founders.
SUM_HIGH_POSITIONS	In this field is reported the total number of positions of top management that the founders of the company have performed.
SUM_NUMCOMP_STARTED	In this field is reported the total number of companies that the founders of the company have started.
AVE_YEARSofEXP	In this field is reported the average among founders of their total years of experience in the same industry of the company, namely the value given by the ratio between the variable "SUM_YEARSofEXPERIENCE" and the variable "NUM_FOUNDERS".
AVE_HIGH_POSITIONS	In this field is reported the average among founders of the total number of positions of top management that they have performed, namely the value given by the ratio between the variable "SUM_HIGH_POSITIONS" and the variable "NUM_FOUNDERS".
AVE_NUMCOMP_STARTED	In this field is reported the average among founders of the total number of companies that they have started, namely the value given by the ratio between the variable "SUM_NUMCOMP_STARTED" and

	the variable “NUM_FOUNDERS”.
HGdegree	In this field is reported the total number of high school diplomas achieved within the founding team of the company.
JD	In this field is reported the total number of Juris Doctor degrees achieved within the founding team of the company.
BA	In this field is reported the total number Bachelor of Arts degrees achieved within the founding team of the company.
UNIdegree	In this field is reported the total number of university degrees for which it was not possible to know the specialization, achieved within the founding team of the company.
BS	In this field is reported the total number *Bachelor of Science degrees* achieved within the founding team of the company. In reality have been indicated by the acronym also the technical specialization or engineering found among the founders
BE	In this field is reported the total number of Bachelor of Econimics degrees achieved within the founding team of the company.
MS	In this field is reported the total number of Masters of Science achieved within the founding team of the company.
MBA	In this field is reported the total number of Masters of Business Administration achieved within the founding team of the company.
PHD	In this field is reported the total number of PHDs achieved within the founding team of the company.
EDUCATION_YEARS	In this field is reported the total amount of years of education of each founding team. For the calculation of this variable were considered 4 years of education for having attended the high school, for the achievement of a bachelor degree or any PhDs while for the achievement of a Master were considered two years.
EDU_YEARS_AVE	In this field is reported the average of the total amount of years of education of each founding team among its founders, namely this value given by the ratio between the variable “EDUCATION_YEARS” and the variable “NUM_FOUNDERS”.

HETEROG_SURPLUS	This variable can assume the value of 3 if in the founding team of the company are present at least one pair of certifications in the technical and economic, otherwise the variable takes the value 0.
EDU_EXCELLENCE1	In this field is reported the value of the score of each founding team, which represents the degree of excellence of education achieved by the individuals constituting the team. The return value is given by the following formula: =(SUM (Hgdegree*1 + JD*5 + BA*5 + UNIdegree*5 + BS*5 + BE*5 + + PHD*4 + MS*3 + MBA*3)/NUM_FOUNDERS + HETEROG_SURPLUS + IF(JD>0;1;0)) *100
EDU_EXCELLENCE2	In this field is reported the value of the score of each founding team, which represents the degree of excellence of education achieved by the individuals constituting the team. The difference with the variable EDU_EXCELLENCE1 resides in the different weights used for the various certifications

Table 1: Dataset: description of the variables

For completeness it should be noted that of all the categories of information collected respectively for patents, trademarks and founders only those related to the latter have been introduced in the final dataset without any exclusion; for the other two types were used only the total number of patents and trademarks owned by each company in the used sample. Most of the data collected for the firms nonetheless remain available for those that will be further research and subsequent studies carried out in order to give continuity to the research project that underlies this thesis. Recall that a problem noticed across all the three stages of collection (patents, trademarks and founders) was the fact that not all the categories of information reported have always been available. Since the aim of this work is based on calculating the impact of human capital capabilities of the founders of the various dimensions related to hybrid firms in OS, the resulting research question and statistical analysis forced us to exclude from our dataset all the companies for which have not been found comprehensive data about the founders despite repeated searches. The final sample was then restricted to 103 hybrid businesses.

In order to make completely clear the understanding of the meaning of the variables in the dataset, reported below are the explanation of the procedures and considerations made to build some of these variables.

With regard to the values attributed to the years of study of each type of education: secondary school, academic and post-graduate, have been put forward hypotheses on the average of years needed to complete each course of study after consulting various statistical sources.

With regard to the variable "HETEROG_SURPLUS", it was generated assuming that it is sufficient the presence of only one pair of certifications indicating the technical and economic skills of one or several founders of the original team of each company for the purpose of ensuring the occurring of the surplus arising from the synergistic effect of competitive knowledge and skills embedded in the several teams. This means that for every company, the presence, within the founding team's total certifications of two or more possible combinations of pairs of a set of technical and economic education have been anyway treated as a single complementary couple, and then it was attributed to the heterogeneity surplus value the maximum assumable value of 3 points.

As for the variables "EDU_EXCELLENCE1" and "EDU_EXCELLENCE2", the criteria used for the selection and assignment of different weights used to their levels of education achieved by the founders have been as follows:

- EDU_EXCELLENCE1

  For the level of high school or secondary education has been assigned a specific weight equal to "1"; with regard to the level of university education achieved by the conclusion of the degree cycle in BA, BE , BS or the other university degrees has been selected a weight of "5". We believe that, regardless of the knowledge gap which every individual suffers when they are faced with the possibility of starting their own business, the contribution provided to knowledge of the individual by a path of university studies is vastly larger than the one that is capable of providing a path of secondary school studies. As instead regards the achievement of a master's degree (MS or MBA) it was decided to assign a weight of "2" as opposed to the weight of "3" chosen for the achievement of a PhD because we believe the first degree less prestigious than the second especially since the amount of transmitted notions and the formation guaranteed by the second type are wider. It has also been added a further value equal to "1" to those previously described, only in the case where within the team of the founders had been present at least one individual with legal qualifications, i.e. with a Juris Doctor degree (JD). The reason for this addition is linked to the fact that we

decided to give more value to the collective capabilities of the founding team since the presence of a law expert could be an important contribution in relation to issues close to the Intellectual Property Rights in the business and then in relation to the administration and management of the practices related to company patents and trademarks. Note that the theoretical literature in fact widely supports as it may be burdensome for the company and for the enforceability of patents, the weight and the incumbency of litigation with third parties.

- EDU_EXCELLENCE2

  This variable instead was designed exclusively to be able to have further confirmation of what resulting from the use of the first variable, and to do so have been reduced of one unit all the weights chosen above for each different levels of education, with exception for the secondary school weight. Furthermore it has not been added to the final sum any surplus arising from the presence of legal skills within the founding team. The criteria used in the allocation of greater or lesser relative importance between the different levels of graduation, however, remained the same as described above.

4. Data Analysis

After identifying the research questions that have resulted from the analysis of the theoretical literature and followed lines of reasoning, this chapter will focus on the verification of their validity in the light of available data, through appropriate statistical analysis.

Before proceeding with the session devoted to the analysis of the research questions, has been provided a descriptive analysis of many collected samples about the main variables which will be taken into account in the statistical analysis.

The two following figures provide a comparison between those that are the endowments in terms of means of intellectual property protection and of OS products between the two groups of firms of our original sample hybrid which are distinguished by the degree of openness to OS: "more_open" and "less_open" companies. We recall that the two groups were carried out starting from the identification of the average value of 0.7066 for all the open ratios identified for the original sample of companies and the subsequent division between companies with a greater open ratio than the average value and with a lower open ratio than the average value.

Variable	Obs	Mean	Std. Dev.	Min	Max
num_patents	44	18.75	63.20293	0	369
num_tradem~s	44	10.77273	10.43666	0	38
tot_patent~s	44	29.52273	64.21855	0	376
num_os_prod	44	2.227273	2.3013	1	14

Table 2: Descriptive statistics of the dependent variables of the "less_open" sub-sample

Variable	Obs	Mean	Std. Dev.	Min	Max
num_patents	59	11.47458	58.9112	0	438
num_tradem~s	59	7.898305	16.65336	0	127
tot_patent~s	59	19.37288	65.81659	0	450
num_os_prod	59	5.372881	4.201389	1	19

Table 3 : Descriptive statistics of the dependent variables of the "more_open" sub-sample

Comparing the two previous tables emerges as in the case of the OS companies' sample which we defined as those characterized by a greater degree of opening can be seen an average value of patent endowment lower than in the case of the sample of companies with a smaller degree of openness, and the same also applies to trademarks. While emerges clearly that the average of the number of open source products of companies with a greater openness is greater than the average of the companies with less openness of approximately 3 elements; this is indicative of the fact that despite the distinction between companies more open and less open to OS depends on the ratio among the endowments of proprietary products and OS

products, the latter indicator is still acceptable as absolute indicator of the degree of openness given the clear difference found between the above two sub-samples.

The next two tables instead allow to perform a first comparison between those which are the different values of the information collected about founders depending on whether we consider more or less open to the OS companies.

Variable	Obs	Mean	Std. Dev.	Min	Max
mba	44	.2045455	.4615215	0	2
ms	44	.2272727	.4239151	0	1
phd	44	.1136364	.3210382	0	1
education_~s	44	12.86364	5.728716	8	30
edu_excell~1	44	753.7879	258.4206	300	1500
sum_yearso~p	44	32.40909	16.21558	7	79
sum_high_p~s	44	7.386364	6.495852	1	31
sum_numcom~d	44	3.318182	2.228491	1	10

Table 4: Descriptive statistics of some founders' variables of the "less_open" sub-sample

Variable	Obs	Mean	Std. Dev.	Min	Max
mba	59	.2033898	.4464288	0	2
ms	59	.3728814	.5842267	0	2
phd	59	.1016949	.3048411	0	1
education_~s	59	15.52542	7.863832	4	32
edu_excell~1	59	749.7175	248.6841	50	1500
sum_yearso~p	59	35.05085	21.1264	11	114
sum_high_p~s	59	7.220339	5.236042	1	26
sum_numcom~d	59	3.050847	2.337282	1	15

Table 5: Descriptive statistics of some founders' variables of the "more_open" sub-sample

Comparing the two tables discloses no clear differences between the averages of the number of masters of PhDs, high positions covered, companies founded or the points of education's excellence; on the other hand the average years of education received by founders is lower of approximately 3 points in the case of open companies, as opposed to the average number of years of experience in the industry sector of the company, that instead is greater of about 3 points in the case of the most open to OS companies.

After this brief descriptive analysis that showed the main differences from the point of view both of the values of the dependent variables and of the values of some independent variables between the two sub-samples differing in the degree of openness to OS, we proceed with the real analysis of this work, namely that of the three research questions identified.

4.1 Research Question 1

What is the effect of the characteristics of generic human capital of the founders of firms with hybrid business model on their degree of openness to OS and on their degree of intellectual property protection?

In order to answer the first research question we have chosen to analyze the effect that the generic human capital of founders exercises on the determinants identified in the following order: degree of intellectual property protection and subsequently degree of openness to OS.
Before starting the actual analysis we introduce what are the variables that will be used as indicators of generic human capital of the founders, namely the total number of years of education attained by founders (first considered as the total sum of all the founders and then also considered as the average among the founders of the total sum of years) and the degree of excellence of education achieved by the founding team of the company in question. The latter variable was mainly used to strengthen the results with statistical significance that were found using the first variable.
We remember however that the variables chosen to represent and measure the degree of intellectual property protection and of openness to OS of the company are: the number of patents, the number of trademarks and the sum of both types possessed by each company in respect of the first performance measured; while as regards the second performance have been used two variables: the first is an absolute variable since it refers to the total number of OS products, the second variable instead is a dummy that allows us to distinguish the companies with a greater degree of openness to OS from those with a lower degree of openness to OS within the sample of 103 companies identified.

First generic human capital's variable: years of education

To carry out the first analysis we considered both the total sum of years of education received by individuals of each founding team and the average of total years of education carried out among the number of founders of each team. Respectively the two variables considered are "education_years" and "edu_years_ave". For both variables, in order to perform the appropriate statistical analysis, have been created two different groupings of the two samples according to their means and their medians:

GROUP 1: *-Companies characterized by a founding team with a total sum of years of education of its individuals higher than the average of the sample or greater than the median of the sample:*

- *"education_years" > 14.38*
- *"education_years"> 12*

-Companies characterized by a founding team with the average years of education of its individuals higher than the average of the sample or greater than the median of the sample:

- *"edu_years_ave" > 8,74*
- *"edu_years_ave"> 8*

GROUP 0: *-Companies characterized by a founding team with a total sum of years of education of its individuals lower than the average of the sample or lower than the median of the sample:*

- *"education_years" < 14.38*
- *"education_years" < 12*

- Companies characterized by a founding team with the average years of education of its individuals lower than the average of the sample or lower than the median of the sample:

- *"edu_years_ave" > 8,74*
- *"edu_years_ave"> 8*

IMPACT ON THE TOTAL NUMBER OF PATENTS

The first test was carried out using the "two independent samples t-test", which tests for the null hypothesis of equality of means of the two samples.

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	57	20.08772	10.07784	76.08601	-.1006175	40.27606
1	46	7.76087	4.731249	32.08889	-1.768356	17.29009
combined	103	14.58252	5.969599	60.58482	2.741852	26.4232
diff		12.32685	12.00467		-11.48719	36.14089

diff = mean(0) - mean(1) t = 1.0268
Ho: diff = 0 degrees of freedom = 101

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.8465 Pr(|T| > |t|) = 0.3069 Pr(T > t) = 0.1535

Table 6: Two-sample t test; impact of "education_years" on "num_patents"

Since the p-value is higher than the threshold value of 0.1 the test allows us to reject the null hypothesis of equality of the samples. It is however possible to note that the average endowments of patents exceeds of about 12 units in the case of the group with lower cumulative years of education of the founders. In order to have a statistically significant verification of the fact that this difference is not accidental was considered a further test: the "Wilcoxon-Mann-Whitney test", which tests for the null hypothesis of equality of values between two samples through the comparison of their medians. Then, as shown above, the two reference groups were selected identifying for the "Group 1" and the "Group 0" respectively the companies with years of education higher and lower than the sample median of 12 years. The aforementioned test gave the following response:

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test

sumeduye~ian |       obs    rank sum    expected
-------------+---------------------------------
           0 |        53      2953.5        2756
           1 |        50      2402.5        2600
-------------+---------------------------------
    combined |       103        5356        5356

unadjusted variance    22966.67
adjustment for ties    -1792.39
                     ----------
adjusted variance      21174.27

Ho: num_pa~s(sume~ian==0) = num_pa~s(sume~ian==1)
              z =   1.357
    Prob > |z| =   0.1747
```

Table 7: Two-sample Wilcoxon-Mann-Whitney test; impact of "education_years" on "num_patents"

Even this case the p-value despite come close to threshold value of 0.1 does not allow us to reject the null hypothesis of equality of the samples, although consistently to first test the endowments of patents of the first group is greater than that of the second as is visible by comparing the relative rank sums. With regard to the analysis carried out taking as independent variable "edu_years_ave" the statistical results are generally consistent with those returned from the above shown. In fact, for both the performed tests, the p-value is greater than 0.1 not allowing to reject the null hypothesis of equality of the samples, even though in line with the two tests shown above, emerges a higher endowment of patents for groups with fewer years of education. The exact data of these two tests are observable in the Appendix to the tables 1 and 2.

IMPACT ON THE TOTAL NUMBER OF TRADEMARKS

In this case the procedure is the same as the first case of analysis. The "two-sample t test" and the "two-sample Wilcoxon rank-sum test" performed on the total number of trademarks of the two different groups gave the following results:

```
Two-sample t test with equal variances

   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |      57     10.7193    2.365128    17.85633    5.981377    15.45722
       1 |      46    7.152174    1.162609    7.885197     4.81056    9.493788
---------+--------------------------------------------------------------------
combined |     103    9.126214    1.413047    14.34086    6.323441    11.92899
---------+--------------------------------------------------------------------
    diff |            3.567124    2.834248               -2.055261     9.18951
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =   1.2586
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.8945         Pr(|T| > |t|) = 0.2111          Pr(T > t) = 0.1055
```

Table 8: Two-sample t test; impact of "education_years" on "num_trademarks"

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test

sumeduye~ian |        obs     rank sum    expected
-------------+---------------------------------------
           0 |         53         2828         2756
           1 |         50         2528         2600
-------------+---------------------------------------
    combined |        103         5356         5356

unadjusted variance     22966.67
adjustment for ties      -139.87
                        ----------
adjusted variance       22826.80

Ho: num_tr~s(sume~ian==0) = num_tr~s(sume~ian==1)
             z =   0.477
    Prob > |z| =   0.6337
```

Table 9: Two-sample Wilcoxon-Mann-Whitney test; impact of "education_years" on "num_trademarks"

As can be seen from the p-value of the two tests both greater than 0.1 can not be argued That the two groups differ in a statistically relevant way. To have a further check was decided to perform both tests on the variable "edu_years_ave" taking as "Group 1" and "Group 0" respectively the subsets composed by the number of companies whose mean years of education of founders was higher than average value of 8.74 and Whose median was greater than the value of 8, as shown at the beginning of the chapter. As one can see from the relevant tables 3 and 4 in the Appendix, the first tests carried out starting from the division of the sample according to the average of the values, returns a p-value very high (0.8), and then the result is not statistically relevant. Instead the second test performed from the division of the sample according to the median of values, returns a p-value at the limit of statistical relevance

(0.1042), which could allow us to reject the null hypothesis and claim that the net difference between the values of the rank sum of the two groups ensures that companies with a lower years of education average among the founders are better equipped with trademarks.

IMPACT ON THE TOTAL NUMBER OF PATENTS AND TRADEMARKS

Since the two tests carried out to determine the impact of years of education of founders on the patents did not give a statistically significant finding one may suspect that the statistical analysis of the 'impact of these variables on the total number of endowments of intelectual property protection gives a similar result. In fact the various statistical results carried out gave as p-value of the "two-sample t test" and the "two-sample Wilcoxon rank-sum test" values, respectively 0.21 and 0.25 as regards the independent variable "education_years" and respectively the values 0.76 and 0.18 as regards the independent variable "edu_years_ave". In both cases, however, it is possible to appreciate a difference between the endowments' values of the two groups of reference in favor of groups with fewer years of education of founders. The exact data of the tests performed to analyze the impact of the two variables referring to the years of the education on overall endowments of patents and trademarks can be found in the Appendix to the tables 5, 6, 7, 8.

IMPACT ON THE TOTAL NUMBER OF OPEN SOURCE PRODUCTS

The tests carried out by observing the impact of the variable "education_years" on the indicator of absolute openness to OS refers to the total number of OS products created by each company, gave the following results:

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	57	3.947368	.5649656	4.265397	2.815606	5.079131
1	46	4.130435	.4821537	3.270125	3.159327	5.101542
combined	103	4.029126	.3779715	3.835991	3.279422	4.778831
diff		-.1830664	.7638284		-1.698297	1.332164

diff = mean(0) - mean(1) t = -0.2397
Ho: diff = 0 degrees of freedom = 101

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.4055 Pr(|T| > |t|) = 0.8111 Pr(T > t) = 0.5945

Table 10: Two-sample t test; impact of "education_years" on "num_os_prod"

It is clear that the "two-sample t test" does not provide statistical evidence of the fact that there is a substantial difference in terms of the amount of OS products created between the

two groups, as is evident that the high value of the p-value would have rendered any other result like this statistically irrelevant. For further checks recourse was made to "two-sample Wilcoxon rank-sum test" which has provided the following response:

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test

sumeduye~ian |       obs    rank sum    expected
-------------+---------------------------------
           0 |        53        2557        2756
           1 |        50        2799        2600
-------------+---------------------------------
    combined |       103        5356        5356

unadjusted variance    22966.67
adjustment for ties    -1030.51
                     ----------
adjusted variance      21936.15

Ho: num_os~d(sume~ian==0) = num_os~d(sume~ian==1)
             z =  -1.344
    Prob > |z| =   0.1791
```

Table 11: Two-sample Wilcoxon-Mann-Whitney test; impact of "education_years" on "num_os_prod"

In this case, the spread between the means of the two groups was not significant and also there is no statistical relevance since the p-value of 0.17 greater than the threshold value of 0.1. The tests performed on the variable "num_os_prod" considering the independent variable "edu_years_ave" gave results consistent with those of the tests shown above and can be consulted in the Appendix to the tables 9, 10.

IMPACT ON THE OPENNESS

To verify the existence of this effect has been used the "Pearson's chi-squared test". It is a test of independence that assesses whether paired observations on two variables, expressed in a contingency table, are independent of each other. Therefore in all the other "Pearson's chi-squared test" carried out with the other dependent variables, have been related the dummy variable "more_open" and the different dummy variables of independence of the various factors considered in each research questions. In this case, therefore, the test was carried out for the variable "education_years" and "edu_years_ave", whose dummy, as is visible in tables 1, 2, 3 and 4 of Appendix B, were calculated both relying on the means and medians of the two samples, obtaining thus ultimately four different "Pearson's chi-squared test" with the dummy "more_open." The results of this kind of test, however, did not return statistical evidence of the fact that the samples are dependent in any of the cases.

In general, the statistical results effected through the variables related to the achieved years of education seem to be partially consistent with the expectations about the effect on the level of intellectual property protection but nothing can be stated with regard to the effects on the degree of openness to OS.

Second generic human capital's variable: excellence of education

As previously mentioned in the presentation of the dataset, the indicative variables of the excellence of the education team of founders of each company are two: "edu_excellence1" "edu_excellence2" and differ only in the values of the weights chosen to calculate them.
For both the aforementioned variables have been identified means and medians of the samples in order to perform the different groupings required for running the "two-sample t test" and the "two-sample Wilcoxon rank-sum test":

GROUP 1: *-Companies characterized by a founding team with a score of excellence of education higher than the average of the sample or greater than the median of the sample:*

- *"edu_excellence1" > 751,45*
- *"edu_excellence1" > 600*

-Companies characterized by a founding team with a score of excellence of education higher than the average of the sample or greater than the median of the sample:

- *"edu_excellence2" > 684,78*
- *"edu_excellence2" > 500*

GROUP 0: *-Companies characterized by a founding team with a score of excellence of education lower than the average of the sample or lower than the median of the sample:*

- *"edu_excellence1" < 751,45*
- *"edu_excellence1" < 600*

- Companies characterized by a founding team with a score of excellence of education lower than the average of the sample or lower than the median of the sample:

- *"edu_excellence2" > 684,78*

- *"edu_excellence2" > 500*

IMPACT ON THE TOTAL NUMBER OF PATENTS

As regards the first test performed namely the "two-sample t test" with the grouping based on the averages of the two samples "edu_excellence1" and "edu_excellence2" have been encountered p-value equal to 0.35 in both cases that then did not allow us to be able to reject the null hypothesis of equality of means of the two samples and therefore the difference among the endowments of patents shown by test and equal to about 11 in favor of the "Group 1" is not statistically significant for of our argumentation. The "two-sample Wilcoxon rank-sum test" has been carried out for both the independent variables to further check this result previous testing for equality of medians of the two groups, and the outcome has been statistically of little relevance also in this case since the two p-value equal to 0.776 and 0.93 respectively are even higher than those which resulted with the initial grouping methodology, and again the null hypothesis can not be rejected "(data available in Appendix A, tables 11, 12, 17, 18).

IMPACT ON THE TOTAL NUMBER OF TRADEMARKS

In this case the two tests performed for the variable "edu_excellence1" respectively gave the following results:

```
Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	64	8.59375	1.060361	8.482884	6.474789	10.71271
1	39	10	3.326173	20.77194	3.266514	16.73349
combined	103	9.126214	1.413047	14.34086	6.323441	11.92899
diff		-1.40625	2.924249		-7.207174	4.394674

```
    diff = mean(0) - mean(1)                                      t =  -0.4809
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.3158         Pr(|T| > |t|) = 0.6316          Pr(T > t) = 0.6842
```

Table 12: Two-sample t test; impact of "edu_excellence1" on "num_trademarks"

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test

excedumedian |       obs    rank sum    expected
-------------+---------------------------------
           0 |        57      3204.5        2964
           1 |        46      2151.5        2392
-------------+---------------------------------
    combined |       103        5356        5356

unadjusted variance    22724.00
adjustment for ties     -138.39
                     ----------
adjusted variance      22585.61

Ho: num_tr~s(exce~ian==0) = num_tr~s(exce~ian==1)
             z =   1.600
    Prob > |z| =   0.1095
```

Table 13: Two-sample Wilcoxon-Mann-Whitney test; impact of "edu_excellence1" on "num_trademarks"

While the "two-sample t test" returned an index of statistical significance p = 0.6316 thus not allowing us to reject the null hypothesis, the "two-sample Wilcoxon rank-sum test" with a borderline p-value equal to 0.1095 would allow us to assert that there is statistical evidence that the two groups differ in terms of medians and that the null hypothesis can be rejected. The test shows a higher rank sum and thus a general higher number of trademarks' endowment for the "Group 0", namely the one characterized by lower excellence of education received by the founders. The same statistical results have also been verified for the variable "edu_excellence2" with a p-value of 0.6 for the "two-sample t test" and of 0.08 for the "two-sample Wilcoxon rank-sum test ", and with a higher rank sum and thus in general a higher number of trademarks' endowment for the" Group 0 "(data available in Appendix A, tables 19, 20).

The results of the carried out analysis help to strengthen those obtained previously in connection with the impact that the years of education exercise on the equipment of trademarks.

IMPACT ON THE TOTAL NUMBER OF PATENTS AND TRADEMARKS

Performing the statistical tests carried out previously even for the total endowments of intellectual property protection of each company, the results, as shown in the table 13, 14, 21, 22 of the Appendix, are not the same as expected in the previous case of trademarks since both the tests performed for both variables "edu_excellence1" and "edu_excellence2" return a p-value higher than the threshold value of 0.1, thus not allowing us to reject the null hypothesis of equality of distribution of the two samples .

IMPACT ON THE TOTAL NUMBER OF OPEN SOURCE PRODUCTS

Even in this case, the statistical analysis performed through the "two indipendent sample t-test" in order to verify if the two samples differ in a statistically relevant way, gave negative results since the tests carried out for both variables "edu_excellence1" and "edu_excellence2" returned a p-value higher than the threshold value of 0.1 and so consequently do not allow to reject the null hypothesis of equality of the samples. Running the "two-sample Wilcoxon rank-sum test" the result does not differ substantially from those of the previous tests since even in this case the p-values are greater than 0.1. The data concerning these tests can be consulted in the Appendix at the tables 15, 16, 23, 24.

IMPACT ON THE OPENNESS

The "Pearson's chi-squared test" carried out between the variables of excellence of education and the dummy variable "more_open" returned no statistically relevant results. Statistical results may be consulted in the Appendix B at the tables 3, 4, 5, 6.

In general, as happened for the first variable chosen for the generic human capital of the founders also in this case it can be argued that the statistical tests performed returned statistical evidence of the fact that the decrease of the level of excellence of the education of founders of a company increases the number of equipment of trademarks. So even if limited the latter the excellence of education impacts on the degree of intellectual property protection of a company.

4.2 Research Question 2

What is the effect of the industry-specific human capital of the founders of firms with hybrid business model on their degree of openness to the OS and on their degree of intellectual property protection?

The second research questions therefore aims to go to verify if the experience gained by the founders in the same industry of the company they founded is also a promoter of the increase of the degree of intellectual property protection and of the degree of openness to OS as well as promoting the growth rate and the probability of survival of NTBFs. Therefore as independent variable for this second research question was chosen the number of years of experience, both considering them such as sum of years accumulated by all individuals in the founding

team of the company, both as an average of total years of experience in the team among the founders. In order to be able to perform the two statistical tests up to now used, therefore the two variables were divided into two groups depending on the respective values of their means and medians.

Industry-specific human capital's variable: years of experience

GROUP 1: *-Companies characterized by founding team with a total number of years of experience in the same industry of their company greater than the mean of the sample or greater than the median of the sample:*

- *sum_yearsofexp> 33.92*
- *sum_yearsofexp>30*

-Companies characterized by a founding team with an average among founders of years of experience in the same industry of their company greater than the mean of the sample or greater than the median of the sample:

- *ave_yearsofexp > 16,96*
- *ave_yearsofexp > 15*

GROUP 0: **-***Companies characterized by founding team with a total number of years of experience in the same industry of their company lower than the mean of the sample or lower than the median of the sample:*

- *sum_yearsofexp< 33.92*
- *sum_yearsofexp<30*

-Companies characterized by a founding team with an average among founders of years of experience in the same industry of their company lower than the mean of the sample or lower than the median of the sample:

- *ave_yearsofexp > 16.96*
- *ave_yearsofexp > 15*

IMPACT ON THE TOTAL NUMBER OF PATENTS

After generating the two new groups the "two indipendent sample t-test" returned the following results:

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	63	18.15873	9.144967	72.58592	-.121798	36.43926
1	40	8.95	5.40998	34.21572	-1.992718	19.89272
combined	103	14.58252	5.969599	60.58482	2.741852	26.4232
diff		9.20873	12.27481		-15.1412	33.55866

diff = mean(0) - mean(1) t = 0.7502
Ho: diff = 0 degrees of freedom = 101

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.7726 Pr(|T| > |t|) = 0.4549 Pr(T > t) = 0.2274

Table 14: Two-sample t test; impact of "sum_yearsofexp" on "num_patents"

The p-value returned by the test is greater than the threshold value of 0.1 which is why we can not reject the null hypothesis of equality of means of the two samples. Nevertheless it is possible, however, to note that there is a substantial difference in average equipment of patents in the two groups found in favor of the group with fewer years of total experience gained by founders in the same industry of the company in question. Therefore we proceeded with the "two-sample Wilcoxon rank-sum test" to check if the not found statistical relevance of the first test persists even considering the grouping on the basis of the median. The results are as follows:

```
. ranksum num_patents, by (sumexpermedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

sumexper~ian |       obs    rank sum    expected
-------------+---------------------------------
           0 |        52      2875.5        2704
           1 |        51      2480.5        2652
-------------+---------------------------------
    combined |       103        5356        5356

unadjusted variance    22984.00
adjustment for ties    -1793.75
                       --------
adjusted variance      21190.25

Ho: num_pa~s(~rmedian==0) = num_pa~s(~rmedian==1)
             z =   1.178
    Prob > |z| =   0.2387
```

Table 15: Two-sample Wilcoxon-Mann-Whitney test; impact of "sum_yearsofexp" on "num_patents"

Even in this case the p-value is greater than 0.1, therefore the null hypothesis can not be rejected. The tests carried out considering the variable "ave_yearsofexp" returned the same results of the two tests shown above, as can be verified by consulting the Appendix A at the tables 25, 26.

IMPACT ON THE TOTAL NUMBER OF TRADEMARKS

With regard to the impact that the variable "sum_yearsofexp" exerts on the endowments of the trademarks "two indipendent sample t-test" returns the following results:

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	63	9.666667	2.12319	16.8523	5.42247	13.91086
1	40	8.275	1.459271	9.229239	5.323346	11.22665
combined	103	9.126214	1.413047	14.34086	6.323441	11.92899
diff		1.391667	2.910328		-4.381642	7.164976

diff = mean(0) - mean(1) t = 0.4782
Ho: diff = 0 degrees of freedom = 101

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.6832 Pr(|T| > |t|) = 0.6336 Pr(T > t) = 0.3168

Table 16: Two-sample t test; impact of "sum_yearsofexp" on "num_trademarks"

The p-value returned by the test is greater than the threshold value of 0.1 and for this reason we can not reject the null hypothesis of equality of means of the two samples. We proceed with the "two-sample Wilcoxon rank-sum test" to check if the statistical relevance is not found with the first test persists even considering the grouping on the basis of the median. The results are as follows:

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

sumexper~ian	obs	rank sum	expected
0	52	2886.5	2704
1	51	2469.5	2652
combined	103	5356	5356

unadjusted variance 22984.00
adjustment for ties -139.97
adjusted variance 22844.03

Ho: num_tr~s(~rmedian==0) = num_tr~s(~rmedian==1)
z = 1.207
Prob > |z| = 0.2273

Table 17: Two-sample Wilcoxon-Mann-Whitney test; impact of "sum_yearsofexp" on "num_trademarks"

Even in this case the p-value is greater than 0.1, therefore the null hypothesis can be rejected and as in the previous case the same results are replicated in the analysis performed with the variable "ave_yearsofexp" as can be verified by consulting the Appendix A at the tables 27, 28.

IMPACT ON THE TOTAL NUMBER OF PATENTS AND TRADEMARKS

The analysis carried out about the effect that the total number of years of experience of founders in the same industry of the company has on the total endowments of intellectual property protection of the company, unlike what occurred previously individually for the two typologies, namely patents and trademarks, confirm that instead there is a certain statistical relevance in relation to the difference of the concentrations between the two samples identified. This finding was not observed in the first type of test carried out, but in the second one:

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	63	27.8254	9.807741	77.84653	8.220003	47.43079
1	40	17.225	5.812287	36.76013	5.468541	28.98146
combined	103	23.70874	6.406314	65.01699	11.00184	36.41563
diff		10.6004	13.16727		-15.51992	36.72071

diff = mean(0) - mean(1) t = 0.8051
Ho: diff = 0 degrees of freedom = 101

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.7887 Pr(|T| > |t|) = 0.4227 Pr(T > t) = 0.2113

Table 18: Two-sample t test; impact of "sum_yearsofexp" on "tot_patentstrademarks"

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

sumexper~ian	obs	rank sum	expected
0	52	2966	2704
1	51	2390	2652
combined	103	5356	5356

unadjusted variance 22984.00
adjustment for ties -62.85
adjusted variance 22921.15

Ho: tot_pa~s(~rmedian==0) = tot_pa~s(~rmedian==1)
z = 1.731
Prob > |z| = 0.0835

Table 19: Two-sample Wilcoxon-Mann-Whitney test; impact of "sum_yearsofexp" on "tot_patentstrademarks"

As is possible to verify by comparing the p-value of the respective tests, only the second is lower than 0.1 meaning that there is statistical evidence that the two groups differ in terms of medians and that the null hypothesis can be rejected. In particular "GROUP 0", namely the group including OS companies which have been funded by people less experienced in the industry, shows a higher rank sum and thus a general and higher intellectual property protection endowment. The results obtained from the analysis with the variable

"ave_yearsofexp" confirmed the results of the two tests shown above (data available in Appendix A, tables 29, 30).

IMPACT ON THE NUMBER OF OPEN SOURCE PRODUCTS

The results of the two tests "two indipendent sample t-test" and "two-sample Wilcoxon rank-sum test" did not confirm the hypotheses of the research question 2. In fact has been no statistical relevance in any of the analyzes carried out, since the p -values are always greater than the threshold value of 0.1. Moreover, even looking at the means and the rank sums of the two tests discloses no significant differences between the two different groups identified, namely those with lower levels of experience and those with higher experience. The exact results of tests conducted on this variable can be consulted in Appendix A to the tables 31, 32, 33, 34.

IMPACT ON THE OPENNESS

The "Pearson's chi-squared test" carried out between the variables of industry-specific human capital and the dummy variable "more_open" returned no statistically relevant results. (data available in Appendix B, tables 7, 8).

4.3 Research Question 3

What is the effect of the entrepreneur-specific human capital of the founders of firms with hybrid business model on their degree of openness to OS and on their degree of intellectual property protection?

The third research questions then asks to verify if there is statistical evidence to justify the fact that the degree of intellectual property protection and the degree of openness to OS of the hybrid firms identified may be impacted under the influence of the two independent variables we chose to measure the entrepreneur-specific human capital of the founders. The latter, as already mentioned in the previous chapter, reflect respectively the managerial and entrepreneurial skills of the various founders and respectively were measured through the number of high position covered and the number of companies founded by them. The two variables were considered both as a total sum and as average among the number of founders.

First entrepreneur-specific human capital's variable : high position experiences

GROUP 1: *-Companies whit a founding team with a total number of high profile's managerial experiences greater than the average of the sample or greater than the median of the sample:*

- *sum_high_positions > 7.29*
- *sum_high_positions >6*

-Companies whit a founding team with an average among founders of the total number of high profile's managerial experiences greater than the average of the sample or greater than the median of the sample:

- *ave_high_positions > 3.64*
- *ave_high_positions > 3*

GROUP 0: **-***Companies whit a founding team with a total number of high profile's managerial experiences lower than the average of the sample or lower than the median of the sample:*

- *sum_high_positions < 7.29*
- *sum_high_positions < 6*

-Companies whit a founding team with an average among founders of the total number of high profile's managerial experiences lower than the average of the sample or lower than the median of the sample:

- *ave_high_positions < 3.64*
- *ave_high_positions <3*

IMPACT ON THE TOTAL NUMBER OF PATENTS

Statistical tests performed since the previous new groupings gave the following results regarding the variables related to the total number of experiences within the founding team: the p-value of "two indipendent sample t-test" and the "two-sample Wilcoxon rank-sum test",

respectively, were 0.8 and 0.38 greater than the threshold value of 0.1, then the test do not return statistical evidence that the two groups differ in terms of mean and median. Despite this, however there is a difference between the endowments of patents of the "Group 0" and "Group 1" in favor of the former (data available in Appendix A, Tables 35, 36).

IMPACT ON THE TOTAL NUMBER OF TRADEMARKS

Even in this case the p-value of "two indipendent sample t-test" and of "two-sample Wilcoxon rank-sum test" are respectively equal to 0.71 and 0.28 and higher than 0.1 but unlike what is clear from the first test the equipment of trademarks is lower for group 1 of the second test, so we tend to prefer the result provided by the second test, more suitable for non-continuous variables, which then highlights the fact that there is a statistical difference between the two samples even though not significant (data available in Appendix A, Tables 39, 40).

IMPACT ON THE TOTAL NUMBER OF PATENTS AND TRADEMARKS

In this case, after performing the "two indipendent sample t-test" and the "two-sample Wilcoxon rank-sum test" one can observe a p-value much lower for the second test conducted with a relative statistical difference between the medians of the two samples, in terms of equipment of patents and trademarks, which, however, is not significant since the value of 0.19 is still higher than the treshold value of 0.1 as well as in the case of the first test (data available in Appendix A, Tables 43, 44).

With regard to the variable "ave_high_positions" were found the same statistically not significant results in both the statistical tests carried out with all the three dependent variables taken into account for the measurement of the degree of intellectual property protection of companies. The exact statistical results of the carried out analysis on the variable "ave_high_positions" can be found in the tables (37, 38, 41, 42, 45, 46) in Appendix.

IMPACT ON THE NUMBER OF TOTAL OPEN SOURCE PRODUCTS

In this case the first two tests carried out considering the variable "sum_high_positions" gave the following results:

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	65	3.461538	.4374736	3.527025	2.587585	4.335492
1	38	5	.6788829	4.184915	3.624453	6.375547
combined	103	4.029126	.3779715	3.835991	3.279422	4.778831
diff		-1.538462	.7721758		-3.070251	-.0066725

diff = mean(0) - mean(1) t = -1.9924
Ho: diff = 0 degrees of freedom = 101

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.0245 Pr(|T| > |t|) = 0.0490 Pr(T > t) = 0.9755

Table 20: Two-sample t test; impact of "sum_high_positions" on "num_os_prod"

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

sumhighp~ian	obs	rank sum	expected
0	57	2797.5	2964
1	46	2558.5	2392
combined	103	5356	5356

unadjusted variance 22724.00
adjustment for ties -1019.63
adjusted variance 21704.37

Ho: num_os~d(sumh~ian==0) = num_os~d(sumh~ian==1)
z = -1.130
Prob > |z| = 0.2584

Table 21: Two-sample Wilcoxon-Mann-Whitney test; impact of "sum_high_positions" on "num_os_prod"

One can notice that the "two indipendent sample t-test" 's p-value is lower than 0.1, and this allows us to reject the null hypothesis that the two groups do not differ in terms of media; the same does not applies in terms of median since the p-value of "two-sample Wilcoxon rank-sum test" is greater than the treshold value of 0.1. Performing both tests on alternative variable "ave_high_positions" has been possible to find the same results in terms of the difference of the samples and in terms of statistical relevance for both tests carried out, further robustness signal for the evidence of the results emerging from the above analysis (data available in Appendix A, Tables 47, 48).

IMPACT ON THE OPENNESS

The "Pearson's chi-squared test" carried out between the variables of high position experience and the dummy variable "more_open" returned no statistically relevant results (data available in Appendix B, Tables 9, 10).

Second entrepreneur-specific human capital's variable: number of founded companies

GROUP 1: *-Companies with founders who have started a total number of companies higher than the mean of the sample or greater than the median of the sample:*

- *sum_numcomp_started> 3,16*
- *sum_numcomp_started> 3*

-Companies characterized by an average in the founding team of the total number of companies started among its founders higher than the average of the sample or greater than the median of the sample:

- *"ave_numcomp_started"> 1,54*
- *"ave_numcomp_started" > 1,5*

GROUP 0: *-Companies with founders who have started a total number of companies lower than the mean of the sample or lower than the median of the sample:*

- *sum_numcomp_started < 3,16*
- *sum_numcomp_started < 3*

-Companies characterized by an average in the founding team of the total number of companies started among its founders lower than the average of the sample or lower than the median of the sample:

- *"ave_numcomp_started" < 1,54*
- *"ave_numcomp_started" < 1,5*

IMPACT ON THE TOTAL NUMBER OF PATENTS

To assess this impact has been reported the results of tests carried out by using the variable "ave_numcomp_started":

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	74	19.37838	8.2526	70.99155	2.93097	35.82579
1	29	2.344828	.7382509	3.975603	.8325891	3.857066
combined	103	14.58252	5.969599	60.58482	2.741852	26.4232
diff		17.03355	13.23038		-9.211957	43.27906

diff = mean(0) - mean(1) t = 1.2875
Ho: diff = 0 degrees of freedom = 101

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.8996 Pr(|T| > |t|) = 0.2009 Pr(T > t) = 0.1004

Table 22: Two-sample t test; impact of " ave_numcomp_started " on "num_patents"

This first test although present a p-value greater than 0.1 shows a significant difference in the averages of the two samples. In particular, the "Group 0" has an average endowment of patents greater than the other of more than 14 elements.

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

avecomps~ian	obs	rank sum	expected
0	74	4039	3848
1	29	1317	1508
combined	103	5356	5356

unadjusted variance 18598.67
adjustment for ties -1451.50
adjusted variance 17147.17

Ho: num_pa~s(avec~ian==0) = num_pa~s(avec~ian==1)
z = 1.459
Prob > |z| = 0.1447

Table 23: Two-sample Wilcoxon-Mann-Whitney test; impact of " ave_numcomp_started " on "num_patents"

The "two-sample Wilcoxon rank-sum test," consistently with the first test shows a p-value of 0.14, which therefore does not allow us to reject the null hypothesis that the two groups do not differ in terms of medians. Even in this case, however, it is possible to note by the respective rank sum of the two groups, an endowment of patents greater for the "Group 0". As regards the analysis carried through the variable " sum_numcomp_started"of the impact of number of started companies on the endowments of patents, the results for both tests are

consistent with those reported above in terms of lack of significance, as one can verify from tables 49 and 50 given in the Appendix A.

IMPACT ON THE TOTAL NUMBER OF TRADEMARKS

Even in this case was used the variable "ave_numcomp_started" and the results of the two tests were as follows:

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	74	10.71622	1.902425	16.36528	6.924688	14.50774
1	29	5.068966	.968635	5.216259	3.084807	7.053124
combined	103	9.126214	1.413047	14.34086	6.323441	11.92899
diff		5.647251	3.106913		-.5160285	11.81053

diff = mean(0) - mean(1) t = 1.8176
Ho: diff = 0 degrees of freedom = 101

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.9640 Pr(|T| > |t|) = 0.0721 Pr(T > t) = 0.0360

Table 24: Two-sample t test; impact of " ave_numcomp_started " on "num_trademarks"

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

avecomps~ian	obs	rank sum	expected
0	74	4153.5	3848
1	29	1202.5	1508
combined	103	5356	5356

unadjusted variance 18598.67
adjustment for ties -113.26
adjusted variance 18485.40

Ho: num_tr~s(avec~ian==0) = num_tr~s(avec~ian==1)
z = 2.247
Prob > |z| = 0.0246

Table 25: Two-sample Wilcoxon-Mann-Whitney test; impact of " ave_numcomp_started " on "num_trademarks"

For both tests were detected p-value lower than treshold value of 0.1, meaning that there is statistical evidence that the two groups differ in terms of means and medians and that the null hypothesis can be rejected. So there is statistical evidence that the lower the number of companies started by the founders, the lower endowments of the trademarks of their respective companies. The same statistical evidence was also found in tests using the " sum_numcomp_started", as can be seen from the respective tables 51 and 52 in the Appendix A, thereby increasing the robustness of the hypothesis of our research questions.

IMPACT ON THE TOTAL NUMBER OF PATENTS AND TRADEMARKS

As in the two previous cases we reported the results of the statistical analysis performed by using the variable "ave_numcomp_started". The results of "two indipendent sample t-test" were as follows:

```
. ttest tot_patentstrademarks, by (avecompstmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	74	30.09459	8.809624	75.78325	12.53704	47.65215
1	29	7.413793	1.221238	6.576567	4.912201	9.915385
combined	103	23.70874	6.406314	65.01699	11.00184	36.41563
diff		22.6808	14.13527		-5.359768	50.72137

```
    diff = mean(0) - mean(1)                                      t =   1.6046
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9441         Pr(|T| > |t|) = 0.1117          Pr(T > t) = 0.0559
```

Table 26: Two-sample t test; impact of " ave_numcomp_started " on "tot_patentstrademarks"

The p-value is close to the threshold value of 0.1, but being higher does not allow us to reject the null hypothesis of correspondence of the averages of two samples. Consequently, the statistical evidence of a clear majority in terms of total endowments that the "Group 0" shows relative to the other group is not significant and does not confirm the hypothesis of the research question. On the contrary, however, the "two-sample Wilcoxon rank-sum test" not only confirms this evidence but it is also statistically significant as the p-value is less than 0.1, as can be seen in the next table.

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test

avecomps~ian |       obs    rank sum    expected
-------------+---------------------------------
           0 |        74        4131        3848
           1 |        29        1225        1508
-------------+---------------------------------
    combined |       103        5356        5356

unadjusted variance    18598.67
adjustment for ties      -50.86
                       ---------
adjusted variance      18547.80

Ho: tot_pa~s(avec~ian==0) = tot_pa~s(avec~ian==1)
             z =   2.078
    Prob > |z| =   0.0377
```

Table 27: Two-sample Wilcoxon-Mann-Whitney test; impact of " ave_numcomp_started " on "tot_patentstrademarks"

The same tests performed on the variable " sum_numcomp_started" respectively gave the same results: a p-value equal to 0.69 with a greater endowment for the "Group 0" and a p-value of 0.09 with a greater endowment for the "Group 0" with subsequent statistical support to what previously evinced. The tables 53 and 54 related to these two tests are shown in Appendix A.

IMPACT ON VARIABLES OF THE DEGREE OF OPENESS TO OS: NUMBER OF TOTAL OPEN SOURCE PRODUCTS AND DEGREE OF OPENNESS

For the first dependent variable used as an index of the degree of openness to OS of companies, namely the number of OS products ("num_os_prod") were carried out the same tests viewed up to now, both using the variable "sum_numcomp_started" and the variable "ave_numcomp_started". The results of "two indipendent sample t-test" have ratified the impossibility of being able to reject the null hypothesis of correspondence of the means of the two samples both in the case of the first independent variable and in the case of the second because of the two p-value, both equal to 0.23 and thus higher than the threshold value of 0.1. Also the results of the two "two-sample Wilcoxon rank-sum test" have returned the same outcome of statistical irrelevance of the results being the respective p-value also in this case greater than 0.1. Observing in detail tables 55, 56, 57 and 58 listed in Appendix A will be possible to note that the rank sum of both "two-sample Wilcoxon rank-sum test" carried out, are higher for the "Group 0".

The "Pearson's chi-squared test" carried out between the variables “sum_numcomp_started” and "ave_numcomp_started”, and the dummy variable "more_open" returned no statistically relevant results (data available in Appendix B, Tables 11, 12).

5. Conclusions

In the first part of this last chapter we review the most important results obtained from the statistical analyses performed in this thesis relying on the information and the concepts learned from the theoretical literature. We discuss here the findings and draw our conclusions. At the end we also explore the limitations of this study and future prespectives.

5.1 Research Question 1

What is the effect of the characteristics of generic human capital of the founders of firms with hybrid business model on their degree of openness to OS and on their degree of intellectual property protection?

The first research question has placed us in front of the doubt that factors such as the generic human capital of the founders can or not influence some determinants of the performance of companies with hybrid business models: degree of intellectual property protection and degree of openness to OS. In general, the statistical analysis carried out showed that factors such as the total years of education of the founders or the excellence of education achieved, seem to impact the degree of protection but does not seem to exert any effect on the degree of openness of companies. In particular, we found that the test performed on the dependent variables "Number of patents" and "Total number of patents and trademarks" in function of "education_years" and "edu_years_ave" it show that the endowments of IPP are greater in the case of fewer years of education received in spite of the p-values reported are greater than 0.1. Among the reasons that prevent us to reject the null hypothesis of equality of samples suggested by the high p-value we identify the deficiency of the dataset size. Other reasons can be attributed to the other determinants of the degree of protection that could not be included in the tests, such as the VC funding factor analyzed in the theoretical literature (Mann & Sager, 2006). It has been shown that the venture financing contributes in several ways to the probability that startup firms apply for and get patents; the venture capitalist facilitates patenting by providing funds and by providing management expertise to assist the portfolio firm in the development process. On the other hand patents can solve one of the most difficult problems for a startup: convincing the venture capitalist that the startup can sustainably differentiate itself from its competitors (Mann & Sager, 2006). Another missing exploration

involves the effect of the age of the company since for example in the early stages generally investors point towards product market experience and management acumen as being more pertinent to initial investment decisions rather than on protection mechanisms (Mann, 2005a).

The statistical results obtained on the endowments of trademarks confirm the trend described above for the other two dependent variables but also have statistical significance since the p-value of the "Wilcoxon-Mann-Whitney test" carried out with the variable "edu_years_ave" is equal to 0.1042, allowing us to deduce that fewer years of education provide a higher endowment of trademarks. This can be explained by the fact that, in a context like hybrid firms, groups of individuals with innovative business ideas can be driven to not continue their studies with additional post-graduate specializations but to immediately enter the business world and try to identify as most effective means of protection, at least in the early stages, the trademarks for their own ideas and innovations.

The managerial and entrepreneurial inexperience, also linked to the young age that coincides with a lower level of education, is then filled through the means of intellectual property protection. Trademarks act as a confidence booster for entrepreneurs who wants to capture value from their products (as opposed to finding good partners to commercialize their technology).

The tests carried out using the two variables "edu_excellence1" and "edu_excellence2" confirm and strengthen the latter result related to the endowments of trademarks detected above. In fact, both "Wilcoxon-Mann-Whitney test" performed with the two independent variables have returned p-value lower than 0.1 and showed a very high presence of trademark for the group of companies with lower level of education excellence. Therefore concluding about the intellectual property protection degree it can be argued that there is a clear negative effect of years of education and education excellence achieved on the amount of trademarks hold by a company. On the basis of the foregoing statements and resuming what is present in the theoretical literature (Askoy, Phosphides & Giarratana, 2011) about the ability of software trademarks or patents to positively influence the relationship between a firm's software product portfolio and its value, it is possible to assert that there is a negative indirect effect between the number of years of education and the ability of these companies to increase their value, although of course the determinants of growth of a company can not be circumstantiate only to this effect.

It is interesting to notice that at the same time there is no evidence for low educated entrepreneurs adopting open source strategies. This has disclosed no significant results either

from the point of view of the trustworthiness of the statistical tests, nor from the point of view of the distributions of means and medians of the various tests, contrary to the expectations of a greater openness for companies with founding team quickly entered in the business world and with less time investment in studies. The confirmation of the expectations would have allowed us to assert that those who drop out before the study and who do not opt for further specializations are people more prone to the development and participation in hands-on projects such as those carried out in the open source communities and therefore more prone to start up companies focused on open source products. Neglecting in this type of analysis the other determinants of the degree of openness to OS that the theoretical literature has indicated (Bonaccorsi et al., 2006) can probably be a further reason for the discrepancy between the results and the expected and summarized forecasts of the first research question.

6.2 Research Question 2

What is the effect of the industry-specific human capital of the founders of firms with hybrid business model on their degree of openness to the OS and on their degree of intellectual property protection?

The results of the second research question in general show that years of experience in the same industry of the firm in which founders work do not seem to impact in a statistically relevant way the performance of intellectual property protection and openness to OS of the different companies of our sample.

The only statistical evidence observed in the analysis comes from the two "Wilcoxon-Mann-Whitney test" conducted to assess the existence of an inequality of samples of the independent variables "sum_yearsofexp" and "ave_yearsofexp" with respect to the dependent variable "tot_patentstrademarks". The two p-values, both equal to 0.08, have allowed us to reject the null hypothesis of equality of the samples. We can therefore assert that the group of companies characterized by a founding team with fewer years of experience in the same industry of their company implies an endowment of means of intellectual property protection greater than the endowment of the companies with a more experienced team. Hence in general, despite the statistical means and rank sums of the tests performed on the individual variables "num_patents" and "num_trademarks" give an indication that the equipment are greater in the case of environments with less experience in the specific industry, the only

important empirical result is related to the total endowments. This can be justified by claiming that founders with less years of experience in the field, resulting in less managerial skills, do not naively pay attention in protecting both their OS and proprietary products, but rely on means of protection such as patents and trademarks.

6.3 Research question 3

What is the effect of the entrepreneur-specific human capital of the founders of firms with hybrid business model on their degree of openness to OS and on their degree of intellectual property protection?

The third research question refers to the impact that higher or lower managerial and entrepreneurial experience distinguishing the different founding teams has on firm performance chosen in our study. The first two variables taken into account in assessing the impact of entrepreneur-specific human capital qualify the managerial experience of the founders and they are "sum_high_positions" and "ave_high_positions", respectively. The tests performed on the latter gave no statistical evidence for effects on the variables used as proxies of the intellectual property protection degree, while statistically relevant results have been found when looking for effects on the variables used to denote the degree of openness to OS. In particular, the unique interesting results from the analysis performed on the first three dependent variables are the found differences of rank sum values. For both variables "sum_high_positions" and "ave_high_positions" in fact the equipments of patents, trademarks and the total of the two types is much higher for the groups of companies characterized by a team of founders with a smaller degree of managerial experience, and therefore with a lower number of total senior positions. This may be interpreted assuming that a smaller knowledge gap in terms of managerial skills means an achieved more advanced awareness of what are the methodologies and the ability of individuals to manage and implement the competitiveness of their business with no need of other tools such as intellectual property protection endowments.

The impact of previous managerial experience on the proxy of the degree of openness, using the two "Wilcoxon-Mann-Whitney test", returns a statistical evidence for a positive influence of bigger managerial experience of the founders on the number of OS products of a company. In this case in fact the p-values are lower than the threshold value of 0.1, contrary to the response of the two "independent two sample t-test". This result, however, partially

controverts the expectations previous to this study since one would expect a lower propensity to openness to OS when the more experienced founders were about to start a new business. This is coherent with what we stated above: in presence of a bigger managerial experience there is a reduced equipment of intellectual property protection. After all, one could give a different interpretation to these results in light of the anecdotal evidence of the new corporate policies adopted in respect of OS realm and of OS communities presented in the theoretical literature section. It is today evident that in the recent years more and more companies, recognizing the value and quality of the contributions of the Open Source communities and projects, followed the direction of active and spontaneous participation in these activities sharing the results obtained from the exploitation of OS software. Therefore, the results may be relevant to explain and justify this new trend: leave space in the business to more and more real OS activities horizontally integrated with the corporate ones.

For the second type of independent variables considered as proxies of the entrepreneur-specific human capital, namely "sum_numcomp_started" and "ave_numcomp_started", statistical tests carried out have given specular results to the previous ones with respect to the two performances analyzed for our firms: the degree of protection and the degree of openness. Starting with the latter performance it can be argued that the two tests have not returned empirical evidence about a substantial difference between the compared different samples. The p-values are greater than 0.1 for both tests and for both variables. Despite this finding it is possible to notice a much higher endowment of OS products for companies with a team of founders with less entrepreneurial experience (fewer firms started). This indication is, within the limits of statistical relevance of the two tests, a signal of the fact that if a founder has less business experience will be more oriented towards the creation of a company with hybrid business model rather than a purely proprietary one. This is the typical case of the new young entrepreneurs, who with a broad technical background in software and maybe in the specific of OSS, decide to start a business voted more to an OS model.

Instead, the tests performed on the variables of the degree of protection, have returned the most relevant and statistically robust results of this work. In fact in particular as regards to the number of trademarks owned by firms, all four tests have returned a p-value lower than 0.1. Concerning the total number of patents and trademarks the only null hypothesis of congruence of the samples that has not been refused involved the "two indipendent sample t-test" performed on the variable "sum_numcomp_started". The total number of patents' tests have returned statistical evidence only with the "Wilcoxon-Mann-Whitney test" carried out through the variable "ave_numcomp_started". However, in general and with particular

validity for the trademarks variable, the results obtained indicate that the greater the number of entrepreneurial experiences of the company founding team the lower the endowment of intellectual property protection of the same.

One possible interpretation of such a robust result is the hypothesis that founders with more entrepreneurial experience can take advantage in their future business from the use and exploitation of the technologies covered and protected by patents or trademarks owned by the companies they previously founded. This offers a minor if not zero risk of incurring in litigation with those previous companies. Therefore this would explain in part the reason for the small number of endowments protection for companies whose founders have more business experience. Another explanation may lie in the fact that individuals with entrepreneurial experience, being able to positively impact on business growth and attraction of funding from VC (Colombo & Grilli, 2005) more than the most inexperienced founders, have less need for means of protection of intellectual property. Their experience is fundamental to obtain a high degree of competitiveness in the industry. However this observation conflicts with what is claimed in the theoretical literature. In fact, the general view is that VCs are more likely to be attracted by companies with more equipments for the protection of intellectual property. The meeting point between these theories and our results may lie in the fact that even if it is true that VCs are attracted by the presence of patents, companies with a strong product quality and therefore marketable business ideas valid for VCs must not necessarily be equipped with large portfolios of protection endowments; the companies can instead be characterized by a reduced number of enough valid and strong patents to ensure the degree of protection they need.

6.4 Limitations and Future Endeavors

The analysis presented in this study examines the possibility that the characteristics of the human capital of the founders of NTBFs with hybrid business model affect or not the degree of intellectual property protection and openness to OS of companies. However we faced some limitations related to both the characteristics and the types of data collected. Starting from this assumption in this section we report then proposals for the future development of the topics discussed in this work.

In general, one of the limitations encountered transversely into all analyses, which we also believe to be one of the reasons why many results have not provided statistical significance, is the small size of our dataset. We built the dataset for all the different used variables starting from 127 "hybrid" firms identified in the initial phase of data collection. This number was later, as explained in the data description chapter, reduced to 103 due to the lack of information about some of the companies' founders. To be fair we need to say that the limitations regarding founders are not exclusively to circumscribe to the incompleteness of the dataset, as just stated, but also to the modalities in which the information have been collected. The fact that this research has not been carried through direct interviews or surveys sent to the considered founders prevented the expansion of the types of information collected. In particular it has not been possible to get detailed information about non-professional or professional experience of the founders in the specific context of Open Source. This further information would have allowed us to perform a more detailed analysis of what is the impact of prior experience in the OS realm on the two performance measured in this work. We believe this is one of the reasons that hindered statistically significant results for the variables of the degree of openness. We moreover could get an inverse effect of the experience on the OS specific degree of openness because the founders with a history connected with OS community or projects usually tend to agree and share those values and transfer them to their companies (Bonaccorsi & Rossi, 2006). Therefore the first proposed follow-up is to deepen and complete the dataset in order to be able to make more specific evaluations on the effect of the variables of industry-specific human capital in relation to degree of protection and openness.

Another restriction imposed by the data is the impossibility to exactly determine the kind of nature of the underlying product of patents and trademarks, i.e. to exactly establish whether

they were hardware or software. This limitation did not allow us to be able to make further and more accurate assessments on the same line of study followed by Fosfuri et al., (2008) who were able to advance conclusions on the likelihood of companies to release OSS products depending on the concentration of different software or hardware patents and trademarks within their portfolios of intellectual property protection. Their study claims that the software trademarks, unlike all the other means of protection, are less likely to push companies to release OSS products. We therefore propose to deepen the analysis of the dataset of identified patents and trademarks to understand if the effects of the characteristics of founders act differently also on the degree of protection, depending on whether the equipment is mainly to protect software or hardware products.

A final element we want to leave as a future idea of investigation is the modularity in OS. This argument, which has been treated in the theoretical literature, has offered important insights to respond to the ongoing disputes on the probability that the two business models, proprietary and hybrid, can continue to coexist in the future, or rather may give way to the emergence of only one of the two models. As explained in the theoretical literature, modularity, one of the main feature of the "object-oriented programming" typical of OS projects, legitimate the project of the characteristic of reusability. The modular concept fits well the characteristics of the Open Source production process because it allows the modules to be developed independently from each other, avoiding problems of inefficiency and bottlenecks and favoring to assemble them once completed (Garzarelli & Langlois, 2008). Consequently, if modularity means reusability and so efficiency, it would be interesting to investigate the underlying architecture of the projects for the creation of found products for the sample's companies, and specifically for those made by companies with lower degrees of openness. This would help to understand if, over time, the adoption of techniques for the realization of modular software projects coincides with an increased performance in terms of internal efficiency (reduced costs, set up times of projects , lead time) as well as in terms of performance seen from the outside (time to market). If that's the case, it could be argued that even the companies mostly devoted to make proprietary products could more easily foresee, adopting permanent modular architectural structures which as mentioned above are perfectly adapted to OS projects, the ability to undertake more initiatives addressed to the OS, and thus stimulate an increasingly hybridization of the business.

6.4 Acknowledgments

I would like to thank people who helped me throughout the whole thesis.

To Prof. Colombo and to Prof. Rossi Lamastra for giving me the opportunity to take part in this project trusting in my commitment. Especially, I would like to express my gratitude to Ali Mohammadi for his continuous and patient support and supervision, essential for the realization of this work. To Prof. Anu Wadhwa and to Giovanni Liotta for welcoming me at *College of Management of Technology* (EPFL) and for their helpfulness, kindness and precious advices which contributed to improve this work. To all of them go my sincere thanks for everything they have done.

My undying gratitude is for people who have made this five years one of the best experience of my life. Merz, Olly, Nanni, Teo, Gianlu and all the others mates of this journey, thanks for the support, the friendship and the great fun, I'll never forget YOU.

Moreover to Viviana, Gino and Erminia; to all my unique and extraordinary friends who encouraged me and never made me feel alone despite the whole Italy separating us for nine long-lasting years; to Roy, Sandro, Egidio and Ciuciù for everything.

To my Strength: Assunta e Biagio fot their sacrifice in love; without You I would have never made it. To Mariapia and all my Family for always being with me.

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Appendix A: Tables of statistical analysis

1. First generic human capital's variable: years of education

1.1 IMPACT ON THE TOTAL NUMBER OF PATENTS: tables 1, 2.

```
. ttest num_patents, by (edu_years_avemean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	63	16.4127	8.968987	71.18912	-1.51605	34.34145
1	40	11.7	6.183124	39.10551	-.8065493	24.20655
combined	103	14.58252	5.969599	60.58482	2.741852	26.4232
diff		4.712698	12.30003		-19.68725	29.11265

```
    diff = mean(0) - mean(1)                                      t =   0.3831
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.6488         Pr(|T| > |t|) = 0.7024          Pr(T > t) = 0.3512
```

Table 1

```
. ranksum num_patents, by ( edu_years_avemedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

edu_years_~n	obs	rank sum	expected
0	59	3131	3068
1	44	2225	2288
combined	103	5356	5356

```
unadjusted variance     22498.67
adjustment for ties     -1755.87
                        --------
adjusted variance       20742.80

Ho: num_pa~s(edu_ye~n==0) = num_pa~s(edu_ye~n==1)
              z =   0.437
    Prob > |z| =   0.6618
```

Table 2

1.2 IMPACT ON THE TOTAL NUMBER OF TRADEMARKS: tables 3, 4.

```
Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	63	8.84127	1.062368	8.432285	6.717626	10.96491
1	40	9.575	3.25771	20.60357	2.985659	16.16434
combined	103	9.126214	1.413047	14.34086	6.323441	11.92899
diff		-.7337302	2.912706		-6.511756	5.044295

```
    diff = mean(0) - mean(1)                                      t =  -0.2519
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.4008         Pr(|T| > |t|) = 0.8016          Pr(T > t) = 0.5992
```

Table 3

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

aveeduye~ian	obs	rank sum	expected
0	59	3311	3068
1	44	2045	2288
combined	103	5356	5356

```
unadjusted variance     22498.67
adjustment for ties      -137.02
                        --------
adjusted variance       22361.65

Ho: num_tr~s(avee~ian==0) = num_tr~s(avee~ian==1)
              z =   1.625
    Prob > |z| =   0.1042
```

Table 4

1.3 IMPACT ON THE TOTAL NUMBER OF PATENTS AND TRADEMARKS: tables 5, 6, 7, 8.

```
. ttest tot_patentstrademarks, by (education_yearsmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	57	30.80702	10.78607	81.43302	9.199928	52.41411
1	46	14.91304	5.078593	34.44469	4.684233	25.14185
combined	103	23.70874	6.406314	65.01699	11.00184	36.41563
diff		15.89397	12.85303		-9.602978	41.39093

```
    diff = mean(0) - mean(1)                                      t =   1.2366
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.8904         Pr(|T| > |t|) = 0.2191          Pr(T > t) = 0.1096
```

Table 5

```
. ranksum tot_patentstrademarks , by (education_yearsmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

education_~n	obs	rank sum	expected
0	53	2927.5	2756
1	50	2428.5	2600
combined	103	5356	5356

```
unadjusted variance     22966.67
adjustment for ties       -62.81
                        --------
adjusted variance       22903.86

Ho: tot_pa~s(educat~n==0) = tot_pa~s(educat~n==1)
              z =   1.133
    Prob > |z| =   0.2571
```

Table 6

```
. ttest tot_patentstrademarks , by (edu_years_avemean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	63	25.25397	9.081837	72.08484	7.099635	43.4083
1	40	21.275	8.344428	52.77479	4.396802	38.1532
combined	103	23.70874	6.406314	65.01699	11.00184	36.41563
diff		3.978968	13.20351		-22.21324	30.17118

```
    diff = mean(0) - mean(1)                                      t =   0.3014
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.6181         Pr(|T| > |t|) = 0.7638          Pr(T > t) = 0.3819
```

Table 7

```
. ranksum tot_patentstrademarks, by ( edu_years_avemedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

edu_year~ian	obs	rank sum	expected
0	59	3268	3068
1	44	2088	2288
combined	103	5356	5356

```
unadjusted variance    22498.67
adjustment for ties      -61.53
                       ---------
adjusted variance      22437.14

Ho: tot_pa~s(edu_~ian==0) = tot_pa~s(edu_~ian==1)
             z =   1.335
    Prob > |z| =   0.1818
```

Table 8

1.4 IMPACT ON THE TOTAL NUMBER OF OPEN SOURCE PRODUCTS: tables 9, 10.

```
. ttest num_os_prod, by (edu_years_avemean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	63	4	.5059806	4.016097	2.988559	5.011441
1	40	4.075	.5665771	3.583348	2.92899	5.22101
combined	103	4.029126	.3779715	3.835991	3.279422	4.778831
diff		-.075	.7793193		-1.62096	1.47096

```
    diff = mean(0) - mean(1)                                      t =  -0.0962
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.4618         Pr(|T| > |t|) = 0.9235          Pr(T > t) = 0.5382
```

Table 9

```
. ranksum num_os_prod, by (edu_years_avemedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

edu_year~ian	obs	rank sum	expected
0	59	2980	3068
1	44	2376	2288
combined	103	5356	5356

```
unadjusted variance    22498.67
adjustment for ties    -1009.51
                       ---------
adjusted variance      21489.15

Ho: num_os~d(edu_~ian==0) = num_os~d(edu_~ian==1)
             z =  -0.600
    Prob > |z| =   0.5483
```

Table 10

2. Second generic human capital's variable: excellence of education

2.1 "edu_excellence1"

2.1.1 IMPACT ON THE TOTAL NUMBER OF PATENTS: tables 11, 12.

```
. ttest num_patents, by (edu_excellence1mean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	64	10.26563	6.832362	54.6589	-3.387761	23.91901
1	39	21.66667	11.11298	69.40057	-.8303944	44.16373
combined	103	14.58252	5.969599	60.58482	2.741852	26.4232
diff		-11.40104	12.31586		-35.8324	13.03032

```
    diff = mean(0) - mean(1)                                      t =  -0.9257
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.1784         Pr(|T| > |t|) = 0.3568          Pr(T > t) = 0.8216
```

Table 11

```
. ranksum num_patents, by (edu_excellence1median)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

edu_~1median	obs	rank sum	expected
0	57	3007	2964
1	46	2349	2392
combined	103	5356	5356

```
unadjusted variance    22724.00
adjustment for ties    -1773.46
                       ---------
adjusted variance      20950.54

Ho: num_pa~s(~1median==0) = num_pa~s(~1median==1)
             z =   0.297
    Prob > |z| =   0.7664
```

Table 12

2.1.2 IMPACT ON THE TOTAL NUMBER OF PATENTS AND TRADEMARKS: tables 13, 14.

```
. ttest tot_patentstrademarks , by ( edu_excellencelmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	64	18.85938	7.00729	56.05832	4.856423	32.86233
1	39	31.66667	12.43663	77.66674	6.490021	56.84331
combined	103	23.70874	6.406314	65.01699	11.00184	36.41563
diff		-12.80729	13.21148		-39.01531	13.40073

```
    diff = mean(0) - mean(1)                                      t =  -0.9694
Ho: diff = 0                                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.1673         Pr(|T| > |t|) = 0.3347          Pr(T > t) = 0.8327
```

Table 13

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

excedumedian	obs	rank sum	expected
0	57	3137.5	2964
1	46	2218.5	2392
combined	103	5356	5356

```
unadjusted variance    22724.00
adjustment for ties      -62.14
                       ---------
adjusted variance      22661.86

Ho: tot_pa~s(exce~ian==0) = tot_pa~s(exce~ian==1)
                z =   1.153
    Prob > |z| =   0.2491
```

Table 14

2.1.3 IMPACT ON THE TOTAL NUMBER OF OPEN SOURCE PRODUCTS: tables 15, 16

```
Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	64	3.921875	.4809386	3.847509	2.960796	4.882954
1	39	4.205128	.6181897	3.860594	2.953669	5.456588
combined	103	4.029126	.3779715	3.835991	3.279422	4.778831
diff		-.2832532	.7825856		-1.835693	1.269186

```
    diff = mean(0) - mean(1)                                      t =  -0.3619
Ho: diff = 0                                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.3591         Pr(|T| > |t|) = 0.7181          Pr(T > t) = 0.6409
```

Table 15

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

excedumedian	obs	rank sum	expected
0	57	2898.5	2964
1	46	2457.5	2392
combined	103	5356	5356

```
unadjusted variance    22724.00
adjustment for ties    -1019.63
                       ---------
adjusted variance      21704.37

Ho: num_os~d(exce~ian==0) = num_os~d(exce~ian==1)
                z =  -0.445
    Prob > |z| =   0.6566
```

Table 16

2.2 “edu_excellence2”

2.2.1 IMPACT ON THE TOTAL NUMBER OF PATENTS: tables 17, 18.

```
. ttest num_patents, by (edu_excellence2mean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	64	10.26563	6.832362	54.6589	-3.387761	23.91901
1	39	21.66667	11.11298	69.40057	-.8303944	44.16373
combined	103	14.58252	5.969599	60.58482	2.741852	26.4232
diff		-11.40104	12.31586		-35.8324	13.03032

```
    diff = mean(0) - mean(1)                                      t =  -0.9257
Ho: diff = 0                                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.1784         Pr(|T| > |t|) = 0.3568          Pr(T > t) = 0.8216
```

Table 17

```
. ranksum num_patents, by (edu_excellence2median)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

edu_~2median	obs	rank sum	expected
0	57	2953	2964
1	46	2403	2392
combined	103	5356	5356

```
unadjusted variance    22724.00
adjustment for ties    -1773.46
                       ---------
adjusted variance      20950.54

Ho: num_pa~s(~2median==0) = num_pa~s(~2median==1)
                z =  -0.076
    Prob > |z| =   0.9394
```

Table 18

2.2.2 IMPACT ON THE TOTAL NUMBER OF TRADEMARKS: tables 19, 20.

```
. ttest num_trademarks, by ( edu_excellence2mean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	64	8.546875	1.063912	8.511299	6.420816	10.67293
1	39	10.07692	3.322191	20.74708	3.351498	16.80235
combined	103	9.126214	1.413047	14.34086	6.323441	11.92899
diff		-1.530048	2.923634		-7.329751	4.269655

```
    diff = mean(0) - mean(1)                                      t =  -0.5233
Ho: diff = 0                                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.3009         Pr(|T| > |t|) = 0.6019          Pr(T > t) = 0.6991
```

Table 19

```
. ranksum num_trademarks, by ( edu_excellence2median)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

edu_~2median	obs	rank sum	expected
0	57	3221	2964
1	46	2135	2392
combined	103	5356	5356

```
unadjusted variance    22724.00
adjustment for ties     -138.39
                       ---------
adjusted variance      22585.61

Ho: num_tr~s(~2median==0) = num_tr~s(~2median==1)
           z =   1.710
    Prob > |z| =   0.0873
```

Table 20

2.2.3 IMPACT ON THE TOTAL NUMBER OF PATENTS AND TRADEMARKS: tables 21, 22.

```
. ttest tot_patentstrademarks , by ( edu_excellence2mean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	64	18.8125	7.008918	56.07135	4.806294	32.81871
1	39	31.74359	12.43204	77.63807	6.57624	56.91094
combined	103	23.70874	6.406314	65.01699	11.00184	36.41563
diff		-12.93109	13.21029		-39.13674	13.27456

```
    diff = mean(0) - mean(1)                                      t =  -0.9789
Ho: diff = 0                                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.1650         Pr(|T| > |t|) = 0.3300          Pr(T > t) = 0.8350
```

Table 21

```
. ranksum tot_patentstrademarks , by ( edu_excellence2median)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

edu_~2median	obs	rank sum	expected
0	57	3116	2964
1	46	2240	2392
combined	103	5356	5356

```
unadjusted variance    22724.00
adjustment for ties      -62.14
                       ---------
adjusted variance      22661.86

Ho: tot_pa~s(~2median==0) = tot_pa~s(~2median==1)
           z =   1.010
    Prob > |z| =   0.3126
```

Table 22

2.2.4 IMPACT ON THE TOTAL NUMBER OF OPEN SOURCE PRODUCTS: 23, 24

```
. ttest num_os_prod , by ( edu_excellence2mean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	64	3.9375	.4812326	3.849861	2.975833	4.899167
1	39	4.179487	.6178538	3.858496	2.928708	5.430267
combined	103	4.029126	.3779715	3.835991	3.279422	4.778831
diff		-.2419872	.7827227		-1.794699	1.310724

```
    diff = mean(0) - mean(1)                                      t =  -0.3092
Ho: diff = 0                                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.3789         Pr(|T| > |t|) = 0.7578          Pr(T > t) = 0.6211
```

Table 23

```
. ranksum num_os_prod , by ( edu_excellence2median)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

edu_~2median	obs	rank sum	expected
0	57	2862.5	2964
1	46	2493.5	2392
combined	103	5356	5356

```
unadjusted variance    22724.00
adjustment for ties    -1019.63
                       ---------
adjusted variance      21704.37

Ho: num_os~d(~2median==0) = num_os~d(~2median==1)
           z =  -0.689
    Prob > |z| =   0.4909
```

Table 24

3. Industry-specific human capital's variable: years of experience

3.1 IMPACT ON THE TOTAL NUMBER OF PATENTS: tables 25, 26.

```
. ttest num_patents, by (ave_yearsofexpmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	63	18.15873	9.144967	72.58592	-.121798	36.43926
1	40	8.95	5.40998	34.21572	-1.992718	19.89272
combined	103	14.58252	5.969599	60.58482	2.741852	26.4232
diff		9.20873	12.27481		-15.1412	33.55866

```
    diff = mean(0) - mean(1)                                      t =   0.7502
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.7726         Pr(|T| > |t|) = 0.4549          Pr(T > t) = 0.2274
```

Table 25

```
. ranksum num_patents, by (ave_yearsofexpmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

ave_year~ian	obs	rank sum	expected
0	52	2875.5	2704
1	51	2480.5	2652
combined	103	5356	5356

```
unadjusted variance    22984.00
adjustment for ties    -1793.75
                       ---------
adjusted variance      21190.25

Ho: num_pa~s(ave_~ian==0) = num_pa~s(ave_~ian==1)
             z =   1.178
    Prob > |z| =   0.2387
```

Table 26

3.2 IMPACT ON THE TOTAL NUMBER OF TRADEMARKS: tables 27, 28.

```
. ttest num_trademarks, by (ave_yearsofexpmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	63	9.666667	2.12319	16.8523	5.42247	13.91086
1	40	8.275	1.459271	9.229239	5.323346	11.22665
combined	103	9.126214	1.413047	14.34086	6.323441	11.92899
diff		1.391667	2.910328		-4.381642	7.164976

```
    diff = mean(0) - mean(1)                                      t =   0.4782
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.6832         Pr(|T| > |t|) = 0.6336          Pr(T > t) = 0.3168
```

Table 27

```
. ranksum num_trademarks , by (ave_yearsofexpmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

ave_year~ian	obs	rank sum	expected
0	52	2886.5	2704
1	51	2469.5	2652
combined	103	5356	5356

```
unadjusted variance    22984.00
adjustment for ties     -139.97
                       ---------
adjusted variance      22844.03

Ho: num_tr~s(ave_~ian==0) = num_tr~s(ave_~ian==1)
             z =   1.207
    Prob > |z| =   0.2273
```

Table 28

3.3 IMPACT ON THE TOTAL NUMBER OF PATENTS AND TRADEMARKS: tables 29, 30.

```
. ttest tot_patentstrademarks , by (ave_yearsofexpmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	63	27.8254	9.807741	77.84653	8.220003	47.43079
1	40	17.225	5.812287	36.76013	5.468541	28.98146
combined	103	23.70874	6.406314	65.01699	11.00184	36.41563
diff		10.6004	13.16727		-15.51992	36.72071

```
    diff = mean(0) - mean(1)                                      t =   0.8051
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.7887         Pr(|T| > |t|) = 0.4227          Pr(T > t) = 0.2113
```

Table 29

```
. ranksum tot_patentstrademarks, by (ave_yearsofexpmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

ave_year~ian	obs	rank sum	expected
0	52	2966	2704
1	51	2390	2652
combined	103	5356	5356

```
unadjusted variance    22984.00
adjustment for ties      -62.85
                       ---------
adjusted variance      22921.15

Ho: tot_pa~s(ave_~ian==0) = tot_pa~s(ave_~ian==1)
             z =   1.731
    Prob > |z| =   0.0835
```

Table 30

3.4 IMPACT ON THE TOTAL NUMBER OF OPEN SOURCE PRODUCTS: tables 31, 32, 33, 34.

```
. ttest num_os_prod, by (sum_yearsofexpmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	63	4	.5184758	4.115274	2.963582	5.036418
1	40	4.075	.5375484	3.399755	2.987706	5.162294
combined	103	4.029126	.3779715	3.835991	3.279422	4.778831
diff		-.075	.7793193		-1.62096	1.47096

```
    diff = mean(0) - mean(1)                                      t =  -0.0962
Ho: diff = 0                                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.4618         Pr(|T| > |t|) = 0.9235          Pr(T > t) = 0.5382
```

Table 31

```
. ranksum num_os_prod, by ( sum_yearsofexpmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

sum_year~ian	obs	rank sum	expected
0	52	2597	2704
1	51	2759	2652
combined	103	5356	5356

```
unadjusted variance     22984.00
adjustment for ties     -1031.29
                        ---------
adjusted variance       21952.71

Ho: num_os~d(sum_~ian==0) = num_os~d(sum_~ian==1)
             z =  -0.722
    Prob > |z| =   0.4702
```

Table 32

```
. ttest num_os_prod , by (ave_yearsofexpmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	63	4	.5184758	4.115274	2.963582	5.036418
1	40	4.075	.5375484	3.399755	2.987706	5.162294
combined	103	4.029126	.3779715	3.835991	3.279422	4.778831
diff		-.075	.7793193		-1.62096	1.47096

```
    diff = mean(0) - mean(1)                                      t =  -0.0962
Ho: diff = 0                                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.4618         Pr(|T| > |t|) = 0.9235          Pr(T > t) = 0.5382
```

Table 33

```
.  ranksum num_os_prod , by (ave_yearsofexpmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

ave_year~ian	obs	rank sum	expected
0	52	2597	2704
1	51	2759	2652
combined	103	5356	5356

```
unadjusted variance     22984.00
adjustment for ties     -1031.29
                        ---------
adjusted variance       21952.71

Ho: num_os~d(ave_~ian==0) = num_os~d(ave_~ian==1)
             z =  -0.722
    Prob > |z| =   0.4702
```

Table 34

4. First entrepreneur-specific human capital's variable : high position experiences

4.1 IMPACT ON THE TOTAL NUMBER OF PATENTS: tables 35, 36, 37, 38.

```
. ttest num_patents, by (sum_high_positionsmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	65	15.73846	8.701577	70.15436	-1.644937	33.12186
1	38	12.60526	6.487381	39.9909	-.5394199	25.74995
combined	103	14.58252	5.969599	60.58482	2.741852	26.4232
diff		3.133198	12.42902		-21.52263	27.78902

```
    diff = mean(0) - mean(1)                                      t =   0.2521
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.5993         Pr(|T| > |t|) = 0.8015          Pr(T > t) = 0.4007
```

Table 35

```
. ranksum num_patents, by (sum_high_positionsmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

sum_high~ian	obs	rank sum	expected
0	57	3091	2964
1	46	2265	2392
combined	103	5356	5356

```
unadjusted variance     22724.00
adjustment for ties     -1773.46
                        ---------
adjusted variance       20950.54

Ho: num_pa~s(sum_~ian==0) = num_pa~s(sum_~ian==1)
             z =   0.877
    Prob > |z| =   0.3803
```

Table 36

```
. ttest num_patents, by (ave_high_positionsmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	65	15.73846	8.701577	70.15436	-1.644937	33.12186
1	38	12.60526	6.487381	39.9909	-.5394199	25.74995
combined	103	14.58252	5.969599	60.58482	2.741852	26.4232
diff		3.133198	12.42902		-21.52263	27.78902

```
    diff = mean(0) - mean(1)                                      t =   0.2521
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.5993         Pr(|T| > |t|) = 0.8015          Pr(T > t) = 0.4007
```

Table 37

```
. ranksum num_patents, by (ave_high_positionsmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

ave_high~ian	obs	rank sum	expected
0	57	3091	2964
1	46	2265	2392
combined	103	5356	5356

```
unadjusted variance     22724.00
adjustment for ties     -1773.46
                        ---------
adjusted variance       20950.54

Ho: num_pa~s(ave_~ian==0) = num_pa~s(ave_~ian==1)
             z =   0.877
    Prob > |z| =   0.3803
```

Table 38

4.2 IMPACT ON THE TOTAL NUMBER OF TRADEMARKS: tables 39, 40, 41, 42.

```
. ttest num_trademarks, by (sum_high_positionsmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	65	8.292308	1.024161	8.257048	6.246311	10.3383
1	38	10.55263	3.424806	21.11192	3.613315	17.49195
combined	103	9.126214	1.413047	14.34086	6.323441	11.92899
diff		-2.260324	2.934357		-8.081298	3.56065

```
    diff = mean(0) - mean(1)                                      t =  -0.7703
Ho: diff = 0                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.2215         Pr(|T| > |t|) = 0.4429          Pr(T > t) = 0.7785
```

Table 39

```
. ranksum num_trademarks, by (sum_high_positionsmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

sum_high~ian	obs	rank sum	expected
0	57	3125.5	2964
1	46	2230.5	2392
combined	103	5356	5356

```
unadjusted variance     22724.00
adjustment for ties      -138.39
                        ---------
adjusted variance       22585.61

Ho: num_tr~s(sum_~ian==0) = num_tr~s(sum_~ian==1)
             z =   1.075
    Prob > |z| =   0.2825
```

Table 40

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	65	8.292308	1.024161	8.257048	6.246311	10.3383
1	38	10.55263	3.424806	21.11192	3.613315	17.49195
combined	103	9.126214	1.413047	14.34086	6.323441	11.92899
diff		-2.260324	2.934357		-8.081298	3.56065

diff = mean(0) - mean(1) t = -0.7703
Ho: diff = 0 degrees of freedom = 101

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.2215 Pr(|T| > |t|) = 0.4429 Pr(T > t) = 0.7785

Table 41

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

sumhighp~ian	obs	rank sum	expected
0	57	3125.5	2964
1	46	2230.5	2392
combined	103	5356	5356

unadjusted variance 22724.00
adjustment for ties -138.39
adjusted variance 22585.61

Ho: num_tr~s(sumh~ian==0) = num_tr~s(sumh~ian==1)
z = 1.075
Prob > |z| = 0.2825

Table 42

4.3 IMPACT ON THE TOTAL NUMBER OF PATENTS AND TRADEMARKS: tables 43, 44, 45, 46.

. ttest tot_patentstrademarks , by (sum_high_positionsmean)

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	65	24.03077	8.823918	71.1407	6.402967	41.65857
1	38	23.15789	8.73398	53.83987	5.461171	40.85462
combined	103	23.70874	6.406314	65.01699	11.00184	36.41563
diff		.8728745	13.34219		-25.59444	27.34019

diff = mean(0) - mean(1) t = 0.0654
Ho: diff = 0 degrees of freedom = 101

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.5260 Pr(|T| > |t|) = 0.9480 Pr(T > t) = 0.4740

Table 43

. ranksum tot_patentstrademarks , by (sum_high_positionsmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

sum_high~ian	obs	rank sum	expected
0	57	3158.5	2964
1	46	2197.5	2392
combined	103	5356	5356

unadjusted variance 22724.00
adjustment for ties -62.14
adjusted variance 22661.86

Ho: tot_pa~s(sum_~ian==0) = tot_pa~s(sum_~ian==1)
z = 1.292
Prob > |z| = 0.1963

Table 44

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	65	24.03077	8.823918	71.1407	6.402967	41.65857
1	38	23.15789	8.73398	53.83987	5.461171	40.85462
combined	103	23.70874	6.406314	65.01699	11.00184	36.41563
diff		.8728745	13.34219		-25.59444	27.34019

diff = mean(0) - mean(1) t = 0.0654
Ho: diff = 0 degrees of freedom = 101

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.5260 Pr(|T| > |t|) = 0.9480 Pr(T > t) = 0.4740

Table 45

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

sumhighp~ian	obs	rank sum	expected
0	57	3158.5	2964
1	46	2197.5	2392
combined	103	5356	5356

unadjusted variance 22724.00
adjustment for ties -62.14
adjusted variance 22661.86

Ho: tot_pa~s(sumh~ian==0) = tot_pa~s(sumh~ian==1)
z = 1.292
Prob > |z| = 0.1963

Table 46

4.3 IMPACT ON THE TOTAL NUMBER OF OPEN SOURCE PRODUCTS: tables 47, 48.

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	65	3.461538	.4374736	3.527025	2.587585	4.335492
1	38	5	.6788829	4.184915	3.624453	6.375547
combined	103	4.029126	.3779715	3.835991	3.279422	4.778831
diff		-1.538462	.7721758		-3.070251	-.0066725

diff = mean(0) - mean(1) t = -1.9924
Ho: diff = 0 degrees of freedom = 101

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.0245 Pr(|T| > |t|) = 0.0490 Pr(T > t) = 0.9755

Table 47

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

avehighp~ian	obs	rank sum	expected
0	57	2797.5	2964
1	46	2558.5	2392
combined	103	5356	5356

unadjusted variance 22724.00
adjustment for ties -1019.63
adjusted variance 21704.37

Ho: num_os~d(aveh~ian==0) = num_os~d(aveh~ian==1)
z = -1.130
Prob > |z| = 0.2584

Table 48

5. Second entrepreneur-specific human capital's variable: number of founded companies

5.1 IMPACT ON THE TOTAL NUMBER OF PATENTS: tables 49, 50.

. ttest num_patents, by (sumcompstmean)

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	73	14.58904	6.813392	58.21365	1.006792	28.17129
1	30	14.56667	12.24263	67.05566	-10.47233	39.60566
combined	103	14.58252	5.969599	60.58482	2.741852	26.4232
diff		.0223744	13.20382		-26.17046	26.21521

diff = mean(0) - mean(1) t = 0.0017
Ho: diff = 0 degrees of freedom = 101

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.5007 Pr(|T| > |t|) = 0.9987 Pr(T > t) = 0.4993

Table 49

. ranksum num_patents, by (sumcompstmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

sumcomps~ian	obs	rank sum	expected
0	73	3937	3796
1	30	1419	1560
combined	103	5356	5356

unadjusted variance 18980.00
adjustment for ties -1481.26
adjusted variance 17498.74

Ho: num_pa~s(sumc~ian==0) = num_pa~s(sumc~ian==1)
z = 1.066
Prob > |z| = 0.2865

Table 50

5.2 IMPACT ON THE TOTAL NUMBER OF TRADEMARKS: tables 51, 52.

```
. ttest num_trademarks, by (sumcompstmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	73	10.76712	1.927976	16.47264	6.923773	14.61047
1	30	5.133333	.9380015	5.137646	3.214905	7.051762
combined	103	9.126214	1.413047	14.34086	6.323441	11.92899
diff		5.63379	3.074756		-.4656996	11.73328

```
    diff = mean(0) - mean(1)                                      t =   1.8323
Ho: diff = 0                                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9651         Pr(|T| > |t|) = 0.0699          Pr(T > t) = 0.0349
```

Table 51

```
. ranksum num_trademarks, by (sumcompstmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

sumcomps~ian	obs	rank sum	expected
0	73	4086.5	3796
1	30	1269.5	1560
combined	103	5356	5356

```
unadjusted variance     18980.00
adjustment for ties      -115.59
                        ---------
adjusted variance       18864.41

Ho: num_tr~s(sumc~ian==0) = num_tr~s(sumc~ian==1)
             z =   2.115
    Prob > |z| =   0.0344
```

Table 52

```
. ttest tot_patentstrademarks, by (sumcompstmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	73	25.35616	7.529202	64.32953	10.34698	40.36535
1	30	19.7	12.34273	67.60389	-5.543708	44.94371
combined	103	23.70874	6.406314	65.01699	11.00184	36.41563
diff		5.656164	14.15859		-22.43067	33.74299

```
    diff = mean(0) - mean(1)                                      t =   0.3995
Ho: diff = 0                                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.6548         Pr(|T| > |t|) = 0.6904          Pr(T > t) = 0.3452
```

Table 53

```
. ranksum tot_patentstrademarks, by (sumcompstmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

sumcomps~ian	obs	rank sum	expected
0	73	4029	3796
1	30	1327	1560
combined	103	5356	5356

```
unadjusted variance     18980.00
adjustment for ties       -51.90
                        ---------
adjusted variance       18928.10

Ho: tot_pa~s(sumc~ian==0) = tot_pa~s(sumc~ian==1)
             z =   1.694
    Prob > |z| =   0.0903
```

Table 54

5.3 IMPACT ON THE TOTAL NUMBER OF OPEN SOURCE PRODUCTS: tables 55, 56, 57, 58.

```
. ttest num_os_prod, by (sumcompstmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	73	4.315068	.477371	4.07866	3.363447	5.26669
1	30	3.333333	.5700037	3.122039	2.167545	4.499122
combined	103	4.029126	.3779715	3.835991	3.279422	4.778831
diff		.9817352	.8302872		-.6653313	2.628802

```
    diff = mean(0) - mean(1)                                      t =   1.1824
Ho: diff = 0                                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.8801         Pr(|T| > |t|) = 0.2398          Pr(T > t) = 0.1199
```

Table 55

```
. ranksum num_os_prod, by (sumcompstmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

sumcomps~ian	obs	rank sum	expected
0	73	3951.5	3796
1	30	1404.5	1560
combined	103	5356	5356

```
unadjusted variance     18980.00
adjustment for ties      -851.63
                        ---------
adjusted variance       18128.37

Ho: num_os~d(sumc~ian==0) = num_os~d(sumc~ian==1)
             z =   1.155
    Prob > |z| =   0.2481
```

Table 56

```
. ttest num_os_prod, by (avecompstmean)

Two-sample t test with equal variances
```

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	74	4.310811	.4708951	4.050793	3.372318	5.249303
1	29	3.310345	.5895298	3.174715	2.102748	4.517942
combined	103	4.029126	.3779715	3.835991	3.279422	4.778831
diff		1.000466	.8386533		-.6631966	2.664129

```
    diff = mean(0) - mean(1)                                      t =   1.1929
Ho: diff = 0                                     degrees of freedom =      101

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.8822         Pr(|T| > |t|) = 0.2357          Pr(T > t) = 0.1178
```

Table 57

```
. ranksum num_os_prod, by (avecompstmedian)

Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

avecomps~ian	obs	rank sum	expected
0	74	4015	3848
1	29	1341	1508
combined	103	5356	5356

```
unadjusted variance    18598.67
adjustment for ties     -834.52
                       ---------
adjusted variance      17764.15

Ho: num_os~d(avec~ian==0) = num_os~d(avec~ian==1)
              z =   1.253
    Prob > |z| =   0.2102
```

Table 58

Appendix B: Tables of statistical analysis (Impact on the openness)

1. First generic human capital's variable: years of education

1.1 "education_years"

```
gen sumeduyearsmean=0
replace sumeduyearsmean=1 if education_years>14.38

. tab more_open sumeduyearsmean, ch
```

MORE_OPEN	sumeduyearsmean 0	1	Total
0	28	16	44
1	29	30	59
Total	57	46	103

Pearson chi2(1) = 2.1393 Pr = 0.144

Table 1

```
gen sumeduyearsmedian=0
replace sumeduyearsmedian=1 if education_years>12

. tab more_open sumeduyearsmedian, ch
```

MORE_OPEN	sumeduyearsmedian 0	1	Total
0	25	19	44
1	28	31	59
Total	53	50	103

Pearson chi2(1) = 0.8841 Pr = 0.347

Table 2

1.2 "edu_years_ave"

```
gen aveeduyearsmean =0
aveeduyearsmean=1 if edu_years_ave>8.74

. tab more_open aveeduyearsmean, ch
```

MORE_OPEN	aveeduyearsmean 0	1	Total
0	28	16	44
1	35	24	59
Total	63	40	103

Pearson chi2(1) = 0.1975 Pr = 0.657

Table 3

```
gen aveeduyearsmean =0
replace aveeduyearsmedian=1 if edu_years_ave>8

. tab more_open  aveeduyearsmedian, ch
```

MORE_OPEN	aveeduyearsmedian 0	1	Total
0	27	17	44
1	32	27	59
Total	59	44	103

Pearson chi2(1) = 0.5231 Pr = 0.470

Table 4

2. Second generic human capital's variable: excellence of education

2.1 "edu_excellence1"

```
gen edu_excellence1mean =0
replace edu_excellence1mean =1 if edu_excellence1>751.45
```

```
. tab more_open edu_excellence1mean, ch
```

MORE_OPEN	edu_excellence1mean 0	1	Total
0	28	16	44
1	36	23	59
Total	64	39	103

Pearson chi2(1) = 0.0735 Pr = 0.786

Table 5

```
gen edu_excellence1median=0
replace edu_excellence1median=1 if edu_excellence1>600
```

```
. tab more_open edu_excellence1median, ch
```

MORE_OPEN	edu_excellence1median 0	1	Total
0	26	18	44
1	31	28	59
Total	57	46	103

Pearson chi2(1) = 0.4373 Pr = 0.508

Table 6

2.1 "edu_excellence2"

```
gen edu_excellence2mean =0
replace edu_excellence2mean =1 if edu_excellence2>684.78
```

```
. tab more_open edu_excellence2mean, ch
```

MORE_OPEN	edu_excellence2mean 0	1	Total
0	28	16	44
1	36	23	59
Total	64	39	103

Pearson chi2(1) = 0.0735 Pr = 0.786

Table 7

```
gen edu_excellence2median=0
replace edu_excellence2median=1 if edu_excellence2>500
```

```
. tab more_open edu_excellence2median, ch
```

MORE_OPEN	edu_excellence2median 0	1	Total
0	25	19	44
1	32	27	59
Total	57	46	103

Pearson chi2(1) = 0.0679 Pr = 0.794

Table 8

3. Industry-specific human capital's variable: years of experience

3.1 "sum_yearsofexpmean"

```
gen sum_yearsofexpmean=0
replace sum_yearsofexpmean =1 if sum_yearsofexpmean>33.92
```

```
. tab more_open sum_yearsofexpmean, ch
```

MORE_OPEN	sum_yearsofexpmean 0	1	Total
0	27	17	44
1	36	23	59
Total	63	40	103

Pearson chi2(1) = 0.0013 Pr = 0.972

Table 9

```
gen sum_yearsofexpmedian =0
replace sum_yearsofexpmedian =1 if sum_yearsofexp>30
```

```
. tab more_open sum_yearsofexpmedian, ch
```

MORE_OPEN	sum_yearsofexpmedian 0	1	Total
0	24	20	44
1	28	31	59
Total	52	51	103

Pearson chi2(1) = 0.5065 Pr = 0.477

Table 10

3.2 "ave_yearsofexp"

MORE OPEN vs AVERAGE years of EXPERIENCE

gen ave_yearsofexpmean =0
replace ave_yearsofexpmean =1 if ave_yearsofexp>16.96

. tab more_open ave_yearsofexpmean, ch

MORE_OPEN	ave_yearsofexpmean 0	1	Total
0	27	17	44
1	36	23	59
Total	63	40	103

Pearson chi2(1) = 0.0013 Pr = 0.972

Table 11

ave_yearsofexpmedian=0
replace sum_ ave_yearsofexpmedian=1 if ave_yearsofexp>15

. tab more_open ave_yearsofexpmedian, ch

MORE_OPEN	ave_yearsofexpmedian 0	1	Total
0	24	20	44
1	28	31	59
Total	52	51	103

Pearson chi2(1) = 0.5065 Pr = 0.477

Table 12

4. First entrepreneur-specific human capital's variable : high position experience

4.1 "sum_high_positions"

gen sum_high_positionsmean=0
replace sum_high_positionsmea =1 if sum_high_positions>7.29

. tab more_open sum_high_positionsmean, ch

MORE_OPEN	sum_high_positionsmea n 0	1	Total
0	29	15	44
1	36	23	59
Total	65	38	103

Pearson chi2(1) = 0.2591 Pr = 0.611

Table 13

sum_high_positionsmedian=0
replace sum_high_positionsmedian=1 if sum_high_positions>6

. tab more_open sum_high_positionsmedian, ch

MORE_OPEN	sum_high_positionsmed ian 0	1	Total
0	24	20	44
1	33	26	59
Total	57	46	103

Pearson chi2(1) = 0.0196 Pr = 0.889

Table 14

4.2 "ave_high_positions"

gen ave_high_positionsmean=0
replace ave_high_positionsmea =1 if ave_high_positions>7.29

. tab more_open ave_high_positionsmean, ch

MORE_OPEN	ave_high_positionsmea n 0	1	Total
0	29	15	44
1	36	23	59
Total	65	38	103

Pearson chi2(1) = 0.2591 Pr = 0.611

Table 15

ave_high_positionsmedian=0
replace ave_high_positionsmedian=1 if ave_high_positions>6

. tab more_open ave_high_positionsmedian, ch

MORE_OPEN	ave_high_positionsmed ian 0	1	Total
0	24	20	44
1	33	26	59
Total	57	46	103

Pearson chi2(1) = 0.0196 Pr = 0.889

Table 16

5. Second entrepreneur-specific human capital's variable: number of founded companies

5.1 "sum_numcomp_started"

gen sum_numcomp_startedmean=0
replace sum_numcomp_startedmean=1 if sum_numcomp_started>3.16

```
. tab more_open sum_numcomp_startedmean, ch
```

MORE_OPEN	sum_numcomp_startedmean 0	1	Total
0	30	14	44
1	43	16	59
Total	73	30	103

Pearson chi2(1) = 0.2697 Pr = 0.604

Table 17

gen sum_numcomp_startedmedian=0
replace sum_numcomp_startedmedian =1 if sum_numcomp_started>3

```
. tab more_open sum_numcomp_startedmedian, ch
```

MORE_OPEN	sum_numcomp_startedmedian 0	1	Total
0	30	14	44
1	43	16	59
Total	73	30	103

Pearson chi2(1) = 0.2697 Pr = 0.604

Table 18

5.2 "ave_numcomp_started"

gen ave_numcomp_startedmean =0
replace ave_numcomp_startedmean =1 if ave_numcomp_started >1.54

```
. tab more_open ave_numcomp_startedmean, ch
```

MORE_OPEN	ave_numcomp_startedmean 0	1	Total
0	31	13	44
1	43	16	59
Total	74	29	103

Pearson chi2(1) = 0.0734 Pr = 0.786

Table 19

gen ave_numcomp_startedmedian =0
replace ave_numcomp_startedmedian =1 if ave_numcomp_started >1.5

```
. tab more_open ave_numcomp_startedmedian, ch
```

MORE_OPEN	ave_numcomp_startedmedian 0	1	Total
0	31	13	44
1	43	16	59
Total	74	29	103

Pearson chi2(1) = 0.0734 Pr = 0.786

Table 20