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Entry, Survival and Growth in a New Market.
The Case of the Encryption Software Industry.

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Entry, Survival and Growth in a New Market. The Case of the Encryption Software Industry

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Abstract

This paper analyzes the birth of the Encryption Software Industry (ESI), a new market niche in the software industry.

This paper will focus on the process of entry and exit into this new market niche by new venture formation. Moreover, this paper will study the firm post–entry performance, describing the different phases of competition during the industry evolution and the strategic responses of main actors.

ESI represents an interesting case study. It originated during the mid–1970s when market opportunities, arising from the military sector, spurred established electronic firms like IBM and Motorola to accumulate knowledge in encryption software technology. Empirical evidence shows that years later, despite their early entry into the technological race, the large firms waited to enter into the civilian market, leaving new comers to dominate the product market for this fast growing demand.

In order to analyze ESI development, we have collected a wide series of data on introduction of products, patents granted by the US Patent Office, worldwide alliances in the sector and some biographical data about founders of startups and their executives.

With a descriptive approach, this paper aims to show how size is an important determinant of firm ability to survive in young and competitive industries. Notwithstanding, size is not an exogenous variable being strongly affected by a firm's technological, strategical and organizational capabilities, that should be fine–tuned according to the principles of coherence and dynamic competition.

Keywords: Entry, entrepreneurship, innovation, software
JEL: M13, L86, O32

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1 Introduction

1.1 Research guidelines

This paper aims to analyze the evolution of industry structure and innovation in the case of Encryption Software Industry (ESI). The paper is focused on the patterns of development of a new market, where new startups, and not large incumbents, exploit first business opportunities, founding its technological competencies on previous research improvements. In this sense, the history of the ESI can be described by the study of small startups dynamics.

Standard literature (Churchill and Lewis 1983) (Kazanjian 1988) (Mitra and Pingali 1999) usually studies small businesses along their different stages of evolution, according to the peculiar problems faced and the strategic competencies required during each phase.

This "stages" approach was criticized (Dodge, Fullerton and Robbins 1994) because it simplifies excessively the study of small business phenomenon, ignoring the important peculiarities of each firm. Notwithstanding, trying to avoid rough generalizations, we opt to give our paper this structure, because it remains the most used and valid approach on this topic. Thus, we divide the study of ESI according to different phases of firm evolution: entry, survival and growth.

In fact, authors (Zacharakis, Meyer and DeCastro 1999) (Hanks and Chandler 1994) (Olson 1987) have long stressed that, after entry occurred, the capabilities that allow firms to survive in the first place are completely different from those yielding firm growth. This makes essential separating the description of the stages, in order to give the more logical and useful comprehension of industry stylized facts. Following this view, first we analyze the entry and survival in ESI, and then the firm growth and late competition patterns. The paper is organized in the following sections: after a brief introduction on industry history, in section 2 we focus on entry and survival phenomenon in ESI, analyzing the environment, the products, the entrepreneurs and the organizations. Section 3 will highlight the process of firm post–entry growth and performance, according to the rate of product differentiation, geographic expansion and organizational changes. In the section 4 we will summarize the late industry competitive forces and challenges.

1.2 Industry history and facts

The early stages of ESI date back to the mid–1970s and the beginning of the 1980s, when US Government financed military projects linked strictly to the security of data transmission. Large ICT firms awarded these types of contracts and worked actively on software security architectures. At this stage, university departments, especially at Stanford and MIT, and government agencies also played a major role.

Some firms, such as Philips, NEC, Pioneer, were also involved in the design of the bulk of first cable TV sets, that included the encryption and the decryption of cable signals through TV decoders. This is also evident from data in Table 6.1 where the most cited organizations (by the sample patents in the period 1993–99) that were granted a patent in the period 1977–1992 were listed.

[Table 1 about here.]

However, the shape of the market has changed dramatically with the development and the high use of computers, networks and Internet applications. The first real security problem that firms and consumers had to face was the earlier computer virus, that gave rise to the birth and diffusion of anti-virus software packages. The first mover in this niche was the McAfee company (now Network Ass.).

Anti–virus products required the application of new competencies in order to track virus codes attached to normal computer files, allowing the anti–virus programs to work on different software platforms.

Finally, the recent and huge development of the Internet, including especially Internet financial transactions, and point–to–point communications, introduced new consumers and market needs that have spurred the proliferation of new products in the industry[1].

These trends increased the spectrum and the complexity of different products and services offered. The industry offers now from the basic products of encryption, such as Virtual Private Networks, Firewall and Virus Scanning to advanced security services like Public Key Infrastructures, Security Certification and Penetration testing (see Table 6.3). The aims are not only to assure the secrecy and protection of data and data transmission against possible privacy attacks from outside an organization, but also to provide verification and testing of possible intrusions and sabotages from inside.

Data provided by the International Data Corporation[2] evaluated the world market of ESI 2.17 billion dollars in 1997 and 3.2 billion dollars in 1998, with an estimate of 4.4 billion dollars for the 1999.

The design of the general security protection of information systems is become a very complex project and it incorporated solutions of problems originated from different technological fields such as mathematics, software, hardware and network design. According to a CEO of a provider of security software solutions: "Security policies are hard to design, hard to update, hard to enforce, and hard to make practical"[3].

Nevertheless, among all the different competencies required, the key feature is the "crypto algorithm", that specifies the mathematical transformations that are performed on data. A crypto algorithm is a procedure that takes the plain text data and transform it into cipher text. The process could be reversed with a secret key. The right balance between communication speed requirements and security protection is what assures the quality of the product, because the time consumed by encrypting and decrypting processes depends on the length of mathematical algorithm and on the power of computing machines (Smith 1999). The crypto algorithm represents indeed the core technology embedded in these products and it is the principal object of a firm's patent.

1.3 Data sources and description

In order to analyze this industry, we collected data from patents granted by the US Patent Office in the USPC class 380 (Cryptography) between 1976 and 1999. We also collected data on worldwide alliances in the same sector (SIC Code 73726) from 1993 to 1999. During the sample period (1993–1999) we ended up with more then 3,000 patents and 1,000 alliances.

The sample includes more than 1,300 firms. We also collected firm financial data, biographical information of firm founders and product introduction data from 1989 to

[1] "Rising E-commerce will drive Growth for Security Software Companies", *Business Week*, 7/4/2000

[2] "Worldwide Internet Security Software Market to close in on 4.4 billion dollars in 1999", *EDP Weekly's IT Monitor*, 40(32), 1999

[3] J. Wilbanks, CEO of SecureWork, in "Managing Managed Security", by Dejesus E.X., *Information Security*, Jan. 2001

2000. We present here a brief description of data sources.

Information about alliances was drawn from Infotrac's Insite Promt database [4], that reports four firm events (strategic alliances, joint ventures, M&As and orders and contracts received) from a large set of trade journals, magazines and other specialized press. For the period 1993-1999 we downloaded all the events included in the SIC Code 73726 (Encryption Software Sector). With these data, we created a value–added database (EVENT database) reclassifying data and introducing some new information like the passive o active firm role (acquirer or acquired, licensee or licenser ...) and the presence of a technological content in the agreement.

Patent data are downloaded from the US Patent Office web site [5]. We considered all the patents granted in the US class 380 [6] (Cryptography) that include *"equipment and processes which a) conceal or obscure intelligible information by transforming such information so as to make the information intelligible to a casual or unauthorized recipient, or b) extract intelligible information from such a concealed representation, including breaking of unknown codes and messages"* [7]. For each patent we extracted all the information reported in the on-line front page of the patent (issue date, assignee, citations, inventors).

Products introduction data were taken from from Infotrac's General Business File ASAP database, downloading all the press articles that report a "Product announcement", a "New software release" and a "Software Evaluation" in the security software sector; as before, the same process of data cleaning was applied here.

Firm's financial data were taken from Hoover's [8], an on-line database, which collects data for the Security Software & Services industry.

Data on the structure of firm groups (including subsidiaries) were taken from Business and Company Resource Center, Gale Group's Infotrac.

Information on firm profiles and histories, on biographical data of firms founders and managers were taken indifferently from Hoover's database and Infotrac's ASAP [9].

2 Entry and Survival

In describing the entry in ESI, we follow the approach of Gartner (Gartner 1985), who proposed an useful framework to study the new venture creation; the author highlighted four main fields of analysis: the environment, the new product or process, the entrepreneurs and the organization. We begin describing the environment.

2.1 The environment

Several researchers (Shane 2001) (Audretsch 1991) (Klepper 1996) have confirmed the importance of technological regimes in influencing the type and the dynamics of entry. Especially in the field of entrepreneurship studies, we agree with Bhide (pag. 31) that –

[4] www.insitepro.com

[5] www.uspto.gov

[6] It could be the case that some firms were granted patents related to these technological competencies in classes different from the 380. Nevertheless, the class 380 accounts for the bulk of inventions in cryptography; it is worth noting that all start-ups that dominate the sector have not granted any patents outside this class.

[7] Us Patent Office classification manual, *www.uspto.gov*

[8] www.hoovers.com

[9] See the several notes in the text that cite the journal articles for more details

startups can more easily turn a profit in some fields then in others–(Bhide 2000). The software industry is generally characterized by low entry barriers. For example, the initial amount invested to set up Check Point Software was 300,000$[10].

Moreover, the industry underwent to a process of market segmentation and firm specialization, that spurred the birth of several market niches (Torrisi 1998). Innovation and imitation have always represented essential strategic variables, giving to the intellectual propriety rights issue a fundamental role in order to protect firm competitive advantages. Patents are usually not seen as a good instruments (Cohen, Nelson and Walsh 2000) to protect software innovations from imitation, and firms had often utilized other privacy techniques such as tacitness and secrecy. However, ESI represents a special case where patents do protect against possible imitation, thanks to the importance of mathematical algorithms.

Given these features, software appeared as a turbulent industry with a high rate of entry, exit, product innovation and imitation, where the low entry and exit barriers spurred firm birth and death more dynamically compared to other industries. In this sense, software industry could represent an ideal environment where to study the birth of new market niches and the behavior of the main actors.

In particular, ESI was characterized by initial low entry barriers first of all from the technological point of view; the breakthrough algorithms were patented about twenty years before the boom of the industry and new firms could easily and with no costs base their product architectures upon those patents without paying any royalties. In Table 6.2 we include the number of patents cited by all the patents granted in the period 1993-1999 and their number of citations; it is not difficult to observe the importance of the patents granted between 1976–1984 compared to the others (see C/P ratio)[11]. Moreover, as a new market niche, distribution channels were not controlled by large firms and downstream capabilities were strategic because they should be still formed.

[Table 2 about here.]

Hamilton and Lawrence (Hamilton and Lawrence 2001) have suggested the separation of firm entry incentives in demand pull and technology push factors. In a technology push case, firms, knowing little about customer preferences and needs in relation of new products (or process), face an high rate of uncertainty and an higher risk of failure. While in the second type of environment, the raising demand usually makes the market less competitive and facilitates the successful entry and survival of firms. The birth of ESI was spurred both by an increasing demand for security software packages due to the development of Internet applications, and, as we will show in the next paragraph, by a stream of technological innovations.

Notwithstanding, the survival rate of firms that entered the market was low, especially in the first periods; the survival post–entry average rate is 19 % after a year and 10% setting the 2000 as the final year.[12]

Graph 6.1 shows firm entry, exit and the number of firms on the market between 1989 and 2001; a constant, increasing trend appears in all the three series suggesting the

[10] "Israel's safety net", *Electronic Business*, 1999, 25(5), p. 72

[11] It is worth noting that on average the patents cited in the period 1976–1992 are the 19.03% of the total patents granted in those years in the 380 class

[12] We count an exit if a firm does not release any new product or any new version or upgrading of existing products after 3 years from the first product introduced.

presence of rising demand and a high rate of turbulence, probably spurred by the low entry and exit barriers. The 1989 is the year where a firm offered for the first time a security software product. The death rate was high and it remains high during all the years. Looking at these data, that do not show any shake–out process, it seems that the classical product life cycle theory does not hold in the case of ESI.

This interpretation slightly changes looking at the next graphs (6.2; 6.3). There we plot the stock of existing firms for each single market niche[13] from 1989 to 2000, dividing the products in two large groups: products related to network (Graph 6.3) and products related to personal computer applications (Graph 6.2). Inside each niche, we observe trends characterized by different phases of entry waves and consolidation processes, more in tune to the PLC theory. The first stream of products introduced in ESI was formed by the PC related products (antivirus, utility software, data protection, ...); in these niches, a S–shaped trend is already visible in the data. The late types of products introduced were those related to network application; in this case, we still do not see any consolidation phenomenon. The fact that the paces of niche firm concentration are not synchronized is the reason for the constant rising aggregate trend of the Graph 6.1.

[Figure 1 about here.]

[Figure 2 about here.]

[Figure 3 about here.]

The high exit rate could be explained by two important factors: first by the uncertainty about the quality of the product. In fact, only after a proved resistance against several attacks, the product could be considered efficacious. This implies that an initial, casual, bad performance of a new product could be fatal to the producer, even if the product was substantially a good one. Secondly, as shown in Table 6.4, the main buyers of security software packages were the large ICT firms which were the technological first movers and which owned the most number of patents related to these technologies (see Table 6.1). This evidence proved that the main customers were highly skilled and capable of a selective evaluation of the software security products.

Some concluding remarks: the process that spurred the birth of the ESI was clearly characterized by demand pull conditions, but the particular technological core of the product, and the presence of high skilled customers generated selective selection phenomena, especially in the earlier years, where only few new ventures were able to enter and survive. To have a better idea of the factors that lie behind the survival capacity of firms, we need now describe the main features of their products.

2.2 The products

2.2.1 Selection after entry

As Geroski (Geroski 1995) has noted, if entry is relatively easy, survival is not. Chrisman et al. (Chrisman, Bauerschmidt and Hofer 1998) indicated in the capacity of firm survival the effective measure of fitness in the contest of entry by new firm creation. According to the authors, the common, and perhaps the only, aim of a new venture in the first stages of its life is working as a self sustaining economic activity.

[13] See Table6.3 for a description of the niches

Along this stream of analysis, after entry, the process of selection is twofold (Hanks and Chandler 1994): there is a first shock of mortality, caused by a preliminary selection factors among firms. Later, the survived firms will experience a second process of selection, characterized by different competitive requirements. It is important to separately study these two processes of selection, even if the division is more theoretical then factual. In fact, while in the first phase, typically, the survival key is linked mostly with a successful product or process innovation, in the second case, managerial, organizational, growth and size issues are the strategic ones. (Wagner 1994) (Kazanjian 1988).

Being the understanding of selection mechanisms that discriminated the survivors, the first aim of this type of studies, an important limitation arises: usually, nothing, but the names, is known about firms that left the market in the germinal stage of an industry (Zacharakis et al. 1999). So, the great dilemma is that we find often only stories and data of successful businesses, while outgone firms, and especially failed startups, often disappeared and did not leave any records or tracks of their life and, mainly, of their errors. –Only success is carried on from the past– (Bhide 2000) and this dilemma is our problem too. Notwithstanding, beware not to forget this limitation and keeping in mind the danger of omitting too many variables, we are sure that with the right caution, collecting common features and similarities among the firms survived could drive us to some sound conclusions and inferences on selection mechanisms (and on what was missed in the outgone firms) (Bradburd and Ross 1989). So in the following parts of the paper, when we are referring to small startups or new ventures, it should be kept in mind that those are the firms that at least introduced more then one product over time, surviving in the first selection phase.

Like other industries, the origin of ESI was basically a story of good innovations: a firm survived if it has introduced a sound technological product. Consequently, the major causes of a firm's survival (or mortality) was the validity of the product, a combination between mathematical algorithm, case sensitive intrusions knowledge and software adaptability. Table 6.3 shows the most important product niches of ESI, according to their SIC code division. Generally, these products are software packages strengthening boundaries between networks and protecting computers against viruses and unauthorized users, integrating at the same time, network access control, authentication, security, and policy management.

[Table 3 about here.]

At the very beginning, small firms entered specialized in a well defined product area like, for example, Checkpoint and Axent in firewall; Network Ass. (former McAfee), Symatenc and Trendmicro in antivirus software; Certicom, Entrust and Cyberguard in the virtual private network architecture; Baltimore in the digital signature protocols.

The success means simply the ability to propose a product with a sound mathematical core that adapts to different software platforms and preserves the speed of the data transmission. Three examples of successful startups could help to better explain this assertion:

- Checkpoint created an innovative process to built firewalls, security products that could go directly off the shelf to a firm and that enforce a boundary between different networks and protect firms against unauthorized users. Check Point's programmers introduced a new language, Inspect, specifically for directing the rapid inspection of communication packets and a compiler to translate policy rules written in Inspect into assembly language. The program opens data packets, checks the content, quickly inspecting each data packet and decides for the eventual rejection. The innovation is that the program sends along the data in parcels after they are checked, rather than waiting to reassemble them before the entire transmission. This methodology increased dramatically the speed of data transmission, with the same level of security[14]. Patent number 5,835,726, filed June 17^{th} 1996, by G.Shwed et al., "System for securing the flow of and selectively modifying packets in a computer network".

- Digimarc's core technology was created by Geoffrey Rhoads, the company's founder, a physicist, who invented a camera to clean up digital spaces images photographed through ground-based telescopes. Rhoads reversed the imaging filtering process and added a micro ownership mark to the photos. The existing technologies made digital data to be imperceptibly embedded in digital visual content (like movies and photos) and valuable documents such as financial data–sheets and passports. Rhoads, instead, introduced a method that allows the identification of a copy of an original signal from the original signal. This could be achieved by modulating the source code with a small "noise" code that will be lost in case of a copied product[15]. Patent number 5,710,834, filed May the 8^{th} 1995, by G.Rhoads, "Method and apparatus responsive to a code signal conveyed through a graphic image".

- Certicom's Elliptic Curve Cryptography is a technology especially useful in what is known as "small-footprint environments" such as smart cards or wireless communications devices, where space is the scarcest resource. If the standard string of computer bits necessary to encode or decode an encrypted message needs about 1,024 bits, Certicom's system accomplishes in 160. The difference is rooted in mathematics[16]. In fact while the standard cryptographic systems is based on integer calculus, the elliptic curve cryptosystem is based on equations that can be calculated more easily and faster[17]. Patent number 6,141,420, filed January the 29^{th} 1997, by S.Vanstone et al., "Elleptic curve encryption system".

These three examples help to understand two important points: first, the importance both of the "quality" of innovation in the selection process and consequently, of the technical abilities of the entrepreneur. Second, the important role of the patent protection in this industry.

2.2.2 The two sub–markets

The core of security products is the mathematical procedure that lie behind the encryption of data. Patents offered therefore a good tool of protection against imitation and preservation of intellectual proprietary rights. For example, Entrust Tech., one of the leading innovator in the field, is responsible for over 90 patents and pending patent applications[18].

[14] "Safe at 100 megabits per second. Check Point Software Technologies creates Internet firewall which supports high speed transactions", *Forbes*, Dec 30, 1996

[15] "Trolling the net. Digimarc's watermarking technology", *Electronic Business*, Sept. 1998, 24(9)

[16] A classical form of an elliptic curve is $y^2 + xy = x^3 + ax^2 + b$

[17] "Cheaper encryption tool gaining momentum. Certicom Corp.'s elliptic curve cryptosystem", *American Banker*, Apr. 2, 1997

[18] "Network Magazine Names Entrust/PKI(TM) Software 2001 Product of the Year", *Market News Publishing*, June 8, 2001

It is worth noting that between 1993-1999 2,816 patents were granted in the class 380 with an annual growth rate of 6%. Even if we standardize by the growth rate of annual total patents granted by the USPTO, the annual average growth rate of patents in class 380 is still positive[19]. We can conclude that the US 380 class represents one of the most rising technology in the latest years. The top firms for patents granted are IBM (195 patents), Motorola (175) and Sony (71).

Mostly thanks to this effective patent protection, two sub–markets were created: a market for the standard products of ESI (firewall, antivirus, ...) and a market for technology, where firms could acquire the right to use the proprietary mathematical algorithm patented. In terms of market size, Hoovers data show that in 2000 for the top 15 firms in ESI (see Table 6.7) the 56.6% of revenues comes from product software, the 28,3% from services and the 14,9% from licensing the technological algorithm.

From our EVENT database, between 1993 and 1999, we collected 119 technological licenses and 143 product order contracts. The most important buyers and sellers, for number of technological licenses and product contracts awarded, are ranked in Table 6.4[20].

[Table 4 about here.]

Concerning the licenses[21], the most important seller of technology, among 53 different sellers, is RSA Data Security with 23 licensing contracts signed (19.3 % of whole licenses signed). Among 105 different firms, the most important buyer of the technology is IBM (8.3% of total contracts). Looking at the product orders (software packages), the most important seller is Verisign (11.1 % of total orders) and the most important buyer Verizon (4.4%).

In conclusion, two factors were common among the survived firms: the first is that survivors entered specialized in a particular niche[22]; the second that they entered with a distinguished innovative product. Interestingly, empirical evidence seems to confirm a strong interdependency between the technological and the product sub–markets. The Pearson correlation coefficient between product orders and technological licenses awarded by firm and by year equals 0.68, with a significance level of 5%. This high correlation supports the thesis that, especially in the first years of industry evolution, innovation played a major role. A good mathematical product core that gives firm success in the market for technology, seems to be a necessary condition for gaining a competitive advantage in the market for products (see Table 6.4). Moreover, the fact that the same large ICT firms are the major buyers in the two sub–markets confirms the importance of the role played both by high skilled consumers and by the quality of product innovation. The interaction between market focus and product innovation has been already spotted in the literature (Vinnell and Hamilton 1999) as one of the key factors of survival in the early stages of a new business. Firm entry with an innovative and sound idea in a particular product area could create a strong reputation effect on the firm, important to sustain a competitive advantage in the preliminary phases of competition (Kazanjian and Rao 1999).

[19] For precision, it equals 0.4%. This means that patents in 380 US class are growing the 0,4% more that average growth rate of patenting at USPTO

[20] Note that it is not the case that order contracts and technological licenses are the two faces of a same agreement. On average, in the 92% of cases, for each firm, the two types of contracts are not in the same agreement between the same firms

[21] Time Warner is the owner of AOL and Netscape

[22] There is no evidence in our product database that a firm entered the market with products of at least two different niches, except for large ICT firms (see paragraph 4.2)

However, being the specialized entry in a product niche a common feature among all the firms (survived and not), we could suppose that it do not play a pivotal role *per se*. It should have been the quality of product innovation, linked with the firm market focus and other factors, that shaped essential survival processes. The fact that all the outgoing firms between 1989 and 1995 were not granted any patents (if we take patent as a minimal measure of innovation quality) by USPTO sustains this hypothesis.

2.3 The entrepreneurs

Several scholars (Terpstra and Olson 1993) (Meyer and Roberts 1986) have noted that in the first periods of new firm life, the firm and its entrepreneur were often indistinguishable. According to Gartner (Gartner 1985), the points of strength and weakness of a new venture are at the beginning those of its founder. Thus, it is quite obvious that the probability of firm survival depends strongly on founder's competencies and abilities (Holmes and Schmitz 1990). Casting under this light, knowing who were the firm founders is critical to highlight what capabilities they brought inside their company, what incentives they had, what business idea they fitted in the organization and how they shaped the firm in the initial stages. The analysis of these factors is usually underestimated in the theoretic literature, where only characteristics like firm size and age are taken into account (Evans and Leighton 1989).

The fundamental question that lies underneath this section is: why in a certain moment and in a certain sector an entrepreneur was born? This long–debated issue is usually studied by literature from two complementary sides that we summarize in Table 6.5; the first one refers on what traits make an economic agent an entrepreneur. The second concerns the factors that influence the birth of an entrepreneur's creation process (Bhide 2000).

[Table 5 about here.]

Considering the first point, scholars (Blanchflower and Oswald 1998) pointed three more common elements in the nature of an entrepreneur: he is low risk adverse, he owns a valuable type of information or capability, he feels frustrated in some way by the existing job position. One of the aim of our research should be to investigate which of these three features could have been present among the founders of encryption software firms. Until now, we have not still conducted any direct interviews or surveys over startup founders, and we have to limit our research on the data available.

First of all, in Table 6.6 the founder's origin of the most important startups were listed. The more evident regularity is that the founder could had have three different origins: an ex-employee of a large ICT firms (especially one of the technological first movers); an ex–founder or employee of a previous software startups and last, an ex–government or university researcher.

From this evidence, we could argue that, especially for those entrepreneurs coming from a large ICT firms, there could be some frustration–leaded behaviors at work. In fact, due to inefficiencies of the internal capital market, large firm management could have preferred to invest in low–risk actual "cash cow" sectors instead of investing in future not–well defined markets (Christensen 1998). This could have forced some employees to try the exploitation of self–employed opportunities.

[Table 6 about here.]

Relating to the point of founder's valuable information, authors have (Shane and Venkataraman 2000) usually highlighted two broad categories of analysis: 1) information regarding the creation of a business opportunity and its evaluation, 2) information linked with the capability to exploit these business opportunities. In other words, in order to recognize an opportunity, an entrepreneur should posses information about specific aspects of production and about user needs (von Hippel 1988). While the latter refers to the ability to tailor business ideas towards possible specific customers (find or build a market), the former is properly linked to the typology of the entrepreneur. At this regard, literature (Bhide 2000) (Shane and Venkataraman 2000) have indicated three types of entrepreneur: the innovator, who creates new information; the arbitrageur, who exploits market inefficiencies and the coordinator, who introduces an alternative use of resources.

Firm founders in ESI are a classical case of the first type, because it is an innovation that has pushed them to set up a new venture. We show in Table 6.6 that most of these founders are granted at least one patent at USPTO and, in this sense, their fundamental entrepreneurial competence was the ability to exploit mathematical skills linked to the ability of software compiling and design. It will be useful to bring some direct examples to support this hypothesis:

- B. O'Higgins, the founder of Entrust tech., has overall responsibility for the technology vision and direction for the company. He was previously with Nortel where he established the Secure Networks group in 1993 and with Bell-Northern Research, which he joined in 1979. At BNR, he was involved with a variety of technology development programs, including public key security systems, technology for new telephone products, in–building wireless communications systems and high–performance computing architectures for call processing applications[23].

- A.Vanstone of Certicom is a professor of Mathematics, and he has published more than 150 research papers and several books on topics such as cryptography, coding theory, finite geometry, and combinatorial designs [24].

- A. Jennings, the mathematician founder of Rainbow tech. , was famous for developing algorithms that, when programmed and plugged into a computer parallel port, worked with code written into the software, forcing the program to shut down if the key wasn't detected correctly [25].

- Prior to launching Trend Micro, S. Chang worked as an engineer at Hewlett Packard. He received his B.S. in Applied Mathematics and his M.S. in Computer Science. He founded Trend Micro in 1988 with the mission of developing antivirus software for personal computers, with a company's focus to address total network security[26].

In the previous paragraph, we have stressed how innovation played a major role in the first stages of the industry competition and it appears evident now how the skills embedded in the human capital of a potential entrepreneur, and his capacity to be an innovator,

[23] "Network Magazine Names Entrust/PKI(TM) Software 2001 Product of the Year", *Market News Publishing*, Jun. 8, 2001

[24] "Certicom's Founder Receives Security Award for Mathematics from RSA", *Market News Publishing*, June 11, 2001

[25] "We're basically Insurance", *Forbes*, Nov. 9, 1992

[26] "Behind-the-scenes attack on the virus plague. Steve Chang, Founder of Trend Micro", *The Financial Times*, Jun. 7, 2000

were the engines of this dynamic process. Therefore, it is a direct consequence that future successful firm founders have gained some advantages by being employees of a large ICT firm or a government–academic institution. In fact, these two organizations represented the producers of the basic technology of the sector (see Table 6.1) and the main users of these products (see Table 6.4). We could suppose that entrepreneurs coming from one of these organization entities could have been subject to some learning processes about the basic technologies (how to innovate) and user's needs (how to exploit). According to this view, Klepper and Sleeper (Klepper and Sleeper 2000) introduced the term of "heredity" that spin-offs received from the parent firm especially when there is some kind of knowledge embedded in human capital.

From another point of study, the type of advantages deriving from a previous startups experience (see for example founders of Aventail and Netegrity), probably concern mostly the ability to set up new organizations in high dynamic sectors, in terms of information about labor and financial markets.

In the last part of this paragraph, we briefly asses the complementary aspect mirrored in the entrepreneur's nature: the factors spurring the process of new venture birth–rate. We have already cited how this process is influenced by typical sector conditions, such as low entry barriers, large expected demand and no intense competition. Hamilton (Hamilton 2000) has indicated in the business idea, in the founder's expected incremental utility and in the financial constrains the most important factors influencing this process. Dwelling briefly upon the late two factors, literature (Blanchflower and Oswald 1998) has deeply analyzed the importance of liquidity constrains in influencing the probability of firm formation. But in the case of ESI, we could affirm that, given the boom of internet company financing in the late 1990s and the small initial capital needed, capital constrains were not the main concerns. The question about the founder's expected incremental utility is quite difficult to assess without any direct survey, even if empirical studies does not show any significant differences on average in the founder's earning differential between ex–ante and ex–post firm creation (Hamilton 2000), suggesting the presence of a series of no–monetary factors.

2.4 The organization

Few are the considerations about the organization structure of a new venture, because in the early firm life periods, where firms were deeply focused on technological and product issues, organization structures are loose, not precisely designed, and sometimes absent.

At Checkpoint for example, was thanks largely to M. Nacht's (one of the founder) eagerness to fly anywhere in the world, live in airports and do business from public telephones, that the firm was able to sign some deals with network hardware makers [27]. At Network Ass. (former McAfee) the employees were all international software engineers so that the common language in the firm was C+. Customer–service department was represented only by three women; engineers referred to them as the "three white witches", because they considered those women's type of work quite mysterious and something not related to the firm mission[28].

This two examples help to explain how organizational issues were not the principal worries of the every day firm agenda. Organization problems will arise during a second

[27] "Israel' safety net", cit.

[28] "From freeware to profitware. Network Ass.", *Forbes*, Aug. 24, 1998

phase, when firms will be submitted to intense processes of growth. We leave indeed this main discussion to the next section.

3 Competition, strategy and firm growth

After first competitive sorting processes, the firms survived faced new challenges. Empirical studies (Klepper 1996) (Audretsch 1991) have found how size and age positively affect the capacity of surviving of new entrants.

[Table 7 about here.]

To better understand how the "size" question became critical in this second phase of evolution, we collected data of a sample of successful startups listed by the database Hoovers[29]. Hoovers classified the most important firms in ESI according to their size, their market value on NASDAQ, their inclusion in important lists of specialized press (E–Fortune Top 50, Financial Times Top 500, Standard&Poor's Top 400). In order to give a view of the dimension of their market power, in Table 6.7 we show the market shares for the top 15 startups at 1998. The top 15 startups controlled about the 43% of the world market for software security products[30].

Graph 6.4 highlights how these firms have experienced in the last years a sound upsurge in size, measured with firm average sales and employees by year .

[Figure 4 about here.]

The more the time a firm is able to remain on the market, the more is the number of requirements, information and feedbacks that it should elaborate. In fact, as some scholars (Dodge et al. 1994) have noted, the firm evolution process in not characterized by a substitution between different problems, but by a creation of new problems over the existing ones. The firm capacity to deal with an increasing level of complexity became one of the most essential determinant of its economic fitness. Therefore, after an initial phase based on technology competitive advantages, the same competition moved towards a multi–variable dimension, but with only one prerogative: growing as fast as possible (Wagner 1994).

Dealing with complexity requires primarily an increasing specialization of firm internal operations and then a superior ability to orchestrate and direct firm sub–units that tend to become more independent (Hanks and Chandler 1994). This means the need for new organizational routines, standardized functions, different strategies and tools to evaluate firm performances (Kazanjian 1988) (Churchill and Lewis 1983). Studies conducted with surveys on small firms stress how in a late stage of their growth the pressing concerns for the founders became the lack of managerial skills, the need of new organizational routines, and correct strategic planning and marketing orientation (Chrisman et al. 1998) (Olson 1987) (Terpstra and Olson 1993). In accordance with some scholars, it should be observed a new venture impulse to look for new managerial skills instead of entrepreneurial ones, after the first period of evolution (Holmes and Schmitz 1990).

[29] The firm sample was also controlled and adjusted by a cluster analysis procedure using variables like alliances/sales, patents/sales and products/sales

[30] "Security Software: a Sure Bet?", *Business Communications Review*, December 2000

Moreover, other authors have noted the no–linearity of small business evolution processes; they occur with intense organizational and strategic breakthroughs that shook all the existing firm structure (Vinnell and Hamilton 1999) (Mitra and Pingali 1999).

Most of the firms survived in ESI have to suddenly understand that if initially being technologically at the frontier was a sufficient condition to survive, soon after it was only a necessary one. But selection mechanisms change according to the development of the market, and they make competition more difficult to understand; thus, a failure of a business, and its consequent exit, could not be explained only in terms of a single cause.

Typically, empirical literature on small firms collapses the study of firm different probabilities of surviving in the analysis between firm size differences (Geroski 1995). Theoretical models explain the different rates of firm growth basically with differences in the firm productivity and cost structure (Evans and Leighton 1989). In this paper, we want to take a step further trying to disentangle the main components underneath the pace of small business growth. It is clear that firm size has a positively effects on the probability to survive for a series of reasons, like for example, easier access to the market of capitals. But it is also evident that firms grow at different rates for some inner causes, and not *per se*. And this holds mostly in sectors where competition is based highly on knowledge resources.

Therefore, we highlight in the next paragraphs four different main factors that are common among the firms that persisted in surviving and growing. These factors could represent a good key to interpret the engine of small firm growth. They are: product differentiation, international expansion, the building of sound downstream channels and the evolution of organizational structures. In analyzing them, we remind that the interactions between these four factors, firm size and the probability of a persistent survival rate are co–integrated and not linear (for example, the more a firm offers a broad range of products, the more it accesses to new international markets, the larger will be its size).

We will show at the end of this section how firms that left the market in this second phase of evolution lacked in one or more of these aspects.

3.1 Product differentiation

One of the mean to obtain and strength a firm's competitive advantage is through product differentiation. Firms selling a broad range of products are in a better position to gain high margins, to increase their costumer base, to process and screen more information about market trends. Literature (Lancaster 1990) includes two main orders of motivations to sustain the rational broadening of product variety: those referring to demand side factors and those including the exploitation of economies of scope, using product variety as strategic purposes.

For the first stream of motivations, product variety favors the reduction of sales uncertainty, the achievement of high market shares, the higher relative prices due to the tailoring of products on customer preferences, and the individuation of new consumers in new niches. Along this view, empirical works have confirmed a positive relationship between market share and product line breadth (Kekre and Srinivasan 1990).

The second type of factors refers to the exploitation of economies of scope, especially those originated by firm knowledge resources. Firms could offer a broad product variety in order to use it as a strategic barrier to pre–empt new specialized markets entrants, lacking in scale economies. Lacanster (Lancaster 1990) studied the use of product variety as a strategic tools to saturate the product space as a deterrent to entry.

In a study on the computer workstation industry, Sorenson (Soreson 2000) has recently found that product variety strongly affects the probability of a firm's exit. In fact, especially in the first stages of industry evolution, when few firms have already expanded their product line, the number of products offered by a firm increases its probability to survive.

Table 6.8 shows the number of different versions of products in each niche in two sub–periods[31]. There is evidence of an increasing product proliferation, linked with the rise of the software packages tailored to network design and security.

[Table 8 about here.]

To better stress the role played by product variety strategies, in Graph 6.5 we map the average Herfindhal index[32] calculated for each firm over the products offered in the different niches, and the ratio between the number of different products and the number of firms on the market by year. It could be observed cycles characterized by two no–synchronized trends: as the ratio between products and firms increases (less firms, more products) the average firm diversification increases, and otherwise. What follow to waves of specialized entrants, that increase the level of average firm product specialization, are periods of market consolidation where specialized firms leave the market, and businesses with a broader product variety survive. These data seem to confirm that outgone firms are specialized (and maybe smaller), while firms that survived are more differentiated (and maybe larger).

[Figure 5 about here.]

If competing with a broad product selection spurs the probability of firm survival, it will be extremely interesting to understand how a firm, born specialized in a particular niche, could have succeeded in expanding its product range. Basically, two are the ways followed by firms to pursue this strategy: the internal development leaded by its own R&D, and the external acquisition towards M&As; we analyze these two aspects in the next paragraphs.

3.1.1 Internal development

The internal development of new products is based on the exploitation of economies of scope from the firm knowledge resources (Teece 1986). As a matter of fact, firms often do not own all the technical competencies needed to develop new products, especially with regard to the timing given by the industry competition. Recently firms have discovered technological alliances as a useful tool to quickly learn new technological competencies and exploiting research synergies. Empirical works on technological alliances reached the conclusions that collaborative ventures are useful to determine the product innovativeness especially for small firms (Kotabe and Swan 1995) and that they are more productive if partners have complementary technological skills (Sakakibara 1997).

From the EVENT database, during the period 1993–1999, 256 collaborative ventures with the clear aim of conducting R&D were set up in ESI. 1996 and 1997 are the years with the greatest number of technological alliances. The number of different firms involved are 273[33]. In table 6.9 the firms are ranked according to their number of R&D ventures.

[31] C2 is the sum of the two most important firm market share

[32] This concentration index spans from zero to one, with the value zero equals to maximum differentiation $H = \sum x_i^2$ where x_i is the single product share

[33] Note that the partners of an alliance could be more than two.

[Table 9 about here.]

The table 6.9 shows how the more active firms are both startups and large ICT firms. In order to better understand the network shape, we draw a simple network graph on technological alliances among the firms with the highest number of alliances, grouping them according to their initial niche specialization (see Table 6.3).

[Figure 6 about here.]

Graph 6.6 shows that a firm specialized in a particular niche set up technological linkages with small firm specialized in other niches of ESI and large ICT firms. This seems to confirm that technological complementarity seems an important factor at work, and it support the hypothesis that small firms used mostly technological alliances as a mean to quickly learn new competencies, in order to enter in new niches and expand their product variety.

However, we should give some specifications over this theme. We believe that being an important actor in a technological network is not an exogenous variable; in fact, this fact should not be separated by the fact that the intensity of firm alliance participation depends on a firm capacity to be a strong potential technological partner. Firms that have the high intensity of participation in this network are those which survived to the first competitive survival process, and consequently those with a sound technological base. Some statistics supports these conjectures: in the EVENT database, among all the firms that set up at least one technological alliance, only the 27% owns a patent in the 380 USPTO class. But this 27% accounts for more then 54% of the participation intensity in technological alliances. Learning from alliances, and in general from external environment, is a function, among other factors (for example cumulative experience in alliance formation), of the internal effort in R&D (Cohen and Levinthal 1989).

3.1.2 Merger and acquisitions

During the period 1993-1999, 82 acquisitions have been completed (EVENT database). Graph 6.7 shows the trend of M&As, compared to the number of firms active on the market. As mentioned before, we classified the firms involved for their active (buyer) or passive (acquired) role. The acquirer firms are 52 in our sample.

[Figure 7 about here.]

The firms with the highest number of acquisitions are Network Associates (5 acquisitions), Axent Technology (4) and RSA Data Security (4). To highlight the firm behavior in M&A, we briefly analyze the acquisition strategy of these three firms:

- In the 1996 Network Ass., specialized in the network access design and security, merged with McAfee, an antivirus and utility software firms. A year later, it acquired Pretty Good Privacy, one of the leading technological firm in the data protection area and in 1998 Trusted Information Systems, a firewall maker.

- RSA Data Security, a data protection specialist, merged in 1996 with Security Dynamics, a firm operating in the authentication and digital signatures niche; in 1997 it acquired Intrusion Detection, a network software security maker, and in 1998 Dynasoft, a specialized firm in unix–security networks.

- In 1997 Axent Technology took control of Raptor Systems, one of the most important owner of patents in firewall technology; in 1998 it acquired Security Network Consulting, a general network design security expert, and in 1999 PassGo tech., a storage data protector.

In the EVENT database, for most of the M&As, the buyer was a startup of ESI, and only in 3 cases the buyer was a large ICT technological first mover. These data show that the M&A dynamics were phenomena that occurred inside the groups of startup firms in ESI. The role of large ICT firms was marginal, albeit during the period some attempts of acquisition from large firms failed (for example the offer that IBM did to Raptor Systems). Among small firms, the criterion that lead the acquirer strategies was again the search of target firms with complementary technological capability. Data confirm that the growth spurred by M&A was direct to the expansion of product variety offered by the firms.

3.2 Downstream capabilities and geographic expansion

Investments in "co–specialized assets", like sales, service efforts and marketing capabilities are an important means of appropriation of the returns in R&D. Building a sound network of downstream channels and distributors implies a better exploitation of firm technological resources (Teece 1986). Also downstream control could lower the rate of possible imitation and act as a barrier to potential entrants. As Teece noted: "A competitive advantage can be gained or lost on the market of complementary assets".

In EVENT database, we registered 296 commercial strategic alliances signed in ESI between 1993 and 1999. These alliances have only a clear distribution and marketing aim. Table 6.10 lists the top firms for number of commercial alliances. It is possible to note that the composition of firms is characterized by small specialized startups (Check Point, Axent, ...), large ICT firms (IBM, H&P, ...) and several software distributors, consultancy firms and small softwarehouse not included in Table 6.10. It is evident that small startups in ESI are using both large firms and independent distributors as downstream channels.

[Table 10 about here.]

The building of these downstream capabilities is directly linked to a firm's capacity to open new geographic markets where it can establish its presence. The positive outcomes of this dual strategy are several, such as sales and profit increase, entry and growth in new product niches, better screening of market opportunities and direct contact with a larger customer base.

Literature has pointed that internationalization tends to be easier among firms with high intensity of R&D, offering technological complex products with an high level of product differentiation. This holds especially for firms in which its intangible asset value is large relative to its market value (Markusen 1995) (Ethier 1986). Moreover, recent studies (Kotha, Rindova and Rothaermel 2001) have found a positive correlation between intangible assets of software firms and propensity to internationalize. Other scholars (Morck and Yeung 1992) found evidence that especially for small, young and dynamic firms the presence of intangible assets is correlated with an high degree of internationalization and high "abnormal" stock market returns. According to this view, building a sound technological base, being able to offer a broad product variety, having strong co–specialized assets and opening new geographic markets are four variables strongly correlated to firm probability to survive and grow.

Economic data show that the main geographic market for encryption software products is the North America; as a matter of facts, according to Hoovers, in 1999 the 66,7 % of the revenues in ESI came from the US market, followed by Europe (16,1%) and Asia (3,8%). Notwithstanding, our data show an important tendency to firm internationalization. In this respect, we calculated for each firms, the Herfindhal index on the commercial alliances by year and by country, attributing at each agreement the country where the alliance investment is direct. As figure 6.8 shows, when the number of commercial alliances is raising, the dispersion of alliances among different countries increases too, giving evidence of a general tendency towards a firm's international expansion.

[Figure 8 about here.]

In Table 6.11 we listed the number of subsidiaries by geographic area for those startups that set up a proprietary subsidiary outside North American at 1999. The number of these subsidiaries is quite important, especially in Europe and Asia. Other firms, such as Digimarc, Verisign, Cyberguard, that are not included in this table, use exclusively local partners, signing particular long–term distribution and marketing agreements.

[Table 11 about here.]

We also should remind that US firms faced government restrictions to sell and export encryption products, and they had to ask for an authorization from government agencies until 1999 when Clinton Administration relaxed all restrictions on export[34]. These law restrictions could have given some advantages to non–US firms both in the US market and abroad. This fact could explain why a series of non–US firms have gained important market shares in ESI like Check Point and Aladdin (Israel), Trend Micro (Taiwan), F-Secure (Finland).

3.3 Management and organization governance

Most of the literature on small business agree that the presence of poor managerial resources and organizational systems is the one of most important causes of firm failure (Chrisman et al. 1998) (Kazanjian and Rao 1999) (Zacharakis et al. 1999).

A small business that experiments a rapid growth process needs a co–evolution of organizational practices and managerial tasks. Facing an increasing complexity requires a simplification, a fragmentation of problems. This implies an increasing division and specialization of different tasks with the right support of an organizational structure that surround the communications and the information flows between different firm sub–units (von Hippel 1990). It is at this point of firm evolution, when the number of variables is multiplying, that strategic assets become important for a firm's value creation, towards the right identification and the fine–tuning between control and state variables inside the organization (Winter 1987). As firm purposes became multiple, organization types are seen as instruments of coordination toward the achievement of firm overall performance (March and Sutton 1997).

It is difficult to have comprehensive data of all the organizational and corporate strategic changes faced by startups in ESI. However, we provide some information that could

[34]Cyberspace Electronic Security Act, 16/9/99

help to understand how firms have introduced organizational routines and strategic practices, along their process of growth.

One of the first prerogative for a fast growing business is to create a separated financial department, specialized in dealing with all the financial requirements. The competencies in financial engineering needed to support investments of a fast growing business are highly specific. All the startup firms in ESI have hired, after an average period of 5–6 years after their entry in the market, highly experienced financial executives who supervised and guaranteed the availability of funds needed for the firm investments, often not so much predictable. Moreover, we could assume that these professional executives, coming into a new firm, have brought inside the organization a series of procedures and tools for the control of the financial and economic firm performance.

Table 6.12 shows the list of the chief financial executives for the most important startups in ESI, indicating the number of years passed from firm foundation date to the creation of autonomous financial department, and the previous firm of the CFO. As shown, it is quite common that these executives have a long experience in dealing financial problems in other software, large ICT and consultancy firms[35].

[Table 12 about here.]

In some cases, the founder left the management and the control of global firm strategies to high skilled managers, holding for himself the chair of president and the direction of the research laboratories. This could suggest that startups adopted strategies and routines typical of the large businesses when their size became bigger. Some examples:

- G. Samenuk, CEO of Symatenc, served as chief executive officer and president of Tradeout, a global online exchange company. Prior to joining Tradeout, Samenuk served in various positions at IBM Corporation from 1977 to 1999 as general manager.

- O. Kallasvuo, CEO of F–Secure, was a Chief Financial Officer of Nokia and a member of the Nokia Group executive board.

- J. Ungerman, President of Check Point Software, responsible for leading the company's worldwide sales, had served in various sales, marketing and general management roles at Hitachi Data Systems.

- W. Conner, CEO of Trend Micro from 1998, was the President of eBusiness Solutions of Nortel Networks, delivering communications-intensive eBusiness applications and services to redefine the relationships businesses have with their customers.

- W. Crowell, CEO of Cylink, came from National Security Agency, where he held a series of senior positions, serving as the agency's chief of staff, deputy director of operations, and finally as its deputy director and senior cryptologist.

[35] In table 6.12 the firm sector are indicated in parenthesis: (S)=software, (C)=consultancy, (B)=bank, (TLC)=Telecommunications, (CMP)=Computer hardware.

4 Late industry dynamics and first mover advantages

We have already seen how ESI evolution was characterized by a first phase of high technological competition, where only firms with innovations, proved to be very competitive, survived. Then, the ability to exploit the economies of scope of the knowledge base, achieving product differentiation and geographic expansion, together with the co–evolution of firm organization systems and practices, were the main determinants of firm economic performance. We now bring the attention on two important points; first, we analyze a case of a firm that left the market in this second phase of industry evolution. Then, we give further considerations concerning the late entry of large firms in the market and how this will affect the industry dynamics.

4.1 Exit

The second phase of industry competition gives us more information about outgoing firms and so, we can draw some sound general patterns on the phenomenon.

First of all, we could look for similarities among all the firm that were acquired during the sample period. The principal common pattern among most of the firms acquired is that they remained specialized in a particular market niche. For each firm acquired, we calculated the Herfindhal index and the C1 over the product range that offered by firms before the acquisition. The firm average Herfindhal index for the acquired firms is 0.804, with a standard deviation of 0.216; the C1 index 0.837 with a standard deviation of 0.199. For the 15 leading startups (see Table 6.7) the average Herfindhal index equals 0.446 with a standard deviation of 0.226; C1 is 0.564 with a standard deviation of 0.208 [36]. It is worth noting that the acquired firms, even if they owned some distinct technological assets, were product specialized and they could have failed to exploit economies of scope from their knowledge base at the same levels of other firms, exposing themselves as an acquisition target.

By the same token, we could provide a case study of a firm that went bankruptcy, even if its product differentiation and geographical expansion were quite important. SystemSoft was formed in 1990 and it specialized its production on utility software programs. Then, the company expanded, developing system-level software that let a PC's hardware communicate with its operating system. It entered several licensing agreements with large ICT firms, especially Microsoft and Intel. SystemSoft went public in 1994 and in 1996 it bought Radish Communications System, with the aim of integrating Radish's modem technology. But curbed motherboard production in Asia (one of the most important market for Systemsoft), and the refusal of Microsoft[37] to renew the contract with Systemsoft, hurt firm sales. The Radish acquisition also caused a loss for 1997 and the company responded with staff cuts, the sale of its Japanese subsidiary and a manager turnover. But in early 1999 the company filed for bankruptcy protection and announced plans to sell off its assets[38]. The case of Systemsoft is important to understand how the fast growing process of a startup usually required high capabilities of its executives in managing long and short term firm financial structure, because it is easy to expose the firm to an irrecoverable

[36] The Herfindhal index for top 15 was calculated cleaning for M&As distortion effects (non–group consolidation)

[37] Microsoft has incorporated into Windows features similar to those of SystemSoft products

[38] "Systemsoft to file for Protection under Chapter 11 of the US Bankruptcy Code", *Business Wire*, Mar. 1999

financial crisis.

From these cases, it seems that firm poor capacity to earn profit from technological resources, exploiting knowledge economies of scope that yield to product differentiation and geographic expansion, with a synchronous evolution of firm structure in terms of managerial, financial and organization capabilities could be the main determinant of firm exit.

4.2 The late entry of large established firms

In considering the late entry of large firms in the sector, we introduce one of the main limitation of our work. The fact that ESI is just entered in another (the third) high turbulent and new phase of competition makes our economic conclusions and implications very difficult to articulate.

Large ICT firms, that were the first technological movers and the actual most important owners of patents, decided to enter into ESI with their own products in the last years of the 1990s, 5–6 years after the first successful products of startups. In particular, IBM and Computer Associates in 1998 and H&P in 1999 have begun to offer a broad range of software security products[39].

H&P have first became a distributor of security products of different startups, offering to the customers the best software packages for each niche under its product umbrella. Then H&P started to produce and offer its own products.

Computer Associates and IBM are actually spending resources in marketing and advertising in order to boost the sales of their software security products[40].

It is too early to establish how this third phase of competition will affect the industry structure, but, for example, at the end of 1999, Computer Associates was already the second large seller of Internet security products just behind behind Network Associates with a world market share of 16.5%[41].

As it happened in other industries (Mitchell 1991), it seems that the large firms have applied a wait–and–see strategy until the new market was consolidated, and only after that, they decided to enter exploiting their commercial and downstream strength. If it was a rational successful strategy for large established firms, it is still daring to demonstrate.

However, it seems a classical case of a trade–off between the advantages of late entrants and first movers (Mueller 1997). If startups were been able to achieve sound and not easily imitable first mover advantages, it could be the case that ESI will be constantly dominated in the future by small–medium specialized firms, with an industry structure characterized by an innovative division of labor (Arora and Gambardella 1994).

Otherwise, if first mover advantages will be small, compared to the technological and commercial strength of large established firms, ESI will be seen as a good case study to understand the role played by new firms in the exploration of new technological fields and in the formation of new market niches that in the long run will be served by large firms.

Actually we could not provide any sound evidence to assess which of the two scenarios have the highest probability to appear, but we think that the study of the ESI has given important improvements and evidence in the theory of firm formation, growth and exit that we will summarize in the next section.

[39] "H&P and IBM go head to head on Net Security", *Unix and NT News*, Feb. 1999

[40] "The Root of the Net Problem", *eWeek*, Jun. 2000

[41] "Worldwide Internet Security Software Market to close in on $ 4.4 billion in 1999", *EDP Weekly's IT Monitor*, 40(32), 1999

5 Conclusions

In this paper we analyzed the birth of a new niche market in the software industry. We focused on the process of entry by new firm formation and post–entry performance. We depict the different phases of competition and the strategic responses of the main actors. Finally, we provide some evidence on the late stages of evolution of the ESI, particularly discussing the entry by large established firms.

We believe that this paper brings novel evidence about industry dynamics and competitive interactions, opening further discussion for many industrial policies issues.

Reviewing the paper with a bird–eye view, we have shown the strict link between innovation and new firm formation, where innovation is the key to open new market niche, avoid entry barrier, discovering new potential customers.

Then, we stress the importance of patents as a tool to protect knowledge assets. The fact is of particular interest especially in the software industry, where theoretically patents have usually played a minor role. But in ESI, patents helped to build a market for technology that was essential in the shaping of the competitive outcome.

The double nature of competition experienced by new firms during the industry evolution was one of the major topic of the paper. We have seen how, after a first classical technological competition, followed a second type of competition process. This dymanics put in the first place the firm capacity of exploitation of the economies of scope from its technological resources in terms of product differentiation, geographic expansion, organizational innovations, surrounded by a co–evolution of organizational skills and strategic actions.

Sound evidence has confirmed the importance of small firms in opening new markets where large firms, for several reasons, have low incentives to invest. This should be kept in relation to the increase of social welfare in terms of a broader product supply.

Moreover, we have highlighted how large established firms acted as incubators of technological competencies embedded in the future firm entrepreneurs, and also as incubators for managerial and financial practices of the high experienced executives which joined the startups in the second phase of the industry evolution.

The late phase of competition where firms that operated on the market are threatened by new entrants, both new small startups and large firms, imply new challenges for all the organizations.

Concluding, we believe to have demonstrated how the size is an important determinant of firm ability to survive in young and competitive industries, but size is not an exogenous variable, being strongly affected by firm technological, strategical and organizational capabilities, that should be tuned according to principles of coherence and dynamic competition.

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List of Figures

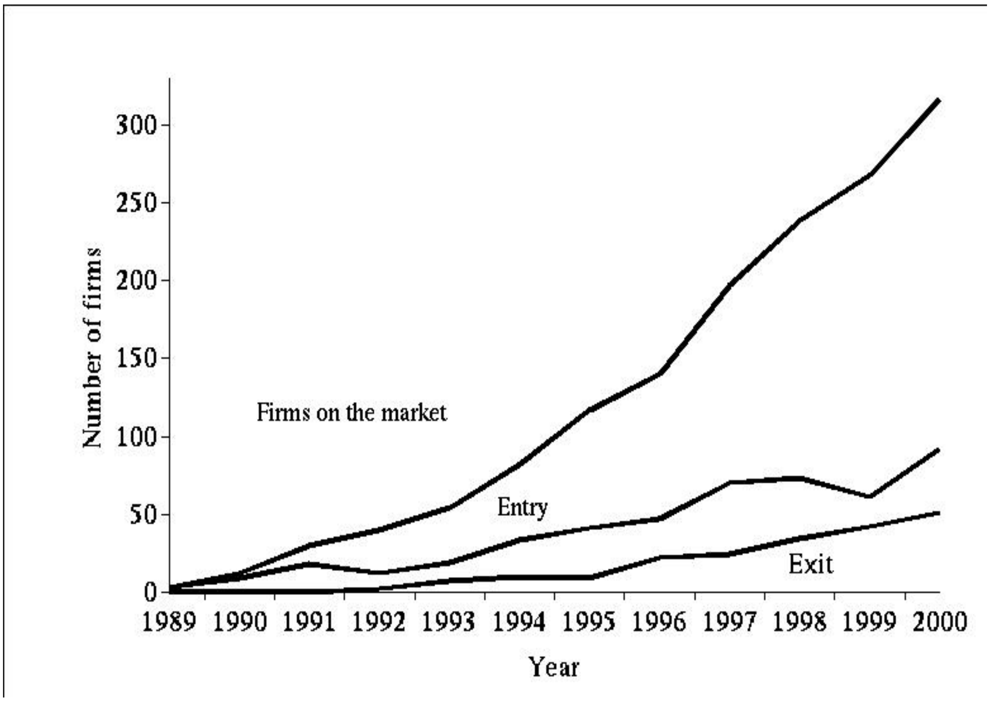


Figure 6.1: Entry, exit and firms on the market in ESI, 1989–2000

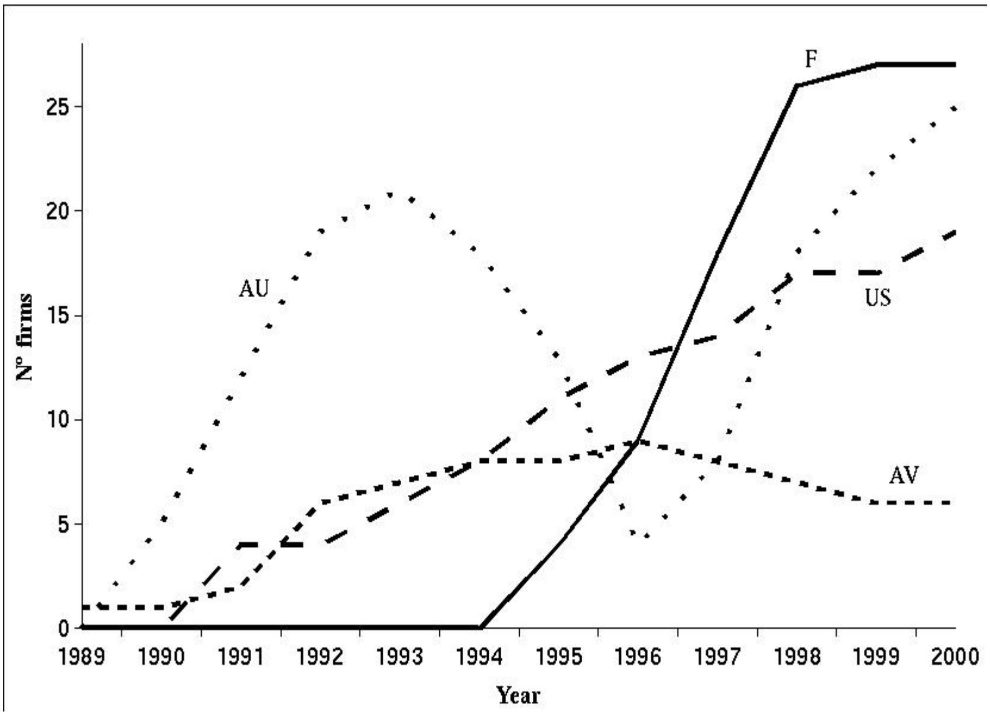
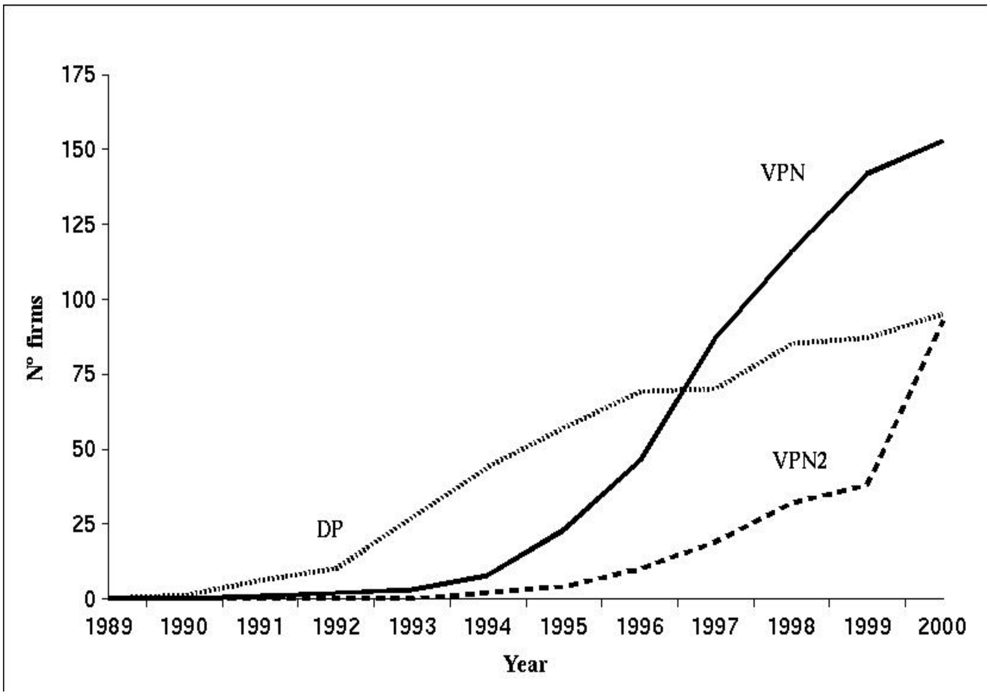


Figure 6.2: Firms on the market in ESI by niche (personal PC product), 1989–2000. 1


175
150
125
100
75
50
25
0
Nº firms
1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000
Year
VPN
DP
VPN2

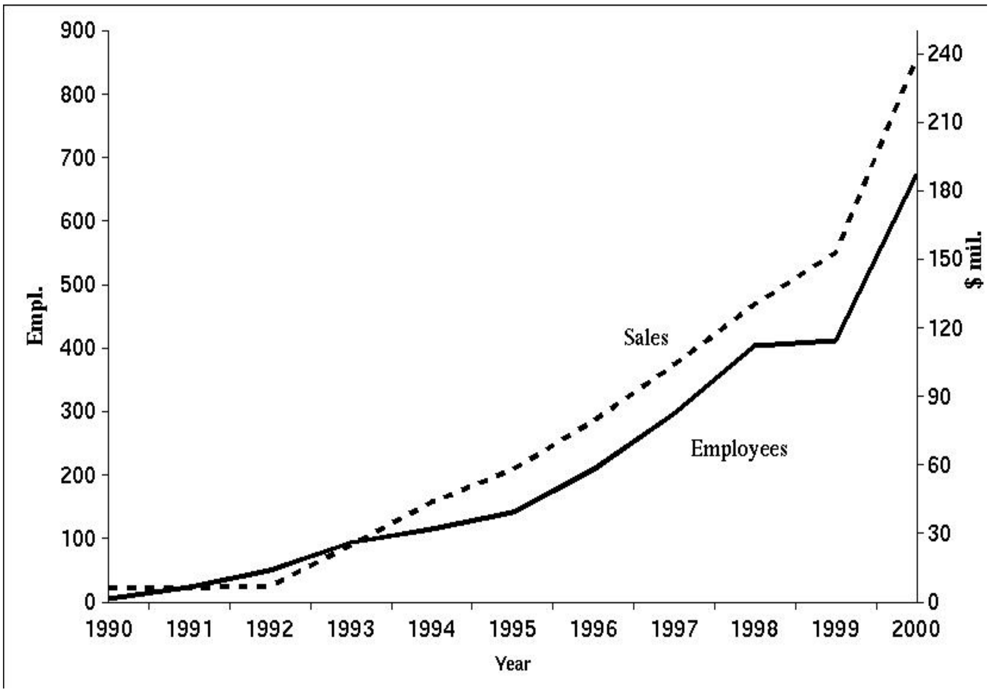


Figure 6.4: Average sales and employees of top 15 startups in ESI

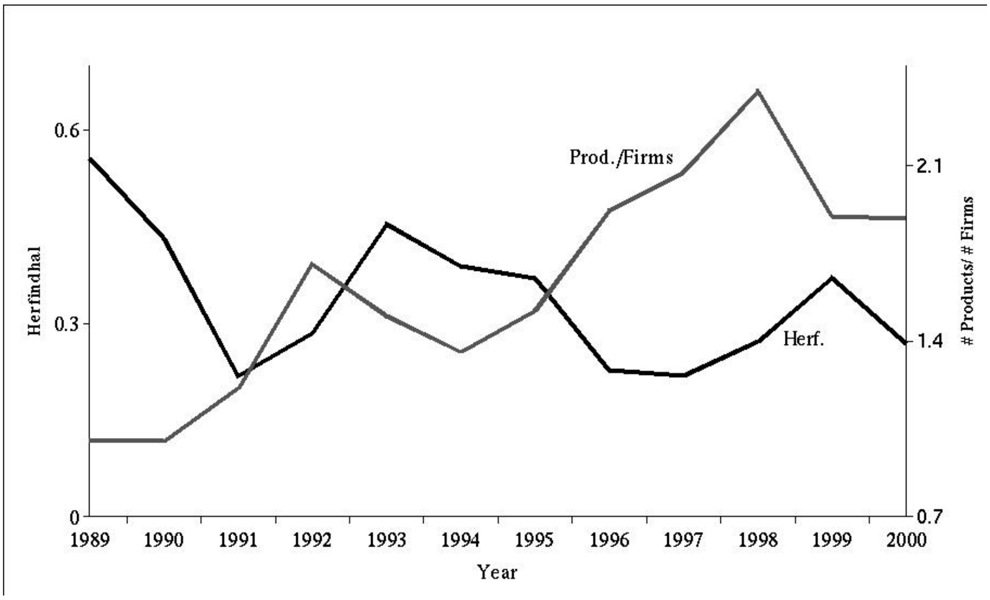


Figure 6.5: Product supply and average firm diversification

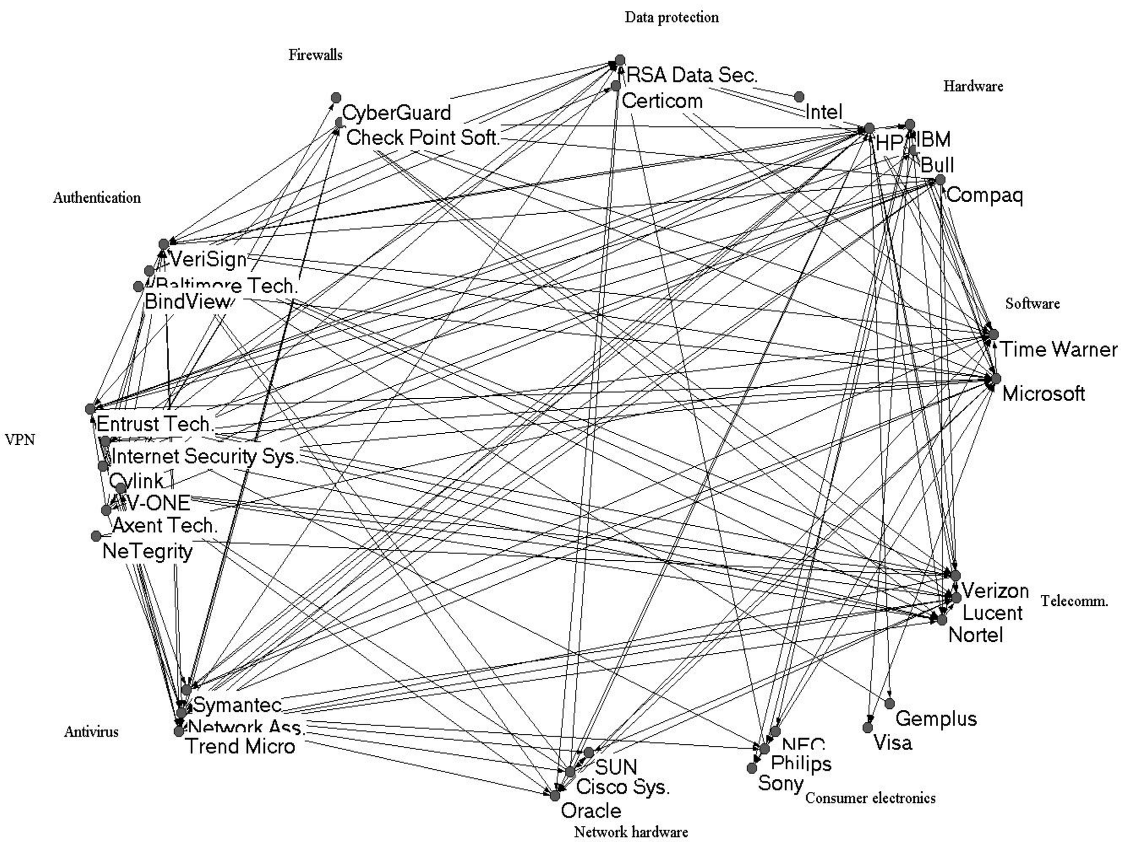


Figure 6.6: Network of technological alliances, top firms by niche specialization, 1993–1999

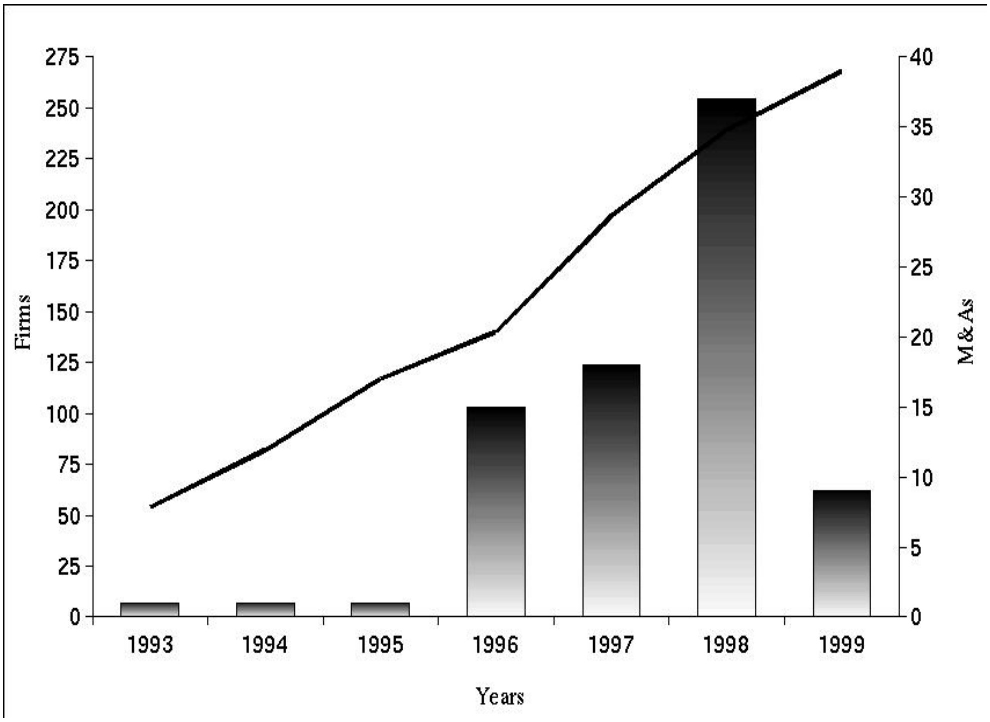


Figure 6.7: M&As and number of firms on the market

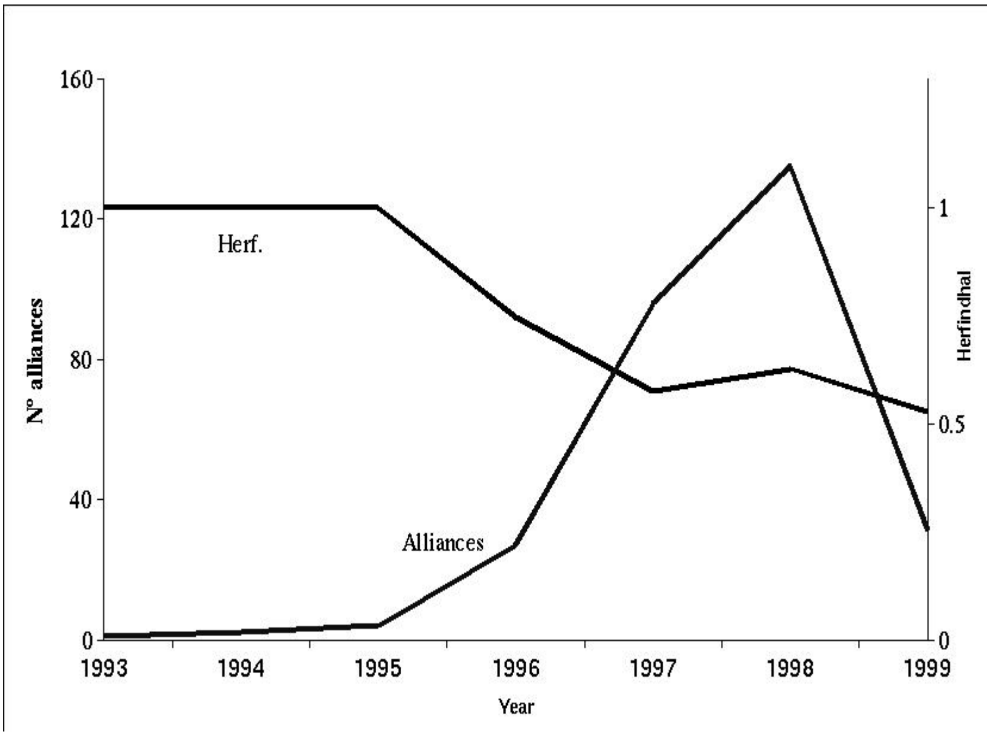


Figure 6.8: Number of commercial alliances and geographic concentration, 1993–1999

List of Tables

Firm	Sector	Citations	Patents	C/P Ratio
IBM	Computer	528	46	11.47
Motorola	Telecom	226	24	9.41
Scientific Atlanta	Telecom	202	18	11.22
Pitney Bowes	Computer	165	16	10.31
Qualcomm	Electronics	97	3	32.33
AT&T .	Telecom	97	8	12.12
Pioneer	Electronics	95	9	10.55
Philips	Electronics	95	7	13.57
Aisin Seiki	Cars	83	6	13.83
Stanford University	University	80	2	40
M.I.T.	University	75	2	37.5
NEC	Electronics	72	6	12
General Instrument	Electronics	68	8	8.5
NCR	Computer	63	5	12.6
Hitachi	Electronics	62	4	15.5
VISA	Services	53	2	26.5
Total		2061	166	17.34
Other		2520	224	11.81

Table 6.1: Most cited firms, pre–sample patents 1977–1992

Year	Citations(C)	Patents(P)	C/P Ratio
1976	19	2	9.5
1977	194	7	27.71
1978	110	7	15.71
1979	50	5	10
1980	189	19	9.94
1981	167	14	11.92
1982	160	14	11.42
1983	165	12	13.75
1984	181	16	11.31
Average	137.22	10.66	13.47
Average 85–92	552.5	250.5	2.20

Table 6.2: Previous patents (1976–1984) cited by "1993–1999" patents

Label	Description	Sic code
AU	Authentication and Digital Signature	7372663
AV	Antivirus	7372612
DP	Data storage protection	7372691
F	Firewalls	7372681
US	Utility software	7372614
VPN	Network Software Security	7372611
VPN2	Virtual private network access	7372613

Table 6.3: Product niches in ESI

	Technological licenses			
Rank	Main licensors	$N°$	Main licensees	$N°$
1	RSA Data Security	23	IBM	12
2	Certicom Corp.	13	H&P	8
3	Network Ass.	10	Time Warner	4
4	Entrust Tech.	5	Microsoft Corp.	3
5	Check Point Software	4	Compaq	4
6	Macrovision	4	NEC	3
7	VeriSign	4	Network Ass.	3
8	Diversinet	2	Lucent	3
9	Cylink	2	Rainbow Tech.	3
10	Finjan Software	2	Secured Comm.	2
	Product software contracts			
Rank	Main sellers	$N°$	Main buyers	$N°$
1	VeriSign Inc.	10	Verizon	6
2	RSA Data Security	8	IBM	5
3	Secure Computing Corp.	5	H&P	4
4	Check Point Software	4	Visa	4
5	Network Ass.	4	NSA	2
6	Cylink Corp.	4	Infonet Corp.	2
7	Entrust Tech.	4	KPMG	2
8	Cisco Systems Inc.	4	Microsoft Corp.	2
9	Axent Tech.	4	Time Warner	2
10	Baltimore Tech.	4	Sun Micr.	2

Table 6.4: Main buyers and sellers of products and technology in ESI, 1993–1999

Entrepreneur's characteristics	Factors influencing firms birth–rate
Low risk aversion	Business opportunities
Valuable information	Incremental profits
Job frustrations	Financial constrains

Table 6.5: Theoretic approaches on entrepreneurship

Firm	Founder	Inventor	Previous founder's firm
			Large Firms
Aventail	C. Hopen		CompuServe and Boeing
Certicom	P.Panjwani	√	Motorola
Cyberguard	B.Murray	√	Harris Corp.
Cylink	L.Morris		Xerox
Entrust Tech.	B. O'Higgins	√	Nortel
F–Secure	R. Siilasmaa		Large Finnish and intern. firms
Network Ass.	W. Larson	√	Apple and Sun Micr.
Network Ass.	J. McAfee	√	Lockheed Martin
Rainbow Tech.	W. Straub		GTE and Compaq
RSA Data Security	C. Stuckey		IBM
RSA Data Security	R. Rivest	√	MIT, Pitney Bowes
Safenet	A. Caputo	√	Computer Ass.
Secure Comp.	K. Beseke	√	Honeywell and Motorola
Trend Micro	S. Chang	√	H&P
			Small firms
Aventail	E. Kaplan	√	ELDEC, aerospace firm
Baltimore Tech.	B. Khezri		VPNet Tech., Network security firm
BindView Dev.	E. J. Pulaski		Network Res., systems integrator
NeTegrity	B. Bycoff		SDC, software distributor
SystemSoft	R. Angelo		Phoenix Tech., a software maker
VeriSign	J. Bidzos		RSA Data Security
			University and Govern. Agencies
Aladdin	Y.Margalit	√	Hebrew Un.
Certicom	S. A. Vanstone	√	Professor of Mathematics
Check Point Soft.	G. Shwed	√	Optrotech, Israel Defense Forces
Check Point Soft.	M. Nacht		Optrotech, Israel Defense Forces
Digimarc	G. Rhoads	√	Oregon Un.
Rainbow Tech.	A. Jennings	√	Mathematician
Safenet	A. Hastings	√	National Security Agency
Symatenc	G. Hendrix		Stanford Un.
V-ONE	J. F. Chen	√	Intelsat
V-ONE	J. Wang	√	Intelsat

Table 6.6: Startup founders and their origins

Rank	Firm	Revenues ($ml)	World market share
1	Network Ass.	990	0.171
2	Symantec	578.4	0.099
3	RSA Data Security	171.3	0.029
4	Check Point Software	141.9	0.024
5	Rainbow Tech.	109.2	0.018
6	Axent Tech.	101	0.017
7	Trend Micro	86.2	0.014
8	Secure Computing	61.4	0.010
9	Entrust Tech.	49	0.008
10	Cylink	42.8	0.007
11	SystemSoft	42.6	0.007
12	VeriSign	38.9	0.006
13	BindView	38.5	0.006
14	Aladdin	36.1	0.006
15	Safenet	23.2	0.005
	Total	2487.3	0.429

Table 6.7: Market share in 1998 for top 15 startups

	Years 1989–95	Years 1996–2000
Description	$N°$ of prod.	$N°$ of prod.
Authentication and Digital Signature	26	39
Antivirus	21	11
Data storage protection	104	207
Firewalls	7	89
Utility software	15	22
Network Software Security	39	340
Virtual private network access	0	242
Other	23	83
Total	235	1033
Concentration Index		
Herfindhal	0.253	0.214
C2	0.608	0.529

Table 6.8: Products by market niche in ESI, 1989–95 and 1996–2000

Rank	Firm	N° of all.	Tech. All./Sales ($ mil.)
1	RSA Data Security	39	0.406
2	Microsoft	27	0.002
3	Check Point Soft.	19	0.273
4	Network Ass.	18	0.053
5	VeriSign	17	0.167
6	H&P	14	0.000
7	Time Warner	13	0.005
8	Internet Security Syst.	12	0.230
9	IBM	12	0.000
10	Entrust Tech.	11	0.235
11	Cisco Syst.	11	0.001
12	Axent Tech.	11	0.315
13	Compaq	9	0.000
14	Certicom	8	1.730
15	Baltimore Tech.	7	0.128
	Sample average	5.877	0.099
	Sample stand.dev.	7.107	0.272

Table 6.9: Top firms for technological alliances in ESI, 1993-1999

Rank	Firm	$N°$ of all.	All./Sales ($ mil.)
1	Network Ass.	28	0.083
2	RSA Data Security	22	0.229
3	Axent Tech.	14	0.402
4	VeriSign	13	0.128
5	Computer Ass.	10	0.003
6	Check Point Soft.	10	0.144
7	IBM	10	0.000
8	Time Warner	9	0.003
9	Secure Computing Corp.	8	0.297
10	Microsoft	7	0.001
11	CyberGuard Corp.	7	0.189
12	Internet Security Systems	7	0.134
13	Baltimore Tech.	6	0.110
14	Entrust Tech.	6	0.128
	Sample average	4.411	0.077
	Sample Stand.dev.	5.194	0.185

Table 6.10: Top firms for commercial alliances in ESI, 1993–1999

Firm	Geographic		Areas		
	Latin America	Australia	Middle East	Asia	Europe
Aladdin	0	0	1	1	4
Baltimore Tech.	1	1	1	4	8
Binview Dev.	2	1	1	0	4
Checkpoint Software	0	1	1	3	10
Cylink	0	0	0	1	2
EntrustTech.	0	0	0	2	8
Network Ass.	3	2	2	6	18
Netegrity	0	1	0	2	6
Rainbow Tech.	2	1	1	2	3
RSA Data Security	0	1	0	2	2
Safenet	0	0	0	0	1
Secure Comp.	0	1	0	3	3
Symatenc	1	1	1	6	16
Systemsoft	0	0	0	2	0
Total	9	10	8	34	85

Table 6.11: International subsidiaries by top 15 startups in ESI, 1999

Firm	CFO	Years after entry	CFO's origin
Aladdin	E.Rosen	3	BASF (chemicals)
BindView	E. Pierce	5	Metamor(S), Arthur Andersen(C)
Certicom	G.Capitolo	4	Coopers–Lybrand(C), Network Ass.(S)
Check Point Soft.	E. Desheh	6	Bezeq(TLC), Bank Hapoalim(B)
CyberGuard	M. Matte	5	Intime Syst.(S), PWC(C)
Cylink	R Chillingworth	5	Ernst–Young(C)
Digimarc	E. Ranjit	4	TriQuint(SEM)
Entrust	D. Thompson	6	Nortel(TLC)
F-Secure	M. Pirskanen	7	JOT (conglomerate)
Netegrity	R. Sommer	5	Revenio(S), OpenMarket(S), PWC(C)
Network Ass.	S. Richards	2	E*Trade Group (S), Coopers–Lybrand(C)
Rainbow Tech.	P. Fevery	8	KPMG(C)
RSA Data Security	J. Kennedy	6	Natural MicroSystems(TLC), Ultimap(S)
SafeNet	C. Argo	8	Optelecom(TLC), Deloitte–Touche(C)
Secure Computing	T. Steinkopf	8	Silicon Ent.(S)
Symantec	G. Myers	5	Novell(CMP)
Trend Micro	M. Negi	8	Merrill Lynch(B)
VeriSign	D. Evan	1	Portal(S), Identix(S), KPMG(C)
V–ONE	J. Nesline	6	British Aerospace

Table 6.12: Chief financial officers of top 15 startups in ESI, 1999