KNOWLEDGE CREATION IN THE TELECOMMUNICATIONS SERVICES INDUSTRY

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Abstract

Our objective is to examine research and development (R&D) and knowledge creation in the telecommunications services industry. This review helps us in finding out which models of R&D management take shape in this industry. We analyse the activities of North American players as well as the European companies France Telecom and British Telecommunications.

Three groups of firms emerge and can be distinguished by their strategic choice between internal and external knowledge acquisition. The large firms, the leftovers of the former monopolies have a well-organised continuous R&D program, with a critical mass of in-house researchers. While doing their own research, they establish links with universities, they have laboratories in the Silicon Valley to do technological intelligence and scanning and they invest in venture capital. The second group encompasses firms that rely both on internal and external sources of knowledge but on a smaller scale than the firms in the first group. These firms collaborate with suppliers and competitors and take part in venture capital projects. Firms from the third group essentially have a strategy of knowledge outsourcing. These firms have little or no internal R&D and some of them have established university programs. For these firms, technology-driven mergers and acquisitions can play a crucial role, and the main purpose of R&D is to facilitate the integration of technologies developed by equipment manufacturers.

1. Introduction

Our objective is to examine research and development (R&D) and knowledge creation in the telecommunications services industry. This review helps us in finding out which models of R&D management take shape in an industry that has experienced profound changes, which have increased technological uncertainty and competitive pressure. We

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analyse the activities of the major North-American players and some European companies (France Telecom and British Telecommunications) and try to identify differences and similarities between these firms.

Roberts (1995) has done an extensive benchmarking of technology and R&D management in the most R&D-intensive firms in the world. The results of his study identify two trends that he sums up with the notions of "linkage" and "leverage". There are good reasons to believe that the trends that became apparent in the early 1990s will develop further in the next decade.

The first trend is the adoption by firms of a technological strategy that fosters closer links between R&D and a firm's strategy so that knowledge investments generate long-lasting returns. This trend has a number of influences on R&D management. First, decisions on R&D priorities are taken at a higher level in the firm's hierarchy. Second, R&D programs are more attuned to customers' needs. Third, R&D resources are shifted from basic research to development.

The second trend is towards a more systematic use of R&D and technology outsourcing. Indeed, Roberts notices that firms feel more and more dependent on outside sources of technology and develop therefore a tendency to collaborate with outside partners.

> "Companies worldwide are evolving rapidly toward increased dependence upon external sources of technology. This is true in research, where the university is becoming a strong complement to internal sources. This movement is paralleled in development by dramatic increases in the uses of joint ventures and alliances to provide product and process advances. The "Virtual R&D organization" is an idea that is growing in conceptual importance, but is still far from practical implementation. Yet all companies worldwide need to develop their own balance between internal and external sourcing of technology, with the effectiveness of external acquisition requiring skills and organizational structures not yet in place in most firms." (Roberts, 1995a, p.56)

Roberts however states that in the early 1990s internal R&D remained the first source of knowledge creation both for development and for basic research. Universities had become the main external collaborators to acquire basic knowledge, to capture new ideas, to evaluate technological directions, and to upgrade human resources in particular through hiring university graduates. Regarding development, Roberts notices a less obvious but nonetheless significant trend in favour of joint ventures, alliances and integration of technologies with suppliers.

In view of these trends, our analysis of R&D and knowledge creation in the telecommunications services industry pays as much attention to internal R&D as to external sources of knowledge acquisition. We also keep an eye on the potential interaction between internal and external sources of knowledge since, as Chesbrough and Teece (1996) put it, "few virtual companies that have survived and prospered have outsourced everything".

Our analysis is organised as follows. Section 2 is devoted to the historical evolution of the telecommunications services industry and in particular to the evolution of its R&D activities. Sections 3 and 4 examine in turn the internal R&D and the external knowledge sourcing activities. This leads us, in section 5, to an attempt at identifying new emerging models of knowledge management in the telecommunications services industry.

2. Evolution of the telecommunications services industry and its R&D activities

2.1 The telecommunications services industry

In the last twenty years the telecommunications services industry has undergone profound changes that have transformed the structure of the industry, its boundaries and the rules of the game. A few keywords can describe this evolution: deregulation, technological and industrial convergence, and globalisation.

2.1.1 Deregulation

The 1980s marked in the United States the beginning of deregulation in an industry that almost all countries had hitherto considered as a natural monopoly with regulated private companies or public firms. The negotiated settlement that put an end to the antitrust case against AT&T in 1984 gave way to seven regional telephone companies[4] (Nynex, Ameritech, BellSouth, SouthWestern Bell, US West, Bell Atlantic and Pacific Bell), that were regulated and responsible for local calls. Long distance and international calls were left to AT&T and open to competition. From then on, the private or public monopoly in telecommunications progressively vanished over a period of roughly twenty years on every market segment (long distance, business, international, and local calls) in developed as well as in developing countries. The Telecommunications Act of 1996 in the United States opened the whole market to competition, which lead to gradual price reductions, quality improvements and innovations. United Kingdom and Scandinavia were fast followers of the United States in deregulation. Canada moved on in the end of the 1980s while Continental Europe and Japan lagged until the mid 1990s.

2.1.2 Technological and industrial convergence

In the early 1980s, some major technological changes took place in the industry. First, there was the digitalisation of information, then the introduction of optical fibre and of wireless telephony and of course the advent of Internet toward the end of the decade. Each of these technologies had major impacts in the industry. The digital transformation of voice lead to the convergence of voice and data and later on the digital transformation of image lead to the convergence of voice, data and image. Optical fibre increased the capacity of data transmission and the potential of delivering content of greater

[4] The regional telephone companies are also known as RBOCs – Regional Bell Operating Companies – or Baby Bells.

sophistication. Wireless telephony, which initially appeared as a complement to wireline telephony, became its direct competitor in the 1990s and is now a major avenue (as it is digitalised) for bringing bandwidth into the local loop. Finally Internet increasingly looks like the integrator of all networks – voice, image and data – and the basis for a large scope of services that we can classify under two headings: e-commerce and multimedia.

The combination of technological convergence and deregulation produced vast changes in the industry as can be witnessed by the numerous reorganisations, mergers, acquisitions and alliances. Over the last twenty years, technological change has blurred the boundaries of the telecommunications services industry, the television industry (cable) and the computer services industry. The advent of broadband and shrinking profit margins on the transportation of information only reinforced the integration of telecommunications and media producers. It was therefore not surprising to see that the number of local telephone companies decreasing to four in the wake of mergers and acquisitions (Bell Atlantic first acquired Nynex and then merged with GTE to form Verizon; SouthWestern Bell, Pacific Bell, and Ameritech belong to the group SBC Communications; BellSouth remained independent; US West acquired Qwest, a newcomer). In Canada, we observed greater concentration in the assets of the nine former regional monopolies. Telus Integrated Communications was formed with the merger of Alberta's Telus Corp. and British Columbia Telecommunications in 1999. The operators from the Atlantic provinces merged to create Aliant and Bell Canada, which was mainly operating in Quebec and Ontario previously, increased its ownership in Aliant. It is also not surprising that from 1996 on we saw a wave of acquisitions of cable distribution companies (AT&T, MediaOne and TCI for example), and that a number of important mergers and acquisitions took place in the media industry and between media and telecommunications companies in the year 2000 (for instance AOL and Time Warner; Vivendi and Seagram; Bell Canada, CTV and the Globe and Mail).

2.1.3 Globalisation

In the aftermath of the deregulation and privatisation wave that occurred in many countries, firms began to supply their services on a worldwide scale and to become transnational. All markets provided profitable opportunities. To begin with, the developing countries, especially the newly developing countries in search of capital and expertise to build a modern infrastructure of telecommunications, offered a golden market opportunity for many telecom firms of the developed countries, as for example BCI's investments in many Latin American countries. The developed countries also provided profitable opportunities and became a fertile ground of competition to offer end-to-end services to the lucrative market segment of the multinationals, to exploit the exceptional advantages of a regional or worldwide network or to capture the benefits from supplying a larger range of differentiated services. We nowadays witness the emergence of large regional and even worldwide groups that intensify the competitive pressure already present on many national markets.

In this environment of deep and rapid changes, the telecommunications services companies have to learn anew the use of R&D as a strategic management tool. It is a quite a different learning process from the one that would have been justified under the status of national monopolies.

2.2 Evolution of R&D

The organisation of R&D and its objectives have been greatly influenced by regulatory changes that altered the rules of competition. At the beginning of the century, when most national markets were still organised under regulated monopolies, large laboratories were set up in France and England by France Telecom and British Telecommunications. In the United States, AT&T and its equipment manufacturing subsidiary Western Electric created and shared Bell Labs, an institution that at some point had a staff of 23000 employees, among which Nobel prize winners, and that introduced some major innovations such as the transistor. In this context of absence of competition, it was customary to diffuse inventions and to view R&D as a public good. It was in any case a policy of intellectual property at AT&T to hand out licenses to whoever asked for it. On the national market, it was indeed in the interest of the company to let knowledge flow to its suppliers who were thereby in a position to reduce their cost of producing equipment and to increase their performance (Grindley and Teece, 1997). Moreover, as the monopolies were restricted to their own national markets, they were not reluctant to share their knowledge.

Bell Canada and Northern Electric – or Nortel, the equipment subsidiary – were part of the AT&T system until the 1956 Consent Decree that forced AT&T to divest its Canadian holdings. From the beginning of the 1960s Bell Canada and Nortel progressively ceased to outsource technologies from AT&T and Western Electric and turn to set up internal R&D. Nortel created its own R&D facilities, first with a lab in Belleville and two years later, the Northern Electric R&D labs were set up in Ottawa. During the same period, Bell Canada also began its own development activities. In 1971, the two firms merged their R&D activities to form BNR (Bell Northern Research), jointly owned by Bell Canada (51%) and by Nortel (49%). Adopting a model close to the one of AT&T, Bell Canada largely supported BNR's R&D programs until the mid 1980s and worked closely with its subsidiary – through a privileged supplier link – in developing new telecommunications equipment technologies for its own use and for export markets. Investments in Nortel technological capabilities were quite lucrative as the telecom service industry was still regulated. With the end of the 1980s and the advent of deregulation, Bell Canada progressively divested from BNR, then a major telecom lab of nearly 10,000 researchers, until Nortel bought all the remaining shares of BNR from Bell Canada in 1998. The privileged supplier link was also abolished.

The year 1984 marked the end of an era. After its divestiture, AT&T kept a much smaller Bell Lab. AT&T no longer needed to give out licences. From then on its R&D got much more geared to business opportunities (Grindley and Teece, 1997).

As to the regional telephone companies, they maintained their monopoly rights on their respective territories. They adopted a co-operative R&D model by setting up a central research lab: Bell Communications Research or Bellcore. Bellcore was to become a closed consortium that belonged to the regional companies. In the mid 1980s the lab employed 8000 people and was the third largest research organisation in telecommunications in the world.

During their first years of existence, the R&D activities of the regional companies were almost entirely concentrated at Bellcore. Bellcore pursued two types of projects. The first category encompassed infrastructure projects that generated business for all members who in turn shared their costs equally. Each project had to be approved by five members. The second category consisted of specific projects financed by one member or a subset of them. Bellcore also had external customers among which Cincinnati Bell, the Southern New England Telephone Company and GTE. In 1995, Bellcore generated revenues worth $US 1.08 billion, $US 830 million of which from its owner customers (Corey, 1997).

A first source of conflict between Bellcore's members had to do with the financing of infrastructure projects. In the end, a ceiling of 36.7% of revenues for this category of projects was agreed upon. This ceiling was, however, never reached because members favoured specific projects. In 1995, infrastructure expenses accounted for 6.25% of total expenses (Corey, 1997).

The reason for the squabbling between the members of Bellcore was more fundamental. Anticipating the abolition of their monopoly position, which was going to take effect with the adoption of the Telecommunications Act of 1996, the regional companies found cooperation less and less attractive and decreased their use of the joint lab's services. They preferred to collaborate directly with equipment manufacturers and to set up their own R&D facilities (Chen, Abetti and Peters, 1998). Since 1994, there were rumours that Bellcore was for sale. In 1997, the rumours became reality and Bellcore was sold to Science Applications International Corporation (SAIC), a firm specialised in telecommunications training that was going to become Telcordia Technologies. That was the end of the co-operative model.

The deregulation and the ensuing wave of mergers and acquisitions between regional telephone companies and some independent companies changed the organisation of R&D in the industry. Let us recall that Bell Atlantic acquired Nynex in 1997 before merging with GTE in 2000 to form Verizon Communications. The R&D lab of GTE was renamed Verizon Laboratories. SBC Communications[5] set up an R&D lab in 1988, the SBC Technology Resources (TRI) (www.tri.sbc.com). The deregulation also allowed the upcoming of new players like MCI Communications that was acquired by WorldCom in 1998. These enterprises, just like US West and BellSouth, did not seem to have put in place any internal R&D activities.

[5] SBC Communications regroups Southwestern Bell, Southern New England Telecommunications, Pacific Bell, Nevada Bell, and Ameritech.

In 1996, another reorganisation took place at AT&T that separated services from equipment. The new AT&T entirely focused on services whereas Lucent Technologies – the former Western Electric – became an independent company specialising in manufacturing equipment. One third of the former Bell Lab became AT&T Lab specialising in computer science, networks, cryptography and mathematics whereas the rest went over to Lucent Technologies.

In this ebullient industry, players are searching for new models of R&D organisation. Whereas some of them do internal R&D, others definitely rely on outside sources of knowledge. It thus seems important to understand the equilibrium between internal and external knowledge sourcing. We now turn to that question.

3. Internal creation of knowledge

In order to evaluate internal creation of knowledge within the firms included in our sample, we use both input and output measures. Input is measured using resources devoted to research namely R&D investments and the number of employees in research organisations. Patents are used as a measure of research output. We also analyse research areas and organisation of in-house research efforts.

3.1 R&D investment and research staff

Data on resources devoted to R&D – R&D investment and research staff – is not available for all firms in our sample. Nevertheless, even based on this incomplete information, it seems clear that three groups of firms emerge.

We include AT&T, France Telecom, and British Telecom in the first group. These firms invest substantially in R&D and have large in-house R&D teams. They are former monopolies in their own country and have a long research tradition. AT&T invested $US 758.9 million in R&D in 1997 (Merrick, 1998) and is employing approximately 2500 scientists and engineers (www.att.com). France Telecom invested $US 958 million in 1998 and has a research staff of 3800. In 2000, France Telecom R&D's (France Telecom research arm) budget amounted to 3 billion francs and was employing 4200 people (GIS Café Company News, 20/12/2000). British Telecommunications invested $US 493 million in 1998 and has a research team of somewhere between 4000 and 4500 people (Fransman, 1994b; Montgomery, 16/10/1999). In 1999, British Telecommunications spent £268.00 million on R&D which represented 1.6% of its sales. These figures increased in 2000 as the company spent £345.00 million which was equivalent to 1.8% of its sales (Wright's Investors' Service).

Group 2 includes Verizon and SBC Communications. These firms invest substantially in R&D but not as extensively as the ones from group 1. SBC's research laboratory has a staff of 300 people (www.tri.sbc.com). Group 3 includes BellSouth, Qwest, WorldCom, a new player, as well as the Canadian firms Bell Canada and Telus. According to the

information gathered, these firms do not devote much in-house resources to R&D[6]. Although Bell is a former monopoly that had invested large amounts in R&D in the past, the company is included in the third group. Whereas AT&T decided to keep a portion of Bell Labs when equipment and services were separated, Bell chose another course of action and progressively subsided its participation in BNR.

3.2 Number of patents

Data on patents are available for all the firms in our sample. The first column of Table 1 shows patents awarded in the United States. The number of US patents is often used as a measure of technological strength. The next two columns contain the number of patents delivered in Europe and Canada. We use these measures as a proxy of the international focus of firms.

Table 1. Research Input and Output

	Number of patents awarded Between 1997 and 2000				
	United States	**Europe**	**Canada**	**R & D ($US million)**	**R&D Staff**
Group 1					
AT&T	830	623	478	759 – 1997	2500
BT	249	178	201	493 – 1998	4000-4500
FT	199	179	7	958 – 1998	3800
Group 2					
Verizon	344	22	7	122 – 1997 (GTE)	?
SBC	78	0	1	?	300
Group 3					
Qwest (US West)	31	0	0	?	?
BellSouth	91	4	7	?	?
WorldCom	355	0	0	?	?
Bell Canada	7	6	0	?	?
Telus	1	0	3	?	?

Sources: Dephion Intellectual Property Network (IBM) web site (www.delphion.com) for American and European patents; Industry Canada's web site for Canadian patents (www.strategis.ic.gc.ca)

[6] The case of WorldCom is problematic. According to PC Magazine (19/10/1999, p.100), the firm invested $US 3730 million in R&D in 1998, without any in-house research facilities. This may reflect the fact that WorldCom's growth strategy relies heavily on acquisitions. The amount of R&D reported by WorldCom is an estimation of the value of the commercial potentiel of acquired technologies (WorldCom's 1999 Annual Report). This amount thus represents the expected return on R&D rather than investment in R&D.

Firms in the first group have a large number of patents both on their domestic and foreign markets. AT&T clearly leads the group for American, Canadian and European patents. British Telecommunications also received a significant number of patents in Europe as well as in North America. France Telecom has fewer patents outside its domestic market. This could be because its privatisation process has been slower than expected.

Firms in group 2 have a substantial number of patents in the United States, especially Verizon Communications (sum of patents awarded to GTE, Bell Atlantic and Nynex). However, Verizon and SBC are not actively seeking patents on foreign markets.

Firms from group 3 have patents even if they do not devote in-house resources to R&D. It seems apparent that research output reflects here an outsourcing phenomenon. Although WorldCom is second in terms of American patents, these most likely result from knowledge developed in firms acquired by WorldCom. In addition most of the patents now owned by WorldCom have been awarded to MCI Communications, a firm that has traditionally relied heavily on outside suppliers (Harari, 1998). Patents awarded to BellSouth and Qwest could have been the result of research contracts undertaken at Bellcore. As for the Canadian firms, they only have a very small number of patents.

3.3 Research areas and R&D organisation

In this section, we look at research areas, the location of laboratories and at the technology strategy elaboration process of the firms included in our sample.

Firms active in R&D have some common features. First, they do not conduct R&D on equipment, which is left to equipment manufacturers. Firms from the service side of the telecommunications industry, however, have equipment selection, testing and integration activities that require technical knowledge on equipment. British Telecom's position is clear on the subject and represents well the choices made by firms specialising in services:

> "The ability to manufacture telecommunications-related equipment is seen as being largely irrelevant insofar as competitiveness in telecommunications services is concerned. Accordingly, BT will purchase the equipment that it requires on the market." (Fransman, 1994a, p.143)

Firms also dedicate a small portion of their in-house efforts to basic research while turning most of their attention to the development of technologies that can have an impact on the marketplace rapidly. They seem to favour the same technologies: software, electronic commerce and Internet, system engineering and network management, services to enterprises, multimedia, as well as broadband and wireless systems (Fransman, 1994a; www.gte.com; www.tri.com).

Firms in group 1 have an international focus. They have strategically located some research labs in proximity of centres of excellence and put in place a formal structure for the elaboration of their technology strategy.

Most of R&D at AT&T is undertaken in four labs located near the company's headquarters in New Jersey – in Lincroft, Florham Park, Middletown and Red Bank. In 1997, AT&T founded two labs in California – in Menlo Park and San Jose – which now employ 300 researchers that concentrate on Internet technologies (Kim, 1998). This lab only receives funding from business units within AT&T (Fernandes, 30/7/1999). In 1999, the company acquired a lab in Cambridge (England) from Olivetti and Oracle, and thus created its first major R&D center outside the United States (AT&T News Release, 10/2/1999). Researchers from this lab, renamed AT&T Laboratories Cambridge, specialise on networks, multimedia and mobile communications systems (Collins, 1999). The lab employs 50 fulltime researchers (AT&T News Release, 10/2/1999). AT&T paid £7 million for the facility and will invest £4.5 million a year in R&D (Computer Wire, 5/2/1999). AT&T Wireless just created a special R&D division to develop the next generation of mobile multimedia services (Gold, 23/1/2001).

R&D strategy elaboration is a very structured activity at AT&T. The process is based on two notions: "futurescapes" and "killer technologies". Futurescapes are defined as future trends in consumers' habits. Strategic planners at AT&T then identify links between these trends and the firm's key technologies, or "killer technologies", which are Internet, intranets, broadband and wireless communications, network services, satellite, voice recognition and electronic commerce (Gwynne, 1998).

The elaboration of technological strategy follows a similar process at British Telecommunications. A division of the company – the Corporate Research Programme Office (CRPO) – is in charge of defining research orientation by evaluating the firm's competitive position in terms of technological trends (Warren and Davies, 2000). BT Laboratories was renamed BTexaCT in July 2000. The company also transformed its Adastral Park R&D facility into a multi-company technology park. Outside England, BT created the Disruptive Lab at MIT and is also planning to establish a center in the Multimedia Super Corridor in Malaysia to conduct research on next-generation mobile technologies. BT plans to invest $US 790,000 annually in the new lab – to be named Asiai Research Center or ARC – and expects to employ 40 researchers (Global Sources, 4/1/2001; Hor, 4/12/2000). Some links with AT&T's laboratories in the United States have been established.

The research centre of France Telecom – the CNET – has seven research divisions, all located in France. France Telecom also has a North American subsidiary in Brisbane, next to San Francisco, put in place in order to monitor technological trends. The subsidiary focuses on product integration and software (Bilan 1999, France Telecom R&D).

Firms in group 2 have a national focus. The research organisation of Verizon includes four laboratories – BBN Technologies, Verizon Laboratories, Federal Network Systems and Emerging Business Opportunities – located in the United States. Verizon Laboratories us the former research arm of GTE, a firm with a long research tradition taking its roots in Sylvania Electric Products research lab, created in 1943 and acquired

by GTE in 1959 (www.gte.com). BBN, created in 1948 and widely known as the Internet birthplace, was acquired by GTE in 1997. The Emerging Business Operations unit was created in 1998 to identify business potential within the Technology Organization and nurture their growth.

SBC Communications founded a research laboratory named SBC Technology Resources Inc. in 1988. The lab has two locations, one in Austin in Texas and another in the Silicon Valley (www.tri.sbc.com).

Although some have patents, firms in group 3 have no research laboratories and have not put in place a structured R&D program. They however have equipment selection, testing, and integration activities. For instance, the Chief Technological Officer's team of Bell Canada employs 400 people. There is also some software development.

4. External knowledge creation

The creation of knowledge is frequently done by leveraging external sources of knowledge. In the following section we review and analyse the links between telecom services companies and with universities, as well as collaboration among competitors and with partners of other industries. At last, we review their activities in venture capital and mergers and acquisitions.

4.1 Links with universities

Generally speaking, universities have a comparative advantage in basic research. Business firms cooperate with university researchers in order to compensate for the reduction in their own internal investment in basic research.

Firms among our first group seem to cooperate closely with universities. The Cambridge lab of AT&T works closely with Cambridge University. The lab in the Silicon Valley running R&D programs on the Internet cooperates with California University at Berkeley (AT&T News Release, 1999). By creating a lab in the Silicon Valley, AT&T was hoping to benefit from cooperation and partnerships with universities and other firms in the region (Telephony, 8/6/1998).

British Telecom outsources long-term research projects at over 70 universities worldwide and has developed a program to manage research with universities and other organisations (Fransman, 1997b; McClure, 1999; BT Innovation and Technology). In 1997-1998, BT spent around £5 million on university-based research. BT funds research that could be classified as "applied" in the sense that projects have to be relevant to the company's interests. The company is also planning to build s postgraduate research institution at Adastral Park that would be controlled by University College London. BT will contribute £2.5 million to the centre over the next 2-3 years (Industry Update, 17/11/2000).

At last, France Telecom cooperates with around 10 universities around the world (Bilan 1999, France Telecom R&D).

Among the other firms studied, cooperation with universities seems more limited. Bell South, for one, is currently financing in part a research project on the Internet led by a research team of Georgia Tech Institute and the State University of North Carolina. Overall, the research consortium is grouping more than 170 universities, industrial partners and the government (Bell South News Release, June 22, 2000).

4.2 Intra and inter-industry cooperation

Telecommunications services companies frequently cooperate between each other in order to promote common standards. For example, Bell South, British Telecom, France Telecom and Nippon Telephone and Telegraph (NTT) jointly developed the specifications for an optical network. Bell South started such an initiative with NTT in 1998 (Bell South News Release, 17/6/1998; 22/6/1999).

British Telecom is part of the "Full Service Access Networks Group" in order to define the standards for broadband network access and of Eurescom (BT R&D Innovation Report 1999). France Telecom participates in many pre-competitive European R&D projects. The firm is committed to projects of the General R&D program (PCRD) of Eurescom and Eureka (Bilan 1999, France Telecom R&D).

Other cooperation agreements are more focused, bringing together just a few partners and can be the premises to further integration in R&D activities. GTE, for example, have a ten-year agreement with Telus giving Telus access to existing and future technologies. British Telecom recently reached an agreement with Japan Telecom for joint R&D projects and employee exchanges (BT R&D Innovation Report,1999). France Telecom and Deutsche Telecom, two major European players, have started a joint R&D lab of 30 employees (ThinkOne inc.) in the Silicon Valley. Such a lab is focusing on Internet, multimedia, network computing and wireless transmission technologies. Some interpreted the creation of that lab as a first step to further integration of R&D among the two European firms (Blau, 1999), but since then, France Telecom bought back the participation of its German partner.

Telecom service companies have always close ties with telecom equipment manufacturers. For example, British Telecom is currently cooperating with Fujitsu in the development of new access technologies (McLure, 1999) and with Lucent Technologies (BT Innovation Report).

Bell Canada collaborates with other firms in standard setting. As for Telus, it is an industrial partner of the Telecommunications Research Laboratories, a not-for-profit applied telecommunications research consortium in Canada founded in 1986. The research of the consortium focuses on network systems, wireless communications, network access, data networking and photonics. (www.telus.com)

4.3 Strategic use of venture capital

Although it might seem strange at first glance, we consider here investments by a venture capital subsidiary of a telecommunications services company as an external mode of creating and acquiring technologies. Venture capital activities run by an industrial group can frequently serve strategic and technological objectives.

Teece (1992) has analysed the investments of Japanese industrial groups in high tech start-ups in the Silicon Valley. The Japanese participation in these start-ups supports technological intelligence and assessment of future technology developments and leaves room for further links and alliances. Right now, Cisco is probably the best example of a firm relying on venture capital investments in start-ups to gain access to technology and knowledge. Technologies developed by start-ups are captured and leveraged by Cisco that moves from participation in equity to acquisition and the absorption of technological knowledge. Many firms have tried to emulate Cisco. In R&D management, we are now increasingly considering those venture capital activities within the broad framework of real option theory. This way of outsourcing knowledge and technology is believed to be faster than internal R&D and to allow a better management of risk in R&D investment.

The use of venture capital by large industrial groups could serve four basic functions:

- *Leveraging firm's knowledge of the industry and the technology*

As the firm accumulates over the years a broad and acute understanding of the industry, the market and the technologies, it can leverage that knowledge by carefully evaluating the potential of start-up companies and making profitable investments in high growth firms. Frequently, in that role, the firm participates in a venture fund with other investors and its participation does not necessarily target strategic or technological objectives.

- *Supporting intrapreneurship and spin-off of employees.*

Through that function, the firm supports by its financial participation the entrepreneurial drive of employees who want to start up companies or spin off technologies that the company does not want to support internally. Such a function is mainly part of a human resources policy but, as those spin-offs are frequently technological, the participation of the firm allows a privilege link with a technology or qualified personnel that could lead to further alliances or options.

- *Technological intelligence and equity alliances*

Here the financial participation in a technological start-up serves as a means of technological intelligence and assessment, a knowledge acquisition mechanism and a strategic support to cooperation and alliance with a complementary firm. This participation is not necessarily planned for the realisation of an option on the technology.

- *Real option management and acquisition*

Here, the firm is carefully organised in order to identify and evaluate technological start-up firms on the basis of their strategic value for the firm of the technology in development. The firm also carefully plans and organises the investment in venture capital in such a way that it could exercise an option at the appropriate moment. At last the firm also plans and organises ways to learn, acquire and integrate knowledge from the prospective start-up.

Many of the telecommunications firms considered in this study are involved in various ways in venture capital activities. Venture capital activities both support spin-offs of employees and participation in start-up companies. Indeed, it is more difficult to differentiate the strategic functions of venture capital activities, whether they are for mere technological intelligence or whether they support real option strategies targeted to knowledge and technology acquisition.

All firms classified in the first group have some venture capital activities. AT&T Ventures, created in 1992, invests in communication firms. Each year AT&T Ventures invests from $US 1 to 5 millions in a dozen of companies. In 1988, France Telecom created Innovacom, a venture capital company investing in telecom and information technology companies. In 1996, Innovacom retained the services of an investment advisor in San Francisco in order to start an investment program in Internet firms (www.Innovacom.com). France Telecom also supports spin-off of employees through its Technocom Ventures Fund. The fund is investing from FF 1 to 5 millions for a first round of financing, up to FF 10 millions on further rounds with a ceiling of 40% of the spin-off's equity. At last, France Telecom started a subsidiary (France Telecom Technology) in order to commercialise innovations coming from France Telecom R&D. For instance, Algety Telecom has been created to develop and commercialise soliton based optical transmission systems (Bilan 1999, France Telecom R&D).

British Telecom did not create its own venture capital subsidiary but is indeed investing through its participation in Viventures Venture Capital Fund. This fund created by Vivendi in 1998 targets investments in the telecom sector and the Internet both in USA and Europe. Investments per transaction are US$ 1 to 4 millions (www.viventures.com).

British Telecom also has an incubator where new and valuable ideas, which do not necessarily fit within the strategic plan of BT, could be developed and commercialised. BT normally keeps some equity participation in those activities (BT Innovation Report).
Among other firms studied, we find venture capital activities in Worldcom, SBC and Verizon. The MCI Worldcom Venture Fund is probably the most important one with a portfolio of investments valued at US $ 1 billion. This fund normally participates in third round financing. For example, the fund invested $US 5 millions in Advanced Switching Telecommunications. By acquiring Ameritech, SBC probably owns the oldest fund in the industry. Ameritech Development Corporation (ADC) is a wholly owned subsidiary of Ameritech created in 1984. ADC is currently investing between $US 0.5 and 2 millions in start-ups developing telecom technologies and media contents. Until now, ADC invested in approximately 40 companies, among which 15 have gone public or have been sold. Those venture funds activities are seen by management as a way to learn

about new markets and are complementary to internal R&D. In inheriting such a portfolio of venture capital, SBC created SBC Venture Capital Corp. at the end of 1999. The firm is buying a minority participation in start-ups in their second round of financing.

SBC is also offering support to those start-ups by giving them access to its own resources such as R&D. In the first half of year 2000 such investments have been completed in three companies (Weiss, 30/6/2000). Verizon did not seem to hold venture funds activities but Bell Atlantic, now a part of Verizon, have since 1989 its "Champion" program which promotes entrepreneurship among employees. Such program backs up entrepreneurs who champions new products and services by offering to them capital, training and advice. At the end of 1990 around 30 new products or services where at the development or commercialisation stage. Bell Atlantic Intrapreneurship is managing such a program.

In conclusion, among the firms studied many are currently using venture capital activities so support spin-offs of ideas promoted by employees. Those activities allow firms to monitor development and assess technologies and markets. Indeed, it is less evident that they are really using venture capital in order to exercise options on strategic technologies.

4.4 Mergers and acquisitions

Mergers and acquisitions are another vehicle to capture new technologies and knowledge. We could hypothesise that such motivation lies behind British Telecom's acquisition of Kymata (a developer of DWDM) in 1998 or Ameritech's acquisition of Clover Technology, a network integrator. In fact, in looking at the many mergers and acquisitions in the industry, it is frequently difficult to differentiate acquisitions based on knowledge and technology seeking from those made in order to consolidate the network or to have access to markets or contents.

5. Conclusion

From our analysis of R&D and knowledge acquisition in the telecommunications services industry, we notice the emergence of a new model of R&D organisation in this industry. After a period of state monopoly and integration of telecommunications equipment producing and service provision under one roof, followed by a period of deregulation during which the divested monopolies operated in a highly protected environment, where equipment manufacturers and service providers still collaborated, we now witness increased independence of both segments of telecommunications, increased privatisation and a trend towards worldwide competition.

In this new environment, vigorous competition and major technological developments such as fibre-optic, wireless telephony, Internet and multimedia have blurred the

traditional division line between telecommunications, television, and computer services. Telecommunications services companies are looking for a new model of R&D organisation.

All are on the lookout for new ideas and do the same kind of R&D. They all patent, with some differences in geographical patent locations. They often collaborate in large networks for the adoption of standards. All keep an eye on whatever knowledge is available outside while doing their own R&D. What distinguishes the players is not really their choice for a completely internal or external way of knowledge accumulation, but the balance between internal and external knowledge sourcing.

Three groups of firms emerge and can be distinguished by their strategic choice between internal and external knowledge acquisition. The large firms, the leftovers of the former monopolies (like AT&T, British Telecommunications and France Telecom) have a well-organised continuous R&D program, with a critical mass of in-house researchers. While doing their own research, they establish links with universities, they open laboratories in the Silicon Valley to do technological intelligence and scanning and they invest in venture capital. The second group encompasses firms such as Verizon and SBC that rely both on internal and external sources of knowledge but on a smaller scale than the firms in the first group. These firms collaborate with suppliers and competitors and take part in venture capital projects. Firms from the third group essentially have a strategy of knowledge outsourcing. This group includes Bell Canada, Telus, Qwest (and USWest), BellSouth and WorldCom, where there is little or no internal R&D and some university programs have been established. For these firms, technology-driven mergers and acquisitions can play a crucial role, as for WorldCom, and the main purpose of R&D is to facilitate the integration of technologies developed by equipment manufacturers.

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