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Fabrizio Cesaroni *

In-Sat Lab, Scuola Sant'Anna and University of Lecce

Alberto Di Minin

In-Sat Lab, Scuola Sant'Anna

Andrea Piccaluga

In-Sat Lab, Scuola Sant'Anna and University of Lecce

Industrial R&D in Italy: What are new dynamics of exploitation and exploration?

Corresponding author
email address: cesaroni@sssup.it

IN-SAT Laboratory
Piazza Martiri della Libertà,33
56127 Pisa (Italy)
Phone: +39 050 883 805
Fax: +39 050 883 839

http://www.insat.sssup.it/
Scuola Superiore Sant'Anna

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1. Introduction

The competitiveness of several European countries is severely threatened by their uncomfortable position between areas which are very active in the introduction of new high-tech products and services (mainly the US and Japan), and others which are exporting manufactured products and (to a certain extent) services at very low prices, due to their very low labor costs. In some cases, this second type of countries also shows an increasing share of high-tech products and services – and not only of fairly traditional ones.

As it has been widely acknowledged, the most concrete solution that European countries can adopt in order to move towards higher value-added and more difficult to imitate products and services is to increase their investments in Science and Technology (S&T). This is continuously reaffirmed at European level (see for example the ambitious Lisbon targets), although at both European and national levels both the widespread concrete willingness and the real possibility of achieving such results is to be taken for granted. In fact, among other factors, the social accountability of investments in research is not always easy, and this generates negative effects in periods of little economic growth, such as the current ones.

Within this framework, the objective of this paper is to discuss the main features of the Italian research system, and particularly the role played by the largest Italian companies. The Italian case is in fact paradigmatic for several reasons. First, compared to the other European countries, Italy has shown the smallest average annual real growth in total R&D investments and a -1.2% annual decline in R&D intensity (against a 0.4% annual growth of EU-15) during the last years (DTI, 2003). Second, the Italian national system of innovation is generally defined as a *dual system*, with a large component of many SMEs in traditional sectors, which innovate but show low R&D spending (the so called "innovation without R&D" model), and a small core of a few large technology-based companies, often former monopolists and former State-owned companies. SMEs account for a very large share of national GDP and total employment in Italy, but are also the most vulnerable building block of the current global competitive arena.

While Italian R&D investments are scarce in both its public and private components, the largest gap from the average of most advanced countries seems to come from private firms, and especially from the largest companies. Indeed, these companies have shown a major weakness in defining robust medium and long-term R&D strategies (Bonaccorsi, 2003). During the last decades, the Italian industrial system could exhibit relevant presences and an early involvement in several sectors with innovative perspectives, such as chemicals, transports, information technologies, telecommunications, and electronics. However, for reasons that have traditionally been associated to mismanagement and poor political planning, these positions were gradually lost, and in several sectors large firms have disappeared. The current situation can be defined as one of "industrial decline" (Gallino, 2003).

As a matter of fact, it can be argued that Italy:

(i) has lost promising technological sectors,
(ii) occupies the very last positions in Europe with regard to inputs, outputs and other variables related to technological innovation (DTI, 2003),
(iii) has only a few companies which operate at a global scale (e.g. the number of Italian companies listed in the Fortune 500 rank keeps declining over time),
(iv) attracts much less foreign investments than many other European and non-European countries.

Against this overall negative background, positive features of the Italian industrial system do exist, and represent possible strengths and potentialities that can be exploited in the future. Among others, it is worth recalling the traditionally strong entrepreneurial spirit of the country. Italians have historically showed the capacity to adopt innovative business behaviors. Furthermore, even though the innovative level of the system has declined over time, the educational and scientific

system has maintained its quality, both in terms of scientific publications and human resources formation. Finally, public research has performed quite well in emerging sectors such as nanotechnology and genomics, where a few excellent results have been achieved.

In this paper we aim at exploring the role played within this context by large Italian firms. Large firms' R&D strategies and investments have been proposed as crucial elements of European national innovative systems, especially for low spending countries such as Italy. In general terms, large firms (with 500 employees and more) account in Italy for about 32.6% of total R&D expenditure and for about 0.4% of R&D as a percentage of GDP (DTI, 2003). They employ roughly 21.9% of total labor force in Italy[2] . They therefore represent exactly the component in the Italian national innovation system, which is urgently called for a sharp discontinuity with regard to its commitment to S&T. In this paper, we focus on some of the largest Italian firms in different sectors, in order to analyze their technological strategies and discuss their managerial approaches. In section two to four, we discuss the cases of Fiat Research Center (CRF), Pirelli Labs, Telecom Italia Lab (TILab), and StMicroelectronics (ST). An analytic framework to look at these four cases is suggested in section six. Section seven concludes.

2. Autonomy and technology transfer: the case of Centro Ricerche Fiat (CRF)

The first case we discuss is Centro Ricerche Fiat (CRF), which can be considered a quintessential example of how large companies can manage their R&D activities in order to both satisfy budget constraints and to maintain high, international standards. CRF is one of the 12 subsidiaries of the Fiat Group, it employs more than 900 workers, and its 2002 revenues were 111 million Euros. CRF has been founded in 1976, and since 1979, it became an independent center of the Fiat Group, with significant autonomy in terms of strategic decisions. At corporate level, Fiat maintains the definition of economic and financial rules for the management of human resources. CRF's 25 million Euros book capital is completely owned by the other subsidiaries of the Fiat Group, with Fiat Auto, Magneti Marelli and Iveco owning the largest shares.

Technology management scholars and practitioners have emphasized the fact that CRF has managed to increase progressively its turnover and employment despite the fact that in the last two decades, a couple of very serious crises of the Fiat Group forced the other subsidiaries to significant decrease in the turnover. CRF has achieved important results (among others, in technology transfer, internal organization processes, European projects) through a mix of innovative strategies and good management practices. Significant autonomy from the mother company and efforts to find new clients for its (research) outputs among large and especially small firms, -- quite often Fiat mechanical suppliers -- are key aspects of CRF current strategy.

The degree of independence of CRF from the Fiat Group can be first appreciated by looking at the composition of the turnover. Approximately 48% of CRF's turnover comes directly from the rest of the Group, while the remaining 52% comes from external sources. This latter is then subdivided into public funds received from the participation to national and European research programs, and transfers from firms external to the Fiat Group – especially SMEs – for technological services.

The increasing independence from the mother company is also the result of relevant historical events. In 1993, most Fiat sectors reacted to the industry's crisis by refocusing their activities and by reducing the overall number of employees. CRF took the opposite direction. Instead of laying off researchers, CRF tried to diversify the sources of revenues, by increasingly taking part to publicly funded research programs, and by offering its services to customers external to the Fiat Group - not a strategic target in previous periods. This strategy was mainly the result of a long-term vision of CRF's top management, and led to positive results. The early success of this choice gave CRF a sense of independence and dynamism much greater than what the simple budget figures could imply. The most relevant effect of this new approach has been an increasing attention

to technology transfer that, in the words of a widely cited CRF's slogan, becomes "CCCP – Competitiveness for Customers at Competitive Prices", meaning that research activities have to be permanently targeted at producing potentially valuable outputs for industrial users.

2.1. The "exploration" and "exploitation" strategies

In order to maintain a leading position in research activities and simultaneously promote an effective transfer of technologies inside and outside the Fiat Group, CRF's focus is both on long-term exploration and on short-term exploitation strategies. Funds to be devoted to the exploration of new technological trajectories cannot be directly linked to "finalized" orders, but they have to be maintained independent from any specific goal of technology transfer. Possible sources of such a type of funds are national and European funding agencies, which finance the participation to public research projects. For this reason, during the last decades, CRF has constantly increased the participation to such programs. At the European level, from 1991 to 1996, Fiat (through CRF) has emerged as the European car producer with the highest number of projects approved and financed within the Brite-Euram program (see Tab. 1 concerning the last two years). During the 1999-2002 period, 198 research projects proposed by CRF have been approved and funded within the Fifth Framework Program. Similar results were also obtained for the Competitive Growth and IST programs.

Table 1. Participation to the Brite-Euram programme

Car manufacturer	**1995**	**1996**
BMW	9%	8%
DB	19%	17%
Fiat (CRF)	26%	30%
Ford	2%	1%
Opel	3%	1%
PSA	10%	8%
Renault	10%	15%
Rover	3%	5%
Volvo	9%	10%
VW	9%	5%
Total	100%	100%

Source: our elaboration on Deiana (1996).

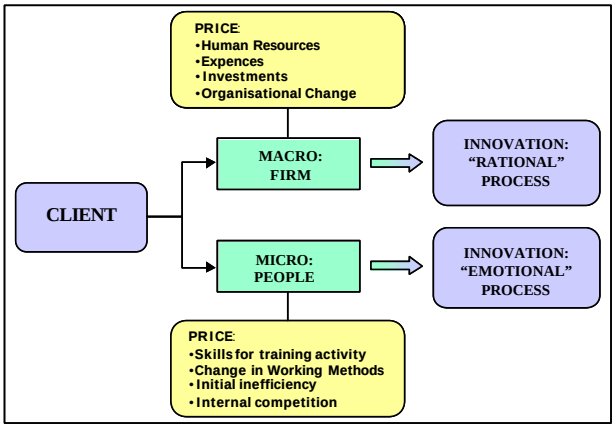
The participation to publicly funded research programs reveals the purpose of CRF to constantly increase its financial (and strategic) autonomy from the rest of the Fiat Group. Furthermore, this strategy allows CRF to have funds to be invested in pre-competitive research programs, and to collaborate with international partners for the same purposes. By participating to such international networks, CRF has the possibility to remain connected with the scientific community, and to enhance its research competencies and capabilities. These competencies will be then devoted to pursue short-terms goals of technology transfer.

Indeed, as far as technology transfer is concerned, CRF's activities are quite diverse. One of the most important is the search of "proper" clients, and the development of "proper" products (Michellone, 1995). CRF usually makes a thorough analysis of these activities before starting any transfer process, in order to identify concrete opportunities, the ways to transfer research results, and the existence of strategic constraints. CRF's strategy primarily derives its strength from a clear focus on customers. The identification of customers and their needs represents the first, initial phase of the process, and research activity follows in a later stage. Results only come at the end.

At the same time, the focus on customers has a deeper meaning as well. For many firms - especially SMEs - the introduction of innovations and new technologies often represents a drastic

change in their organization, routines and capabilities. Accordingly, CRF identifies the proper persons within customers' organizations in order to start an effective interaction with them. CRF makes a distinction between macro- and micro-clients. *Macro-clients* are usually identified in clients' top managers (the entrepreneur, in the case of SMEs), who are among the first to perceive technological needs and are interested in financing an innovative project. On the contrary, *micro-clients* are the persons, within each firm, who will have to manage – and directly pay for – the innovation. While the former have an active role in the process, the latter have often a passive one. Thus, the distinction between these two categories of clients becomes relevant in order to define the "price" that each of them will be asked to pay for the innovation (see Fig. 1).

Figure 1. Segmentation of customers



Source: our elaboration on Michellone (2001).

The price macro-clients have to pay comprises the costs of additional investments and organizational changes needed to transform the introduction of a technological innovation into competitive advantages. On the contrary, micro-clients do not pay a "monetary" price for the introduction of a technological innovation. The more radical the technological change, the higher is the price they have to pay in terms of new skills, competencies and knowledge they have to learn and adopt. The adoption pattern has in this case strong emotional features, and a complete success can be guaranteed only by reducing obstacles to the transfer, and by avoiding the "not invented here" syndrome.

As far as products are concerned, CRF's policy is to define products by using a four-level scale: a) *generic products*; b) *expected products*; c) *integrated products*; and d) *potential products* (Michellone, 1995). By moving from the first to the fourth level, additional features and characteristics are added to the new products, in order to satisfy, not only minimal customers' expectations, but also their latent expectations and considerations related to customers' competitiveness. At the forth level of the scale, the markets where customers operate have to be taken into account. The goal is that, by introducing the new technology, CRF's customers can respond to *their* customers' needs.

CRF's effort is to define products at the fourth level, even though this goal implies both a relevant technological, organizational and managerial effort. CRF's researchers are required not only to integrate know-how and competencies from different technological areas, but also to analyze the complex environment in which customers usually operate. Customers' success depends on the fact that their network of suppliers, distributors, and other external agents is able to positively react to changes induced by the new technology. In turn, CRF's success is strictly related to its capacity of preventing these changes, and the tensions that will emerge with the external system of relationships.

2.2. Knowledge transfer and the transfer of human resources

CRF's attention to technology transfer and to the proper definition of outputs to be transferred is paralleled by a similar attention on the management of human resources. In fact, the transfer of human resources - i.e. of those CRF's researchers actively involved in the development of the technology to be transferred - often complements the technology transfer process. The transfer of human resources ensures that their tacit knowledge is transferred with the technology. In this sense, cognitive problems in technology transfer are almost completely resolved.

Advantages of this approach are twofold. From the customer's viewpoint, the transfer of human resources makes technology transfer completely effective, simply because those researchers are specifically trained for a specific technology. From the point of view of CRF, those same researchers represent the future preferred interface between CRF and the customer itself, and this network allows CRF to create even stronger linkages with its clients' portfolio. In turn, this approach increases customer's loyalty, as it creates mechanisms of cognitive and organizational lock-in, and increases customer's costs of moving to different suppliers.

However, this approach creates internal problems with regard to the management of human resources. CRF's reaction to this problem is to constantly map its internal competencies, in order to identify those that can be transferred, and those that have to be acquired. Researchers are distinguished according to the competencies they possess, in terms of *core*, *standard*, and *actual* competencies (Hamel and Prahalad, 1994). Actual competencies are usually transferred to external customers. Indeed, their presence is a key competitive factor for CRF concerning actual products, processes and methodologies, but not in the long-run. In the long-run they have to be either sold or re-trained. At the same time, these competencies are key for the CRF's customers, and often become *the* core competencies of the customers. By transferring those resources to customers, CRF obtains a direct economic benefit, and an indirect benefit in costs reduction. As a matter of fact, CRF annually transfers a relevant share of its researchers to external firms. In the last ten years, the average annual turnover of researchers has been about 8.9% (Michellone, 2001).

3. Pirelli: when the market for firms becomes the market for technology

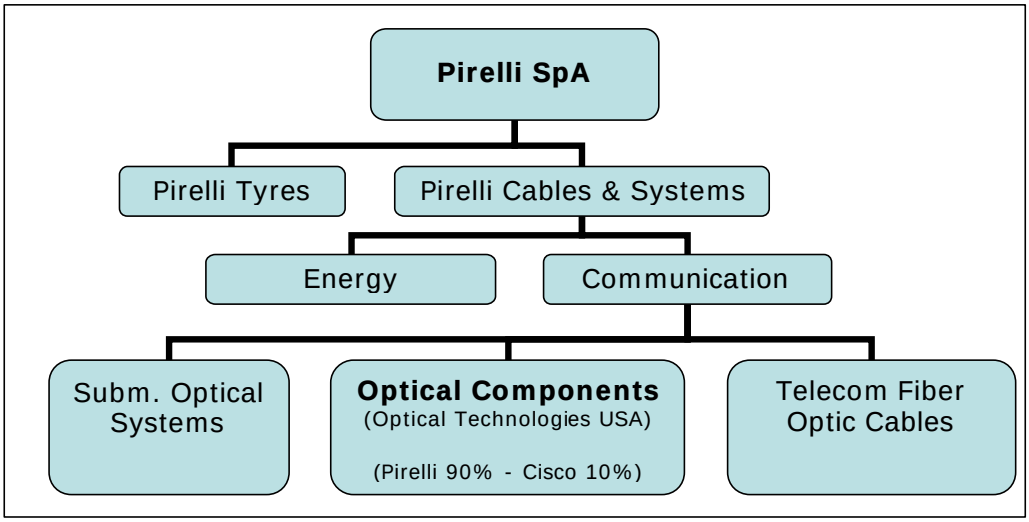
Another relevant example of industrial R&D in Italy is that of Pirelli, which attracted the attention of international business and financial press at the end of year 2000, when it closed a deal with the American company Corning for the sale of its optical division. That agreement represented an extreme but quintessential example of the strategies that companies can pursue for the exploitation of successful technological outcomes. Hence, it is worth trying to summarize the main details of the agreement and analyze the motivations that brought Pirelli to sell a whole division of its company, and Corning to invest such an exceptional amount of money in it.

Pirelli's main businesses are centered on the key markets of tires, energy cables and systems, telecom cables and systems and real estate, in most of which Pirelli maintains a leading manufacturing and innovative position. Worldwide, the Pirelli Group coordinates several affiliates in 24 countries. In 2002, Pirelli's consolidated revenues reached 6,7 billion Euros and operating profits amounted to 118 million Euros. At the beginning of 2003, the Group employed approximately 37,000 people worldwide[3].

Before 2001, the Pirelli group comprised two main divisions, *Pirelli Tyres* and *Pirelli Cables & Systems*, which provided about 40% and 60% respectively of total turnover[4]. The Cables & Systems division was further divided into the Energy and the Communication divisions, and Communication was finally composed of three branches, Optic Cables, Optical Components and Submarine Optical Systems. As shown in figure 2, the optical components research and manufacturing activities were conducted by an American subsidiary of Pirelli (partly owned by

Cisco Systems), based in Delaware. This (small) company, named Optical Technologies (OT), was the target of the Corning's deal.

Figure 2. Pirelli's business structure, Year 2000



Source: http://www.pirelli.com/en_42/this_is_pirelli/investor_relation/file_pdf/corning_deal.pdf.

While OT's contribution to the total revenues of the Pirelli's group was marginal, Corning's evaluation of the venture was 167 times its 2002 revenues of about 22 million dollars. Corning ended up paying 3.6 billion dollars for Pirelli's 90% share of the company. In order to fully understand the motivations behind such a price, it is worth recalling the competencies of OT and comparing the different business strategies pursued by Corning and Pirelli.

OT's activities were directed towards the development and manufacturing of optical components and technologies, such as modulators, pump lasers, filters, compensators, and so on. Particularly relevant were the technologies for the production of lithium niobate modulators, and of submarine 980-nm pump diodes, to be used in high-speed, long-haul optical communication networks. These two technologies were particularly relevant to Corning. Indeed, by adding the lithium niobate technology to its technological portfolio Corning enhanced its position as a supplier of photonic products to optical layer companies. Furthermore, the OT's capabilities in pump lasers for submarine use directly complemented and supplemented Corning's terrestrial pump capabilities (CED, 2000).

From Corning's point of view of, the real value of OT was not in its market share or manufacturing capabilities, but in its technological competencies. In the words of Pirelli's chairman, Marco Tronchetti Provera, "Corning saw hidden value" in the firm's optical patents (Business Europe, 2000). This was the main motivation for Corning's decision to pay such a high revenue multiple of OT. Corning, indeed, was investing heavily in the optical fibers telecommunication systems, and was aiming to become one of the few market leaders in such a sector. The technologies developed by OT could play a particularly important role. Furthermore, the optical communication market was expected to grow very rapidly in subsequent years, so that the amount paid to Pirelli could be considered coherent with expected future profits.

Pirelli, on the other hand, had very different strategic needs. Optical components were of marginal importance in Pirelli's business portfolio. The core activities traditionally were in tires, and more recently in optical fibers and cables, and in energy cables. In order to become competitive in the optical component market, Pirelli had to have a market share much larger than OT's actual market share. At the same time, OT had developed relevant technological competencies patiently waiting to be exploited. Therefore, by selling OT to Corning, Pirelli had the possibility to extract the maximum value from its technological assets in optical components, and to reinvest the money earned in the sale in order to reinforce its core businesses. As a matter of fact, it is argued by several

analysts that much of Corning's money was used by Pirelli's chairman to buy Telecom Italia, the most important Italian telephone company (see next section).

The key point of the Pirelli-Corning case is that when complementary technologies have to be combined in order to offer a complex system, the ownership of only one part of the whole technological system does not allow the owner to extract all the possible rents. In this situation, the greatest value goes to the institution that controls and integrates the different components. While Corning was clearly acting in order to pursue such a goal, Pirelli's competencies were limited to a marginal – albeit extremely valuable – aspect of the entire technological system. Furthermore, this asset was far enough from Pirelli's core business, and it would have required strong investments in complementary assets and technologies to be fully exploited. As it has been recently emphasized (Arora *et al.*, 2001), the possibility to have a market for technologies and technological competencies represents an additional, valuable option for those firms with strong technological capabilities, but weak complementary assets. The acquisition of firms (or parts of firms) represents an extreme but attractive solution to operate in the international market for technologies.

4. From monopoly to technology exploitation: the case of TILab within the Telecom Italia Group

4.1. Dealing with turbulence in the telecommunication industry

During the Nineties, research centers of the main telecommunications (Tlc) operators went through relevant changes that changed both the technological and competitive arena. The convergence of Tlc and Information Technologies (IT) led to a complete revision of the business. Incumbent Tlc operators had to review their key competencies, and had to identify new partnerships and sources of knowledge.

The deregulation process led to the emergence of new actors, which made the market more fluid and complex; in several cases incumbents for the first time faced a real competitive environment on the domestic markets. Consequentially, profitability and competition for new markets, led to a stricter control of overhead costs, and in particular, those related to R&D activities. Former monopolists are still trying to find new ways to achieve or keep profitability in a rapidly changing industry, and are therefore setting new demands, objectives and pressures on their R&D centers.

As in the case of CRF, just discussed, one of the possible solutions was to let R&D centers to seek for additional financial resources, especially from outside their industrial group, and to *exploit externalities* from R&D activities. One of the main sources of profitability shifted from the architecture of a functional and efficient network infrastructure, to the definition of advanced services. Therefore, research that could previously focus on "hard components" (network) had now to look into "soft variables" such as services. That shrunk the time horizon of research projects and also called for a new kind of skills, competencies, and understanding of market dynamics that was much less required before. All this determined closer cooperation between (research) labs and (operating) departments. It seemed necessarily for the R&D center to incorporate the functions of an innovation hub (Leifer et al., 2000) able to gather innovative ideas inside the industrial group and to hunt for opportunities and talents wherever that was possible.

These strategic choices translated into internal spin-off and incubators, as well the setting up of specialized competencies for the marketing of inventions produced in the laboratories. New corporate venture capital activities were also used to detect and attract new ideas, technologies or business opportunities. In the rest of this section we will describe the strategic choices that Telecom Italia (the former monopolist Tlc operator in Italy), and its research center Cselt (later Telecom Italia Lab-TILab), attempted to implement in the 1999-2001 period. This attempt did not give the expected results, most probably because, after a phase of transition, its implementation lasted one

year only, before the control of the company changed hands in 2001. The new owners and management did not share the same strategic vision, and a new direction was followed.

4.2. Years of transition

Until 2001, the focus of Cselt/TILab was to promote research, experimentation and qualification in the telecommunication and information technologies. Its purpose was to make both short and long-term research, and to provide the best technologies and competencies for all the companies of the group. In 1999, Cselt personnel consisted in about 1,200 researchers. Its budget was about 280 billion Liras (approximately 140 million Euros). The flow of revenues from outside the Telecom Italia Group grew in the last years (see Fig. 3), showing a greater interest of the company for European and national research projects, and operations abroad. Overall, the research budget of the Telecom Italia Group was generating important results, comparable by quality – if not by quantity – with the results of other European and American competitors (Bonaccorsi and Giuri, 2003).

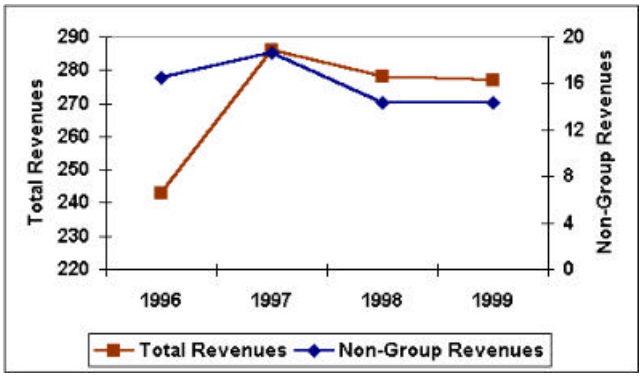
During the Nineties, Telecom Italia undertook radical changes, which affected the role and organization of its research labs as well. The first radical change was the privatization of the former public monopolist - although the Italian State retained golden-share privileges - and the consequent creation of the Telecom Italia Group. A second important event was Roberto Colaninno's acquisition of the group in February 1999. Colaninno was the Ceo of the Omnitel/Tecnost Group, the biggest (new) competitor of (incumbent) Telecom Italia. Antitrust laws prevented the creation of a new (private) quasi-monopoly, and Omnitel had to be sold. Colaninno adventure in Telecom Italia lasted two years. A new buyout in 2001 led the industrial group Pirelli to the control of Telecom. The Italian government chose not to interfere with these changes.

During this period, Cselt/TILab enlarged its mission and changed its organization. In 1997 a functional organization was introduced, and 11 areas were defined. Gradually, the 1997 organization changed into a "systematic solution", with a project-based division of labor, which allowed Cselt to answer more efficiently to the interdisciplinary demands coming from the other companies of the Group. The capacity to offer interdisciplinary and systemic solutions was clearly identified as one of the main asset of the lab.

In March 2001, TILab was reorganized in three business areas: Technology Integration & Research, Venture Capital, and ICT Skill Building. The objective of these changes was to create an extremely flexible organization, able to integrate new realities through the creation of autonomous units, partnership with external subjects, and financial participation to new entrepreneurial activities. TILab has also become the incubator for new innovative initiatives, both from internal scientific and technological activities, or only indirectly related to them, such as new strategic alliances, new business opportunities, and so on.

For almost two years, from 2001 to 2002, Telecom Italia Lab was the company of the Group devoted to promote innovation in the ICT field through the development of new technologies and the definition of new business opportunities by means of venture capital operations. TILab was founded in 2001 by merging the pre-existing Telecom Italia research center (the large and consolidated Cselt – Centro Studi E Laboratori Telecomunicazioni) and the young Telecom Italia "Venture Capital & Innovation" business unit, plus three other smaller research laboratories belonging to the same group – i.e. the Future Center in Venice (Italy), the Consumer Lab in Rome (Italy), and the Technology Observatory in San Francisco (CA). This independence was short-lived. One of the first moves of the new Pirelli management was to review the responsibilities given to TILab, and to move back the venture capital team to Telecom Italia. Today the center employs 1050 people, TILab is still strongly integrated in Telecom Italia, and no significant efforts are underway to integrate TILab and the research center of the acquiring group (Pirelli Labs) although synergies and integration of a few research projects is pursued.

Figure 3. Cselt Revenues (billions Italian Liras)



Source: Telecom Italia Lab, 2001.

4.3. The model of the innovation hub: internal gathering and external hunting

Cselt had always been an "observatory point" for new trends and technologies in the ICT sector. During the reorganization phase that we are describing and that concluded in 2001, these observatory activities have been strengthened with the introduction of new programs, resources and infrastructures that allowed TILab to interact more directly with organizations outside the group. Two are the categories of possible partners:

1. SMEs operating in the ICT sector,
2. "emerging talents" among TILab researchers and outside the group.

The goal was to hunt for partnerships (or acquisitions) and placements in TILab, and to gather innovative ideas within the labs, to translate them into profitable ventures. An important aspect of this technology transfer strategy was to exploit the spillovers from internal research activities. Moreover, the goal was to offer universities and SMEs financial instruments, competencies and infrastructures to develop entrepreneurial ideas.

The definition of a new Venture Capital Area was the final achievement of this business model. The role of a research center that operates on the venture capital market is to be an early spotter of emerging trends, technologies and possibilities. This is possible only if the observatory is located close to the sources of innovation, like universities, customers, users and other competitors. Such a position allows the research center to reduce transaction costs related to the exchange of information, knowledge, services and innovation.

Such a flow of know-how is indeed bi-directional, and needs to be built with a long-term perspective. It is therefore useful to have structures that are able to interact and use resources outside the group and to transform a vision or a clue into scenarios and business opportunities which can be developed inside or outside the Group. TILab assigned this task to the Future Center in Venice. In the first phase of its life (1999-2000), the Future Center had the role of being a sort of an incubator for SMEs and also to promote the uptake of telecommunication and information services in vertical markets. During the transition phase of 2000-2001, the goal of the center was to create a set of competencies for scenario building, in order to investigate how innovation could change the business and what kind of business opportunities could eventually arise. The Center became a point of reference within the Group, and for companies that wished to interact with Telecom Italia and outside the group or use some of the technologies and products of TILab research activities.

Historically the focus on internal human resources had been a top priority for Cselt/TILab. The research center was traditionally considered the place that "forges the competencies" needed for the group, and transfers them, both in terms of new ideas and projects and in terms of technical personnel to the rest of the group.

In 1999, the management implemented relevant changes to the professional system of the firm, qualifying three different roles, the *technical leader*, the *project manager*, and the *competence* (or cluster) *manager*. These reforms reflected the adoption of a matrix model of the business units. Moreover during the same year, Cselt started a program to facilitate mobility within the various areas of the Center, and technical update.

Besides the activities of traditional competence retention, in 2001 TILab started to support internal spin-off processes and incubator structures, in order to promote a sort of "controlled spillover" of its personnel. The management gave researchers the possibility to develop their projects in a quasi-market environment, with the necessary autonomy, but not with all the risks connected with normal entrepreneurial activity.

One of the most interesting examples of activities that emerged from these choices was *Loquendo*. The project started in February 2001 with the goal to explore new business possibilities and exploiting the competencies of Cselt in the field of voice recognition. TILab management decided to allow Loquendo to operate as an independent company with proprietary technology not commercialized by Telecom Italia. Loquendo, in the early years of operation, has tried to leverage on the solid partnership with Telecom Italia, to provide a variety of solutions within and outside the Group.

In 2000-01, a new strategy for talent scouting was experimented. A new branch, called *ICT Skill Building* introduced new ways for talents to get in touch and collaborate with the Group. These were much more flexible and "customized" than the previous ones. Besides the possibility of internships, graduation/PhD theses, collaborations with other research institutes and universities, initiatives such as Dreambay were used to attract young people with an entrepreneurial aspiration and sound technical background, even if not necessarily connected with Academia. Furthermore, another task was to develop initiatives to strengthen ICT competencies already present inside the Group. The priorities for 2001-02 changed again, and activities such as e-learning, e-university and publication of technical newsletters replaced a more aggressive hiring strategy.

4.4. An incomplete journey

The recent history of Cselt/TILab has not been characterized by a consistent and long-lasting model. The changes, which have taken place in the TLC sector and specifically in the R&D center's ownership, have not allowed the emergence of a robust strategic direction. The top management in the Telecom Group has probably spent a lot of effort in understanding how to deal with the complex competitive dynamics of the TLC sector, and only after that has tried to devise a strategy for the R&D lab. Nonetheless, a few concepts and changes became quite clear among researchers who in the past had been asked to search only for scientific excellence. Challenges such as strategy building and behavior alignment have been so far rather difficult in TILab. First of all, because during Colaninno's period (1999-2001) there was probably no clear idea about what to do with a large R&D center. Secondly, because during the last months of the Colaninno's period and in the first months of Pirelli's period, the project of joining together venture capital competencies and assets with scientific and technological resources has become much clearer, but would have required an even stronger commitment in communication, diffusion and incentives for researchers.

In a moment when the transition in TILab required still more resources and open support from the new top management, recent events seem to suggest that indeed the intention is to change, once again, strategy. The "innovation factory" refocused its activities towards more traditional R&D services for the Group, such as studies and feasibility tests, experiments, and normative specifications. The lack of positive results and a truly convincing success story from the model of "internal entrepreneurship" contributed to the decision to change direction. Further analysis on the future performance of TILab and the Telecom Italia Group will be needed to fully appreciate the direction and success of these choices.

5. StMicroelectronics: good forecasting and coherent strategic choices in a very competitive sector

It is hard for analysts and academics to recognize that years ago it would have been really difficult to expect that StMicroelectronics (ST) would have later emerged in the semiconductor industry as a truly successful experience. In fact, looking back at the history of the company, when in 1987 the French Thomson Sémiconducteurs (TS) merged with the Italian Sgs, the premises were very bad. However, ST did manage to become a success story, basically thanks to:

1. the definition of a visionary long run roadmap for the development of the semiconductors industry which revealed totally correct and adequate;
2. the management of internal competencies and external resources in coherence with the technological roadmap which had been defined;
3. last, but not least, the leadership of a very talented CEO, Pasquale Pistorio, who returned to his place of origin, Sicily, after a long experience in the USA, and was able to motivate a management team towards ambitious targets.

Before the merging, in the mid 80s Sgs was going through a deep financial crisis, with huge liabilities, although the manufacturing structure was still able to produce net income. On the other hand, Thomson enjoyed a relatively better financial situation, but it was producing at loss. The semiconductor industry was dominated by American and Japanese companies, and down the road the Asian tigers were ready to take over huge chunks of waffle production (by 2002, South East Asian countries became responsible for 37% of the entire world output). It was not exactly the best time to think about a European champion in the semiconductor industry, and especially starting from the situation of TS and SGS.

Nevertheless, ST proved to be a rewarding bet. ST outcome went from 800 million dollars in 1987 to 6 billion dollars in 2001. It is today among the top five largest company in its sector, with an impressive global presence and investing strategy.

ST management has long ago perceived the location advantages which a semiconductor company can exploit through investing and innovating in relatively peripheral places, creating links with local public investment in basic research and employing highly qualified and in some cases relatively unexploited and cheap human resources. This is for example what has determined the heavy investment of ST in Catania, Sicily.

5.1. A vision of the semiconductor industry: convergence and system on chip.

Throughout the 80s and 90s, relevant and well-known changes affected the semiconductor industry. In terms of the innovation path that was followed, Moore's law accompanied the constant and upgrade of manufacturing technologies. However, two other phenomena made the recent history of the sector particularly interesting and turbulent.

On the demand side, in the electronic sector, a vast amount of new applications demanded more and more sophisticated silicon supports. The most immediate consequence was the fact that the vertical control of the technologies for many consumer applications in electronics became impossible for one single firm. One of the main sources of competitive advantage became the definition of standards for specific phases of production, with the goal to create lock-in situations for "open but owned" systems (Borrus and Zysman, 1997).

The development of semiconductors towards the use of MEMS called for the integration and interaction of scientific competencies and languages that were not used to work together. Great creativity became therefore necessary in order to find solutions for different scientific and technological communities to collaborate effectively in increasingly complex projects. ST was

among the first group of companies that perceived the disruptive transformation that the emerging architecture of a "system-on-chip", was going to bring to the semiconductor industry. Besides the growing complexities for the manufacturing of a chip, which called for more dependence and interaction with the CAD industry, ST understood that in order to excel in the design and production of systems on chip, a vast and diverse network of partners had to be involved in a complex value chain structure (Cuomo, 2003b).

For example, this vision of the development of the semiconductors industry had an early validity test with the production of MPEG encoders and decoders. ST found in this market a niche that American and Japanese giants had not been able to exploit. This gave ST the initial spark to establish itself as a global leader for a beachhead application, and to accumulate resources to reinvest in the development of internal human resources and the establishment of local and global ties with the scientific and technological community.

A second phenomenon, more on the technology side, fostered the development of a more specialized and vertically disintegrated and geographically dispersed supplier network (Macher, Mowery et al., 2002). Advances in the CAD industry and new e-commerce practices made it possible to establish a new division of labor at a global scale. In this new model, fabless companies localized in the most innovative places such as Silicon Valley, Shangai or Vancouver, and foundries were built by local contractors or by the mother companies in more peripheral sites, in order to exploit other types of location advantages (Leachman and Leachman, 2003).

The most obvious consequence, for both these phenomena, was that incumbents in the semiconductor industry had to further develop their relational capabilities. The goal was to become strategic centers in complex supplier networks (Lorenzoni and Baden-Fuller, 1995), where the source of competitive advantage was exactly a visionary and efficient interaction with clients and the ability to capture and exploit specific location advantages.

5.2. Strategic choices coherent with the vision

Courageous and risky choices always have to accompany a correct forecasting exercise, in order to exploit the "early mover" advantages that an early start on a new market might have. The convergence of knowledge and technologies, and growing architectural complexities called for:

1. collaboration with different local partners;
2. the definition of an a-centric metanational structure;
3. investment on strong internal capabilities and entrepreneurship;
4. decisions to locate globally, but at the same time with a strong local involvement.

The impossibility of a complete vertical control of the technologies behind an application leads to the unfeasibility for one company to develop in-house all the stages of early sensing, adaptation, standardization and engineering of a new technological solution. Nevertheless, for incumbents it is crucial to stay on top of new approaches and solutions before they become common practices. Various large firms - in semiconductors, but also in electronics, software, and biotech - identified in industrial venture capital practices one possible solution. In the CAD industry, for example, much of the R&D budget is spent acquiring and adapting the technology developed by start-ups that develop and take to the market an innovative idea. The final goal is to integrate these technologies as new features in the existing products' portfolio.

However, "innovation by acquisition" is a risky activity, and the savings are not clear. The obvious saving for a manufacturing company that invests and controls a newly set-up activity is on the sunk upfront costs, typical of an R&D expenditure. Nevertheless, when acquiring a start-up and its technology, there are high information asymmetries that increase the risks connected to the evaluation, pricing and exploitation of the acquired intellectual property. Also, assuming that the technology acquired is indeed valuable, there are high transaction costs related to the acquisition and adaptation of a start-up.

The approach taken by ST recognizes the limits of both vertical control of the technology and of innovation by acquisition. This is why tight alliances with key customers, suppliers and technological partners represent ST strategy to face a very challenging competitive environment. Risks and opportunities are shared within a network, in which key players are not only customers and other producers, but also universities and public research laboratories.

In order to make the collaboration fruitful for both ST and its partners, two elements have to be present within the company:

- high technical competencies of the internal teams;
- an a-centric structure with key roles assigned to internal entrepreneurs that have the authority to mobilize, fast and effectively, resources for innovative projects around the world, where ST is located (Fisher, 2002).

It is also necessary to identify the right tasks and assign them to the right people, making sure that every single researcher and engineer is doing exactly what he/she is best at (Cuomo, 2003a).

The collaboration between ST, the University of Catania, and the Italian National Research Council (CNR) seems to be an example of such a partnership, and in fact led to good scientific results and exploitable industrial outcomes. Today ST and the local university exchange researchers and are partners in patents and publications. Di Guardo and Schillaci (2003) calculated that in 1999 10% of Italian patents assigned to ST are the result of joint projects with public universities. In the same year, out of the 34 scientific publications by ST, 29% are results of similar collaborations.

Till only a few years ago, innovation in the periphery, and in particular the decision to locate R&D facilities in places like Catania, was against the common practice in the industry. However, this choice was following a coherent logic, i.e. to locate where there was heavy public investment in research and abundance of unexploited high quality human resources, all coming at a reasonably low price. Also, ST management claims that the absence of other equally interesting employment opportunity increases the researcher's corporate loyalty, and this environment creates an efficient barrier for the loss of key technological competencies.

Collaboration and early partnership in development projects are also the approaches that ST used to interact with its local suppliers in Italy. In Catania, a high tech industrial district rotates around the activity of the multinational. The majority of these firms are small companies, which have part of their working force dedicated to the management of ST requests (Di Guardo and Schillaci, 2003). The risk of an overspecialization of the region, and a dependence for many high quality job on the fate of ST are obvious, but so far the trade off has been positive, and Catania clearly stands out in terms of high-tech employment, patents and number of researchers with respect to the rest of Sicily and Southern Italy. Moreover, the truly metanational and global nature of ST, allows Italian scientists to collaborate and get access, through the ST network, to the latest research in the sector, avoiding, or maybe even reversing, the brain drain phenomenon.

ST has been recently described as a "clear success story, where a public owned company has been transformed into a truly multinational corporation, able to compete and excel at the cutting edge of the technological frontier" (Bonaccorsi and Giuri, 2003). We have argued that two elements contributed to the success of ST. First, the early identification of a clear business opportunity, since ST was among the first companies that perceived the potentials of the system-on-chip architecture. The second element was the definition of a coherent business strategy, based on the assumption that research in peripheral regions – for example in the South of Italy - can be of good quality, and on the simple, but effective paradigm that innovating in peripheral places costs less. ST is adopting similar approaches in all its locations, exploiting the many paradoxes of globalization by following the strategy to "locate globally and engage locally" (Porter, 2001). As a result, ST can count on important partnerships with universities in Europe and around the world, both in peripheral and central hubs for the development of the technology and the industry.

6. Different challenges need different strategies. But is it possible to define a common framework?

The four cases of large Italian R&D centers that the present work discussed can be analyzed in terms of a common framework, which considers the relationship between the technological dimension, on the one hand, and the positioning of the company with respect to the competitive environment, on the other. Figure 4 represents this framework.

Figure 4. A framework for the definition of innovative strategies

Technological dynamics	Incumbent	New Entrant
Turbulent	(A) Explore new technological / business opportunities *(…but do not threaten your main business)* **[the case of TILab]**	(B) Define a new competitive structure, by integrating internal and external S&T *(i.e., strengthen your position)* **[the case of ST]**
Stable	(C) Rationalize R&D expenditures *(i.e., maximize profits from innovation)* **[the case of CRF]**	(D) Find a partner or License / Sell unused technologies *(i.e., increase the focus on the core business)* **[the case of Pirelli]**

Relative Competitive Position

Freeman and Perez (1988) consider different types of technological dynamics. What characterizes their taxonomy is the "proximity of the effect of change" with respect to the center of innovation. When a technology is going through very turbulent dynamics we will observe innovations that lead to new technological systems, the appearance and disappearance of new paradigms, the convergence of separate knowledge and technological domains. The adoption of system-on-chips, the advent of CAD, for semiconductor, or the convergence of TLC and IT for telecommunications, are indeed examples of very turbulent technological dynamics. On the other hand, sectors, like automotive and optical telecommunication systems, have technological trajectories that are more clearly defined. Competencies and resources that have to be acquired and activated in order to compete are commonly known. Technological changes are a constant also for mature industries, but efforts in these cases are usually directed towards incremental innovations, since disruptive innovations are hardly expected.

One important implication, for strategic R&D management, follows this distinction between turbulent and stable technological change. In order to safely go through a technological system shift during times of high turbulence, it is important that resources and competencies come from different sources, and it is unlikely that the leaders of the old technological paradigms can go on just with their own. Technological alliances become key assets for the control of emerging markets (Chesbrough and Teece, 2002). On the contrary, in less dynamic environments, firms cannot base their competitive strategies on the exploitation of new technologies, and key competitive

competencies are usually located downstream, in order to own and control distinctive manufacturing or marketing capabilities. The main concern of leading incumbent firms is to defend their position and to avoid competition from potential entrants. This often calls for a rationalization of internal processes (among which R&D activities), in order to gain economies of scale and increase the gap of efficiency with potential entrants. Innovative efforts are then directed towards the development of new processes or innovations to be incorporated in existing products, rather then in the development of radically new products. The pressure on the minimization of costs is overemphasized in these cases. Hence, when the potential of an innovation can be better exploited outside the core business, licensing or technology transfer activities can be encouraged towards partners who are not direct competitors.

The case of CRF can be explained within this context. The automotive sector has certainly reached a maturity stage of its life cycle, and companies' competitive positions are defined on a global base. Even if in the future, technological system shifting innovations are expected - for example in combustion - today the existing structure of the industry is quite established. Furthermore, while all the leading companies in this sector tend to use the results of their innovative activities in order to differentiate their products from those of competitors, the need to reduce R&D expenditures implies that innovative results have to be exploited both internally and externally. The emphasis that CRF poses on the transfer of technologies represents a clear attempt to maximize profits from R&D activity, to counterbalance R&D costs.

With a low level of technological dynamics, and established competitive environments, potential entrants find significant difficulties in using the technological dimension as a competitive weapon. When relevant technological results are achieved, these cannot be used to threaten the position of leaders, whose key advantage mainly comes from the control over manufacturing and marketing capabilities. In order to gain profits from R&D activity, non-leading firms often have to share the new technologies with other partners owning complementary competencies. In some extreme situations, technologies can be sold or licensed out to incumbents. The case of Pirelli represents this latter situation. Pirelli is not a leading company in optical technologies. In this market, Pirelli had to share its competencies with other partners in order to achieve successful exploitation. The decision to sell the OT company --and the relative technological competencies-- was the direct consequence of this strategy.

In the presence of a turbulent technological environment, the definition of standards and the goal to impose new technological paradigms to the market is at the heart of a firms' strategy. The dominance of old markets or experience in the manufacturing processes might not represent sufficient barriers to defend marketshare. The dynamic capabilities of firms (Teece et al., 1997) in turbulent technological arenas translate into correct technological foresight, strong and coherent leadership. Opportunity recognition can play a crucial role only if backed up by a strategic management, whose goal is to translate into action a technological vision.

As both TILab and ST cases show, incumbents and new entrants have to be aware of the different sources of technological change (Pavitt, 1984). Disruptive innovations will not be the result only of corporate R&D investment. Absorptive capacity (Cohen and Levinthal, 1990) and relational capabilities (Lorenzoni and Baden-Fuller, 1995) are two concepts that the management literature has used to describe the various means through which firm are able to attract, manage and fully exploit ideas coming from different sources, outside the boundaries of the firm.

In general, competitive strategies to be pursued, differ according to the relative competitive position of the firm. In the case of leading companies, their main strategic concern is to avoid new entrants to erode their positions and, at the same time, to acquire competencies in the emerging technological fields. As it has been largely discussed in the managerial literature, companies have in this case to be able to operate in both the traditional and innovative environments, often by adopting coherent organizational solutions (Tushman and O'Reilly, 1996). Controlled spin-off companies and corporate venture capital might be a feasible strategy to pursue, when new technologies, whose real potential is not clear, do emerge (Christensen, 1997). The R&D strategies of Intel, Cisco, the

industrial dynamics of the CAD and pharmaceutical-biotech sectors are only a few examples in which market leaders were indeed able to defend and reinforce their dominant position.

TILab tested this strategy with mixed results. During the 90s, new technological paradigms emerged in telecommunications, and new market opportunities became evident to companies. However, their real potential was not completely clear, yet. Being a leader of the traditional telecommunication market, Telecom Italia tried to explore these new opportunities, at the same time defending its leading position. The effort to gather internal opportunities and to hunt for new talents and ideas was going exactly in this direction.

On the contrary, non-leading competitors can take advantage of the business opportunities arising from the technological dynamics by trying to impose a different industrial structure. If new entrants are better able than incumbents to manage the new technologies and to organize the required complementary competencies – e.g., by defining a better network of non-competitive relationships with external partners – they can seriously threaten the leading positions. New technological trajectories offer to potential entrants the opportunity to enter the market and play a leading role. Traditionally, we have seen Japanese companies playing the role of outsiders and achieving important results in the consumer electronics, automotive, motorcycle industries (Womack et al., 1990; Mintzberg et al., 1996; Glasmeier, 2000). The advent of e-commerce and disruptive changes in distribution, created tremendous opportunities for companies such as Amazon, Ebay and Dell, that reinvented key concepts for the industry (Fields, 2004).

Among these examples, ST represents a clear case of success. ST was not among the leading producers of semiconductors in the global market. However, the upsurge of system-on-chip as a dominant design concept gave ST the possibility to climb the rank towards the top positions. Better than other competitors, and especially better than many traditional leaders, ST was able to set up a new value-creating network around this new platform, and its new applications. By leveraging this organizational competence, ST could maximize the returns from R&D activity and constantly increase its market share. Started as a medium-level global manufacturer in the mid-80s, it has become the third company in the semiconductor industry, mainly thanks to a visionary management that believed in the exploitation of such a strategy.

7. Conclusions

The analysis of the four cases seems to confirm that industrial R&D centers cannot develop all the research that their mother company needs, even though the recipe is not so clear about how to achieve and maintain an effective network structure. CRF and ST seem to have been particularly successful in maintaining network relations. CRF with its clients, which in most cases are Fiat's suppliers; ST with both its clients/partners, with whom co-design activities are carried out, and with public and private "research suppliers", through which ST keeps active windows on new technologies and competencies all over the world through an amazing network of collaborations.

A second conclusion is that clear decision-making is often fundamental, and that in certain historical periods, the leadership of skilled individuals does matter a lot. Again, CRF and ST show that the contribution of their CEOs, Giancarlo Michellone and Pasquale Pistorio respectively, has been very important in defining, defending and further expanding strategic decisions. The way they have been able to motivate their immediate collaborators, as well as larger teams, becoming sort of "icons" within their organizations is a well-known phenomenon, which has revealed of crucial importance.

On the other hand, slow decision-making processes, and poor organizational communication, has a negative impact on knowledge-intensive organizations. This is particularly so in firms where restructuring and change in ownership generates among researchers fears about drastic changes in the mission of the R&D center, or even fear that the center might be closed, divided and sold. From this point of view, the lack of a well-communicated vision produces

particularly negative results in organizations whose task is to produce breakthrough scientific and technological results.

Third, in a country such as Italy, privatization processes are particularly important for the definition of an oligopolistic core of companies in charge of carrying out R&D on a large scale. Italy, for example, has not a tradition of fierce defense of national champions (such as France, for example, and to a minor extent the UK). On the contrary, in recent years, it has perhaps lacked a long-term vision with regard to the post-monopolistic or post-privatization period in sectors such energy, transport, telecommunications. Cselt/TILab is a clear example of a large R&D center in a sector that is going through continuous transformations, whose future is still not yet fully clear, which was and still is an important asset for the whole country. Other companies operating in the same sector, such as France Telecom and Deutsch Telekom, have been able to hold on to their large R&D center with greater vigor.

Finally, the example of Pirelli, and the deal with Corning for the sale of Optical Technologies, shows that the complete valorization of technological assets has not necessarily to be reached through internal paths. If the company has developed relevant technologies, which are far from the main business core, and if the vision of the top management is clear about the future growth patterns to be followed, the sale of a company might represent the preferred strategy, even because it can generate financial resources to be devoted to reinforce the core activity. Rather, what should be criticized is the sale of companies, or of stakes of them, without a deliberate strategy, but just for budget constraint reasons. Unfortunately, plenty of such cases characterize the story of the Italian industrial system during the second half of the twentieth century. The hope is that the (few) remaining large Italian companies will be able to raise the value of their technological competencies, and to use the same competencies to enhance the value of the companies.

8. References

Arora, A., A. Fosfuri, and A. Gambardella (2001). *Markets for Technology: the Economics of Innovation and Corporate Strategy*. Cambridge, MA: MIT Press.

Bonaccorsi, A., and P. Giuri (2003). Alle radici del ritardo tecnologico italiano. In *Il Sistema della Ricerca Pubblica in Italia*, edited by A. Bonaccorsi. Milano, Italy: Franco Angeli.

Bonaccorsi, A., ed. (2003). *Il sistema della ricerca pubblica in Italia*. Milano, Italy: FrancoAngeli.

Borrus, M., and J. Zysman (1997). "Wintelism and the changing terms of global competition: prototype of the future?" *BRIE Working Paper* 96B.

Business Europe (2000). "Multinational Monitor: Pirelli strikes it rich." vol. 40 (20), p.3.

CED (2000). "Corning swallows up Pirelli's Optical Components for $3.6B." vol. 26(11), p. 12.

Chesbrough, H.W., and D.J. Teece (2002). "Organizing for innovation: when is virtual virtuous?" *Harvard Business Review* (August).

Christensen C.M., 1997, *The Innovator's Dilemma: When new technologies cause great firms to fail*, Harvard Business School Press, Boston.

Cohen, W.M., and D.A. Levinthal (1990). "Absorptive capacity: a new perspective on learning and innovation." *Administrative Sciences Quarterly* 35:569-596.

Cuomo, A. (2003a). Innovazione e imrese high-tech: il caso ST Microelectronics. In *Distretti Industriali e Distretti Tecnologici. Modelli di Sviluppo per il Mezzogiorno*, edited by F. Cesaroni and A. Piccaluga. Milano, Italy: Franco Angeli.

Cuomo, A. (2003b). Ricerca ed innovazione nell'era della convergenza. In *Knowledge Management e Competitività*, edited by E. Bortezzaghi, M. Raffa and A. Romano. Milano, Italy: Edizioni Scientifiche Italiane.

Deiana, M. (1996). *Verso Nuovi Modelli della R&S. I Casi: Europa Metalli*, CSELT, CRF. Laurea Thesis, Facoltà di Economia, Università di Pisa, Pisa.

Di Guardo, C., and C.E. Schillaci (2003). Le prospettive di sviluppo di un aggregato territoriale high-tech: il caso di Catania. In *Distretti Industriali e Distretti Tecnologici, Modelli Possibili per il Mezzogiorno*, edited by F. Cesaroni and A. Piccaluga. Milano, Italy: Franco Angeli.

DTI (2003). *R&D Scoreboard* 2003 [cited 15th Jan 2003 2003]. Available from http://www.innovation.gov.uk/projects/rd_scoreboard/introfr.html.

Fisher, L.M. (2002). "STMicroelectronics: the metamorphysics of a metanational pioneer." *Strategy and Business* third quarter.

Fields, G. (2004). *Territories of Profit: Communications, Capitalist Development and Innovation at G.F. Swift and Dell Computer*: Stanford University Press.

Gallino, L. (2003). *La Scomparsa dell'Italia Industriale*. Torino: Giulio Einaudi Editore.

Glasmeier, A. (2000). *Manufacturing Time: The Rise and Fall of Watch Industries and Regions Around the Globe*. New York: Guilford Press.

Hamel, G., and P.C. K. (1994). *Competing for the Future*. Boston: Harvard Business School Press.

Leachman, R.C., and C.H. Leachman (2003). Globalization of semiconductors: do real men have fabs, or virtual fabs? In *Locating Global Advantage*, edited by M. Kenney and R. Florida. Stanford: Stanford University Press.

Leifer, R., M. Rice, C.M. McDermott, G.C. O'Connor, and R.W. Veryzer (2000). *Radical Innovation: How Companies Can Outsmart Upstarts.* Cambridge, MA: Harvard Business School Publishing.

Lorenzoni, G., and C. Baden-Fuller (1995). "Creating a strategic center to manage a web of partners." *California Management Review* 37 (3):146.

Macher, J.T., and D.C. Mowery (2003). "Vertical Specialization and Industry Structure in High Technology Industries." *Unpublished Manuscript*.

Macher, J.T., D.C. Mowery, and T.S. Simcoe (2002). "E-business and disintegration of the semiconductor industry value chain." *Industry and Innovation* 9 (3):155-181.

Michellone, G.C. (1995). "Organizing science: Constraints and new challenges." *ATA - Ingegneria Automotoristica* 48 (12):675-684.

Michellone, G.C. (2001). "Dalla ricerca all'industria: Miti e realtà per le PMI. L'esperienza CRF". Paper read at *Link Day. Tecnologie, Imprese, Capitali*, March 2, 2001, at Lecce.

Mintzberg, H., R.T. Pascale, M. Goold, and R.P. Rumelt (1996). "The "Honda Effect" revised." *California Management Review* 38 (4).

Pavitt, K. (1984). "Patterns of technical change: towards a taxonomy and a theory." *Research Policy* 13 (6):343-76.

Porter, M.E., and S. Stern (2001). "Innovation: location matters." *MIT Sloan Management Review* 42 (4).

Teece, D.J., G. Pisano, and A. Shuen (1997). "Dynamic capabilities and strategic management." *Strategic Management Journal* 18 (7):509-533.

Tushman M.L. and O'Reilly C.A., 1996, "Ambidextrous Organizations: Managing Evolutionary and Revolutionary Change", California Management Review, vol. 38(4), pp. 8-30, Summer.

Womack, J.P., D.T. Jones, and D. Roos (1990). *The Machine that Changed the World: the Story of Lean Production*. New York: HarperCollins Publishers.

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[2] See http://www.istat.it/Imprese/index.htm for details (last visited, January 14, 2004).

[3] See http://www.pirelli.com/en_42/this_is_pirelli/company_overview/the_group/the_group.jhtml for details (last visited, January 12, 2004).

[4] See http://www.pirelli.com/en_42/this_is_pirelli/investor_relation/file_pdf/corning_deal.pdf for further details (last visited, January 11, 2004).