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Organizing Innovation within Incumbent Firms: Structure Enabling Strategic Autonomy[1]

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ABSTRACT

In this paper we will discuss how large established firms can be effective in organizing innovation alongside their current business. We examine the trajectory of an incumbent firm in the telecommunication industry – Alcatel – which has been successful in exploring and exploiting the promises of broadband access technology (ADSL). Our findings reveal the effectiveness of a hybrid organizational structure, characterized by semi-permeability, which allows the simultaneous presence of entrepreneurial autonomy and the enactment of technological complementarities. Adopting such a structure seems especially relevant in high-velocity environments where technical configurations combine new components and functionality with existing technological infrastructures. Our analysis strongly suggests the relevance of combining insights stemming from the fields of strategic management, entrepreneurship and organizational design theory to arrive at more comprehensive accounts of the complex and challenging processes of reconciliation that incumbent firms face within dynamic environments.

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KEY WORDS innovation strategy, organizing R&D, complementary technologies, intrapreneurship

I. Introduction

Exploring new technologies and exploiting them effectively on markets is a challenge for incumbent firms. In particular, the question how to organize these innovative activities alongside current business activities is challenging, as it confronts organizations with multiple, often contradictory demands, stemming from the need for experimentation and flexibility on the one hand, and focus and commitment on the other hand (Ghemawat, 1991; Benner & Tushman, 2003; Leonard-Barton, 1992). Firms trying to achieve both types of activities are being confronted with many, often opposing demands, imposing upon these organizations the challenge of reconciliation. Perspec-

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tives and concepts developed on how to arrive at a reconciliation within one and the same firm differ considerably. Generally speaking, two different approaches can be delineated. A first set of studies pays particular attention to the scope of the technological activities of the firm and argues that relatedness and/or complementarities are crucial to reconcile both activities effectively. A second set of studies puts a strong emphasis on the choice of appropriate organizational design arrangements in which both types of activities become embedded.

Within this contribution, we will argue that both perspectives are complementary, albeit to some extent incomplete. We will do so by providing a description of the successful development of a new technology within an incumbent firm (The development of ADSL within Alcatel Antwerp). The analysis and interpretation of this case study reveals the effectiveness of a hybrid organizational structure, characterized by semi-permeability. Adopting such a structure seems especially relevant in high-velocity environments where technical configurations combine new components and functionality with existing technological infrastructures. At the same time, this account would be incomplete without acknowledging the decisive role of autonomous strategic processes within the incumbent firm. These 'intrapreneurial' processes not only result in 'variation' – on the level of technological platforms; they recursively imply these hybrid organizational arrangements.

As such, our paper strongly suggests the relevance of combining simultaneously insights stemming from the fields of strategic management, entrepreneurship and organizational design theory to arrive at more comprehensive accounts of the complex and challenging processes of reconciliation that incumbent firms face within dynamic environments.

The paper is structured as follows. First, we will provide a short introduction to the relevant literature. This overview will take into account organizational design theories and a resource based perspective on firm performance. Then, the development of the ADSL architecture at Alcatel in the early 1990's will be described in-depth. In the final part of this paper, we analyze the underlying processes in terms of constituents, and arrive at the aforementioned conclusion.

II. Theoretical Background

Following the distinction between exploitation and exploration, advanced by March (1991), several scholars (*e.g.* He & Wong, 2004; Jansen *et al.*, 2006; Levinthal & March 1993; McGrath, 2001; Tushman & O'Reilly, 1996) argue that firms – in order to be effective and sustainable over longer time periods – need to divide attention and resources between explorative and exploitative activities. Exploitation refers to

the leverage of existing capabilities by means of activities such as standardization, scaling and refinement. Exploration refers to the creation of new capabilities by engaging in fundamental research, experimentation, and search activities. The central tenet of this literature is that firms benefit from a balanced mix of exploration and exploitation activities, and that firms, that are able to combine both activities effectively, improve their survival chances and performance (O'Reilly and Tushman, 2004; Raisch *et al.*, 2009). While combining exploitation and exploration seems a plausible strategy on the firm level, organizing both activities effectively does not present itself as a straightforward exercise. The complexities entailed stem directly from the multitude of objectives such as strategy comprises. In this respect, relevant distinctions have been advanced and outlined by, amongst others, Abernathy and Utterback (1978), Anderson and Tushman (1991), March (1991), Ghemawat (1991), Bower and Christensen (1994), Brown and Eisenhardt (1997), and Garud and Karnoe (2002). The notions of incremental versus radical innovation, flexibility versus commitment, divergent versus convergent behavior, exploitation versus exploration or path creation versus path dependence, form the core of the dichotomies being outlined.

Perspectives and concepts developed on how to arrive at reconciling this dichotomy within one and the same firm differ considerably. When reviewing the literature on this matter, two different approaches can be discerned. A first set of studies pays special attention to the scope of the technological activities of the firm and more recently they argue that relatedness and/or complementarities are crucial to reconcile both activities effectively. A second set of studies puts a strong emphasis on the choice and development of proper organizational design arrangements in which both types of activities become embedded.

A. Scope: The Importance of a Diversified Knowledge Base and the Presence of Related and Complementary Capabilities for Combining Exploitation and Exploration

A generally accepted foundation for theorizing on the nature and rationale of firms' technological capabilities is the resource-based view of the firm. The resource-based view is one of the most influential strategic management theories on the origins of firms' competitive advantage (Hoopes *et al.,* 2003). Early writings in this literature strand (Penrose, 1959; Wernerfelt, 1984; Barney, 1991; Peteraf, 1993) emphasized that firms can achieve a competitive advantage by building up portfolios of valuable assets. Technology assets are considered as valuable as they are rare, difficult to trade, and hard to imitate due to their (partly) tacit nature and protection by intellectual property rights (Teece, 1980; Barney, 1991; Grant, 1996; Spender, 1996; Granstrand, 1998). More recent contributions stress that, in rapidly chang-

ing and unpredictable environments, a competitive advantage is only sustainable to the extent that firms continuously renew themselves by creating new assets and capabilities, including technological skills (Markides and Williamson, 1994; Teece *et al.,* 1997 and 2007; Eisenhardt and Martin, 2000; Helfat *et al.,* 2007). Exploring such new technical capabilities is affected in a positive way by the level of technology diversification: firms that can rely on knowledge in a variety of fields have the potential to cross-fertilize, yielding new inventions and functionalities and/or increased product and process performance (Granstrand, 1998, Suzuki & Takeda, 2004). Closely related to this, is the fact that a broad technology base may enable firms to create complete new products and services resulting from the combination of knowledge from different technology fields (Hargadon *et al.,* 2003; Kodama, 1992). Recent empirical evidence by Garcia-Vega (2006), Leten *et al.* (2008) and Belderbos *et al*. (2010) confirms the positive impact of technology diversification on firms' technological performance.

Notice that the presence of a diversified set of capabilities does not limit itself to technological capabilities; as outlined by Tripsas (1996) and Tripsas and Gavetti (2000), the presence of specialized complementary assets, which are necessary to produce and commercialize a new technology, can play a crucial role as well. As long as these assets retain their value in a period of turbulence, firms can be more effective when engaging in both exploitation and exploration. This insight has recently been further corroborated by Taylor & Helfat (2009).

A final moderator that results from this research and that contributes to an effective reconciliation of exploitation and exploration relates to the synergetic potential of the available technology portfolio. Diversified firms can outperform focused or less diversified firms when technology or knowledge relatedness allows enacting synergies (Van Looy *et al.*, 2005). Synergies on the level of R&D are dependent on the 'knowledge coherence' of the technology portfolio. A technology portfolio is considered coherent when it implies technologies that share a common knowledge base, rely upon common scientific principles or have similar heuristics (Breschi *et al.,* 2003; Nesta and Saviotti, 2005). Firms that diversify their technology portfolio in a coherent way will experience less coordination costs. At the same time, technologically coherent diversification is likely to put firms in a better position to enact the cross-fertilization potential offered by being active in a variety of technology fields. Recent empirical studies that confirm the impact of relatedness on the effectiveness of exploring new technological domains include Nesta and Saviotti (2005) and Leten, Belderbos & Van Looy (2008, 2010).

Combined, these studies/scholars develop valuable insights on how to pursue both exploration and exploitation effectively, by pointing out specific, instrumental, resource characteristics (scope, relatedness and complementarities). Organizational and managerial practices that allow to reconcile both activities receive less attention; these become focal points of attention in the second research stream which advances organizational design choices as,crucial to arrive at a reconciliation.

B. Incorporating Different Objectives into Organizational Design

An increasing number of scholars stress the relevance of organizational design choices in order to effectively organize innovation within one and the same firm. Concepts advanced over the last decades include the notion of spin outs (Christensen, 1997, Christensen & Overdorf, 2000) or internal ventures (Burgelman, 1983), ambidextrous organizations (O'Reilly & Tushman, 2004, Tushman *et al.*, 2010) as well as the notions of semi- or quasi-structures (Brown & Eisenhardt, 1997; Schoonhoven & Jellinek, 1990; Gibson & Birkinshaw, 2004). All these notions stress the importance of differentiating between exploration and exploitation. Exploitation benefits from homogeneity, whereas exploration presupposes heterogeneity; exploration implies episodes of conflict and a redefinition of identities, while exploitation thrives on consensus and can be seen as identity confirming (Benner & Tushman, 2003). These observations lead authors like Christensen (1997) to conclude that management practices that are most productive for exploiting existing technologies are counterproductive for exploring radically new technologies. As a consequence, Christensen (1997) favors a strong differentiation between exploration and the current business; the latter activities should be organized in separate, entrepreneurial units, so called ventures or spin outs.

Likewise, Tushman and O'Reilly (1997) defend the idea that units, focusing respectively on exploration and exploitation, should be separated in order to respect the specific nature of both activities. For Tushman & O'Reilly, both activities can be situated within one, ambidextrous, organization which combines operational separation with integration capabilities at more senior levels: "These organizations separate their new, exploratory units from their traditional, exploitative ones, allowing them to have different processes, structures, and cultures; at the same time, they maintain tight links across units at the senior executive level. Such 'ambidextrous organizations' allow executives to pioneer radical or disruptive innovations while also pursuing incremental gains". Such organizational forms are further characterized by a clear, encompassing strategic vision and maturity at the level of senior management in order to handle the conflicts and ambiguity that arise from the portfolio of different and sometimes contradictory activities within the firm.

While for O'Reilly and Tushman (2004), integration implies 'loose coupling', other scholars argue in favor of integrating both activities more explicitly (*e.g.* Van Looy *et al.*, 2005; Janssen *et al.*, 2009) in order for positive spillovers or synergies to occur. Gibson and Birkenshaw (2004) argue that within a single business unit, a behavioral context can be created that fosters both current and innovative activities. According to them, contextual ambidexterity can be established through the balanced development of clear standards, ambitious goals, candid and rapid feedback systems, good access to resources, freedom of initiative and mutual trust and commitment. This enables people to autonomously divide their time between exploration and exploitation,

which involves – in comparison to structural separation – less coordination costs and more opportunities for knowledge spillovers.

Surprisingly, no studies have attempted to analyze the effectiveness of innovation strategies while considering simultaneously the presence of related or complementary capabilities and organizational design choices (including accompanying managerial practices). At the same time, it becomes clear that the presence (or absence) of related and complementary capabilities will influence the impact of organizational design choices on technological trajectories of a more exploratory nature. To the extent that incumbent firms can leverage existing technological capabilities – towards new developments – the relevancy and nature of differentiation/integration mechanisms will likely become affected. Moreover, recent studies that focus on the impact of varying levels of differentiation (and hence integration) do not include the potential time varying nature of such arrangements. As suggested within the work of Tripsas (2000) and more recently by Taylor and Helfat (2009), different stages of the development trajectory might require varying levels of differentiation and integration. These considerations justify further research on effective strategies for incumbent firms to enact both exploitation and exploration simultaneously. Within this contribution, we aim to contribute to this void by means of an in-depth case study.

III. **Research Design**

We analysed the innovation journey (Rip, 2010; Van de Ven *et al.*, 1999; Visscher & De Weerd-Nederhof, 2006) that lead to the successful development and deployment of the ADSL architecture within a large multinational telecommunication firm (Alcatel) by adopting a longitudinal case study design (Pentland, 1999; Pettigrew, 1990). Data have been collected through semi-structured interviews with involved engineers and managers at all hierarchical levels (n = 25) and through document analysis for the time period 1986-1996. Document analysis included both internal documents (*e.g.* minutes of relevant meetings, strategy documents (n > 1500) and external documents (press releases, technology and industry reports, patent documents and scientific publications).

Within the following pages, we will provide a chronological overview – based on interview data and document analysis – of the developments leading to the effective deployment of the ADSL architecture by Alcatel. We will conclude by outlining some major insights that emerge from this case analysis and comment on the implications for organizing innovation processes within incumbent firms in an effective and comprehensive manner.

IV. The Development of ADSL at Alcatel

Alcatel is a large multinational telecom company. It employs 77,000 employees and has operations in over 130 countries (Alcatel-Lucent, 2006-2009). The company was established in 1986 by the merger of the telecom activities of ITT Corporation and CGE; in 2006, the company merged with Lucent. At the beginning of the 21st century, Alcatel was market leader in Asymmetrical Digital Subscriber Line (ADSL),[4] a technology that brought the company considerable profits and that had an enormous impact on society, as it enabled broadband access to the internet.

In the 1980s, solution providers such as Alcatel were not concentrating on ADSL. They focused on developing a technology called Integrated Services Digital Network (ISDN), which enabled the integration of speech and data on the same line. This technology made services possible that were additional to telephony, such as digital telephone, telefax, teletext, and videotext (Annual Report 1986). Initially, transmission speeds of 64 kilobits/second were reached; later on, a maximum of 144 kilobits/second proved possible, in an architecture called Broadband ISDN. Alcatel made an important contribution to this Broadband ISDN by developing Asynchronous Transfer Mode (ATM), a novel technology which encapsulated data into fixed cells (Goralski, 2002). Broadband-ISDN was an important part of Alcatel's corporate strategy, and Alcatel believed that it would remain so for the coming years and decennia. "Considering future developments, we put ISDN at the first place; Alcatel owns the required resources to maintain a central role in these developments" (Annual Report 1986, p. 5)

Initially, Alcatel attempted to exploit broadband ISDN by developing it as a modular product. However, they soon noticed that they were far ahead of the market. Operators were not ready to upgrade their networks to broadband networks. Alcatel therefore decided to integrate broadband technology in their 'System 12'. System 12 was Alcatel's central product and cash cow. The integration of ISDN functionality within this system was considered of strategic importance by top management. Developmental work was done within the main Switching division of the company. The first Broadband ISDN prototype was ready in 1991 and presented at a meeting in Geneva. The integration of Broadband ISDN into System 12 had taken three years to complete. Still, at that moment, telecom operators did not see much demand for potential applications of Broadband ISDN.

A. Exploration of ADSL

In the early 1990s, Alcatel believed that the maximum capacity over copper wire had been reached by Broadband ISDN (144 kbits/s). However, within the framework of a cooperative R&D agreement with Bellcore (nowadays Telcordia), Alcatel's Martin de

Prycker – manager of the central research division in Antwerp, Belgium – and Willem Verbiest – senior advanced system engineer – visited the U.S.A. in 1990. During this visit, Bellcore researchers demonstrated that a transmission of 1.5 mbits/s over copper wire was possible; more than ten times the assumed maximum capacity by using Broadband ISDN. Bellcore started to explore the potential of ADSL under the impetus of J. Lechleider, who strongly believed in the importance of the ideas of J. Cioffi who suggested already in 1979, that by using a wider range of frequencies (up to 1,2 Megahertz, whereas traditional phone use works only with frequencies till 4 kilohertz) a data transmission capacity of 1 to 2 megabits/second should be feasible.

> "I remember that the model of Bellcore allowed 1,5 mbit to be transmitted over a copper wire. That was a huge amount, but the technology was obviously not ready for commercialization yet. The idea that you can actually send that amount of data over copper wire was inspiring and we wanted to do research on whether even more could be achieved" (Interview excerpt M. de Prycker).

Upon returning to Antwerp, Martin de Prycker proposed to senior management within Alcatel, in particular the CEO of Alcatel in Antwerp (Julien de Wilde), to start a small research program – within Alcatel's central research unit – on these new possibilities for data transmission over copper wire. The focus of this research program was on ADSL, the technology that had allowed the high speed transmission of digital and voice data at Bellcore.

> "When Martin came back from the United States, he was convinced of the potential of ADSL and believed that it could really turn out to become something" (Interview excerpt, J. De Wilde).

Prior to the discoveries at Bellcore, Alcatel already pursued research in optical fiber and COAX cable technologies for broadband access. Both technologies enabled much faster data transmission than Broadband ISDN, and were regarded as promising new access technologies. Fiber was generally considered as the most promising and received the most attention. Confronted with these competing technological options – fiber, COAX, and ADSL for copper wire – Alcatel decided to maintain a broad technological portfolio. To explore these technologies, they formed – in 1992 – a dedicated broadband research program, within the central research department.

The exploitation of ADSL on a large scale, requires the development and adoption of standards on the level of a line coding technique, a technique that enables the actual transmission of data by determining how bits are being sent (Chen, 1999). In the early 1990s, there were two competing line coding techniques, called CAP (Carrier-less Amplitude Phase) and DMT (Discrete MultiTone). Solution providers such as Alcatel had to make an initial choice between these two line coding techniques, in order to allow inter-operability. CAP was favored by almost all solution providers and operators,

as it was simpler than DMT, better known and more thoroughly researched. Consequently, Alcatel also decided to focus its efforts on CAP. In March 1993, the American National Standards Institute (ANSI) organized 'Line Coding Olympics' in order to solve the dispute and to set a standard. To the surprise of almost all participants, the DMT prototype, made by John Cioffi and his company Amati, won the Olympics. The DMT prototype ran four times faster (6 Mbits/s) on the same length of telephone line (DeLacey et al., 2006) and proved to be more efficient and more flexible than CAP. As a result, ANSI chose DMT as the standard for ADSL (standard T1E1.4), in which it was followed by ITU (International Telecommunications Union) and ETSI (European Telecommunications Standard Institute).

To comply with the new standard, Alcatel had to reorient their work from CAP to DMT. In particular, they had to develop new chips to enable this line-coding technique. They started in April 1993, just a month after the standard was set. "We were forced to reorient our work to DMT. Despite our initial handicap in the DMT domain" (Presentation Paul Spruyt, 1995). The DMT chips were developed in close cooperation with Alcatel's own chip division – Mietec. This division had experience in developing chips for System 12 and now invested in developing DMT chips. With the support of senior management, resources were quickly mobilized – over 100 full time equivalents – for the development of these chips. The efforts were productive. In about six months, they were at the same level as with CAP before, and in 1995, the first workable DMT chipset for ADSL was finished. This was fast compared to Alcatel's competitors, such as Motorola, forecasting their DMT chip release for 1997 (Tzuo, 2004).

B. **Opportunities for Exploitation**

In the early 1990s, the foreseen 'killer application' for broadband access technologies – both ADSL, COAX, and optical fiber – was Video on Demand (VOD). VOD would enable customers to order videos at the moment of their choice, through a broadband access network. Alcatel started the development of VOD with ADSL and fiber in 1993. In cooperation with the Switching business unit, research carried out several trials, and in 1995, Alcatel was ready for the first release of an ADSL system, with DMT chipset for the delivery of VOD (Galatioto, 1996). However, in the last months of 1995, the great expectations for Video on Demand collapsed. In hindsight an Alcatel engineer concluded:

> "The technology was not mature enough, therefore in order to make the product profitable, the tariffs would have been too expensive. And although the idea was great, the market was not ready for VOD" (Interview excerpt, Y. Guinee).

At the time that Video on Demand had been regarded as killer application, another potential application – the internet – had also gained attention. "ADSL is increasingly

seen as the solution for higher speed access to on-line services (including access to internet) and for remote access to LANs."(ADSL.doc, 1995). One of the main advocates to focus on the emerging internet technology at Alcatel was Martin de Prycker, the manager of central research. He initiated a minor research program focusing on internet technology within the central research unit in 1993. Two years later, it became part of the corporate strategy. At this time, ISDN was not perceived as an adequate technology anymore. The COO of Alcatel stated that in 1995, he could not believe that people would start using the internet at the speed of ISDN. Given the competition of the cable companies (COAX), telecom operators were under pressure to offer similar access capacities. They were looking for an access technology that would enable greater capacity without costly and time-consuming upgrades of the current network (Tzuo, 2004). Implementing optical fiber would be too costly and time-consuming. Therefore, ADSL was the most viable solution to compete with the cable companies.

C. **Virtual Company**

To further develop ADSL technology for internet usage, Alcatel set up a semi-autonomous unit, which they named a virtual company (VC). The VC was an organizational unit within the boundaries of Alcatel. It had an autonomous position and was allowed, for instance, to determine its own purchase and HR policies.

> "The VC was an independent structure within Alcatel. We received quite some freedom, but were allowed to use the basic facilities within Alcatel" (Interview excerpt M. de Prycker).

Martin de Prycker was the entrepreneurial champion within the VC. He had identified internet as a viable application for ADSL and realized that the market for internet would first emerge in the United Sates. It was important to him that the development of ADSL would be set aside from Alcatel's central product, the telephone switch System 12, which did not have an installed base in the American market. If ADSL was to be integrated into System 12 – as had been done for Broadband ISDN in the early 1990s – it could not become successful in the United States.

> "We are not selling System12 in the United States and that is where the initial market for the internet is. If we are going to integrate it, we will sell zero lines in the United States and I do not want to do that. I want to go for a modular product" (Interview excerpt M. de Prycker).

Integration would also imply a loss of time and momentum.

> "Based on my experience with [Broadband ISDN], I was convinced that if we want to make some money out of ADSL fast, we should manage it independently from System12" (Interview excerpt M. de Prycker).

To pursue the ADSL goals, de Prycker and his colleagues received support from members of the senior management team. Especially the general manager of the Alcatel

Antwerp location and the chief operating officer of Alcatel in the Paris headquarters supported the idea. The decision to start the VC rather than to integrate it in the Switching division was not evident, though.

> "Switching dominated everything, thus also new developments. Normally these had to be integrated in switching. It was obvious that if we were to leave it to the Switching 'machine' that it would take too long. We needed people. And Martin believed in it. The idea was a virtual company, away from Switching. These were heroic discussions, and absolutely not evident" (Interview excerpt, J. De Wilde).

On a corporate level, support for large investments in ADSL was absolutely not evident. Some countries did not demand ADSL at all and preferred fiber (*e.g.* Japan, due to the bad quality of the installed copper base), or relied on the old installed ISDN base (*e.g.* in Germany).

> "Stop with ADSL! That was the argument we heard a lot, the English, the Japanese and the Germans do not want it. What are you doing?!" (Interview excerpt, J. De Wilde)

Nevertheless, developments of ADSL continued, due to perseverance and believe in ADSL by several key individuals in Alcatel at different levels. Martin de Prycker was appointed as manager of the VC, as he had technical knowhow, strong believes in ADSL, and the ability to motivate people.

> "Martin had charisma, employees wanted to work for this man" (Interview excerpt, J. De Wilde).

Employees of the VC were attracted from the central research department, but also from the Switching division. The COO – a strong supporter of de Prycker – explained:

> "R&D programs were my responsibility and these were centrally controlled. We decided to put more employees on the development of ADSL, which we extracted from the Switching division" (Interview excerpt, J. Cornu).

D. **Winning the JPC Contract**

A crucial moment in the emergence of ADSL-based internet technology, for the industry in general and for Alcatel in particular, was the granting of the JPC contract to Alcatel in 1996. Four American telecom operators – Ameritech, BellSouth, Pacific Bell and SBC Communications – formed the Joint Procurement Consortium (JPC) with the aim to jointly purchase ADSL equipment to offer internet services to their customers.

JPC sent out a proposal request for ADSL to a number of solution providers, among which Alcatel. This request contained several technical specifications and a request for standard compliance. The solution providers who received the request for proposal, had to deliver their proposal to JPC on August 6, 1996. From the issued propos-

als, three solution providers were shortlisted by JPC, namely Westell, Ericsson and Alcatel. Westell was a medium-sized US solution provider (Tzuo, 2004) and both Ericsson and Alcatel were larger foreign solution providers. Alcatel put a lot of effort into attaining the JPC contract, as it would give them the most prominent position in the ADSL market and a strong foothold in the United States, where Alcatel was still a minor player. During the JPC committee visit to Antwerp, Alcatel showed them their full ADSL architecture, which was an end-to-end solution.

> "During their visit they have seen a combination of skills and products. Actually we had all the ingredients to offer internet on ADSL. JPC could launch ADSL by just talking to Alcatel. They did not have to extract components from here and there. .... so in fact it was a combination of diverse technologies, good preparation and thorough system development knowhow." (Interview excerpt, D. Rabaey).

On the 7th of October 1996, press releases announced that Alcatel had been selected by the JPC to deliver ADSL equipment. The stock prices of Westell, which had hoped to win the contract, dropped considerably. The JPC turned out to be an important milestone in the market success of Alcatel and for the emergence of ADSL (Ginsburg, 1999).

In hindsight, a combination of factors can be identified that contributed to the success of Alcatel in winning the JPC contract. For one part, these factors related to technological choices and capabilities. JPC preferred technologies that were compliant with the industry standards, in particular the line coding technique DMT. Alcatel had been engaged in standard-setting throughout the development of ADSL and Alcatel's ADSL system was compliant with the industry standards. This was a competitive advantage. "Alcatel is the only vendor that will be able to deliver DMT ADSL units in volume in the time frame specified by the Gang of Four." (Theodosopoulos & Heritage, 1996). Alcatel's competitors for the JPC were not in such a good position. Westell, for example, had chosen Ethernet and CAP technology, which were non-compliant. The other shortlisted competitor, Ericsson, relied on DMT chips from Motorola, but these were delayed. In contrast, Alcatel had its own chip-division, enabling quick DMT chip development. As result, Alcatel was the only solution provider with a workable DMT chipset.

Next to technological choices, several organizational factors played a role, as they enabled the development of a compliant, end-to-end ADSL solution in a short period of time. First, the combination of bottom-up, entrepreneurial action, and top-down support proved crucial. The driving forces behind the development of ADSL were the employees within central research, particularly Martin de Prycker, who had an entrepreneurial mindset and visionary focus on ADSL as the next access technology.

The vision of selling internet on the market was our own vision; it did not come from management" (Interview excerpt, M. de Prycker).

Several senior managers at Alcatel Antwerp and in the headquarters at Paris supported him at vital moments, in the fierce competition for resources with the standing divisions. The development of ADSL was absolutely not evident at Alcatel, especially after the failure of VOD.

> "There were conversations in the corridors [...] people were considering stopping ADSL, as people thought it would not emerge"(Interview excerpt, W. Verbiest).

> "There were thousands of reasons not to further invest in it..." (Interview excerpt, J. de Wilde).

Nevertheless, de Prycker repeatedly proved to be capable of igniting the enthusiasm for his vision at top management level, giving ADSL a central place in Alcatel's strategy, and getting the support and resources he needed to develop an ADSL architecture rapidly.

The Virtual Company structure proved to be an effective design to facilitate and make use of intrapreneurial dynamics and top management support. The VC provided flexibility in terms of ADSL development options and enabled fast decision making. On the other hand, it made the use of corporate resources possible, in terms of financial buffers and technological expertise. Alcatel had a broad range of skills and complementary technology platforms, and the VC could tap into these to develop the ADSL architecture. For instance, the so-called DSLAM – a vital component that connects the signal to the internet backbone – was developed by tapping into knowledge gained from optical fiber trials, where a similar technology was used for VOD. Another example relates to the DMT chipsets for the modems, which were developed by tapping into the competences of Mietec, Alcatel's own chip division. The use of this broad range of skills contributed to the successful development of the ADSL architecture as an end-to-end solution, from the customers' premises to the central office and the internet backbone. For the JPC, this end-to-end solution was decisive.

V. Discussion and Conclusion

The developments after the initiation of the ADSL research project in 1992 are summarized in Table 1. A major distinction can be made between the period 1992 till 1995 – in which efforts were focused on the creation of building technical capabilities and in which market development failed – and the period form 1995 onwards – in which market development efforts turned out to become successful. In the first phase, the research division of Alcatel was the center of gravity for the exploration oriented activities, while exploitation was led by Switching, the dominant business unit. In the second phase, the market development efforts were organized in a 'semi-independent' structure.

Table 1. The Development of ADSL within Alcatel.

	1992–1995	**1995–1996**
Critical Incidents	• Detection of technical feasibility via Bellcore: ADSL becomes a research topic within Alcatel's Research portfolio (1992) • Switch from CAP to DMT line coding (1993) • Prototype development and trials of ADSL for Video on Demand (1993-1995). • First workable DMT chipset for ADSL (1995) available. • Failure of Video on Demand as killer application (1995)	• Focus on the Internet as killer application (1995). • Creation of a Virtual Company to exploit the market for ADSL (1996). • Successful engagement in the JPC Bid (1996)
Technological and Organizational Design Choices	• Strategic autonomy of Research to define relevant technological platforms for exploration. • Exploitation within major business unit	• Combining entrepreneurial dynamics with corporate sourcing: Hybrid structure for exploitation • Critical Roles: Entrepreneurial champion and supportive senior management

During the first phase, research activities got differentiated from business development activities. At the same time, developing capabilities with respect to competing technological platforms (Fiber, Coax, ADSL) happened within one and the same research organization. This portfolio approach – where the research teams were sitting literally next to each other – was favored over a more differentiated approach as spillovers and synergies between the different technological platforms were present and envisaged. These synergies pertain to signal processing capabilities, software and hardware development as well as system integration requirements. In terms of defining and redefining the research portfolio, one observes considerable autonomy and room for entrepreneurship. Technical experts within the research division proposed to include ADSL as a separate research project and obtained approval swiftly. Initially, development efforts were limited to a team of 5 to 7 people. While such a small research team was instrumental for the creation of 'entrepreneurial' dynamics, resources present within the broader organization were actively solicited when appropriate. This became apparent when the team was forced to make the shift from CAP to DMT in 1993. Developing a chipset capable of handling the new functionality – which became a de facto standard after winning the 'Olympics'– suddenly became a necessary condition to start competing on the market. At this stage other parts of the organization became involved to support the required hardware developments.

Complementing the efforts of a small, dedicated, and relatively autonomous team with available corporate resources turned out to be also characteristic for the second phase, in which a virtual unit was being created, devoted to the development of the market for ADSL.

In the second phase, when the internet was targeted, the further development of the ADSL product architecture took place within a specific, dedicated, organizational structure. Creating such a semi-independent and dedicated structure, alongside the major business unit, was not obvious. In this case, bottom-up entrepreneurial initiatives backed up by senior management support – both in Antwerp and in the Paris headquarters – enabled the enactment of this 'separated' structure. Combined, these observations display a strong resemblance to the constituents of internal venture processes as outlined by Burgelman (1983).

This structure proved adequate to ensure sufficient levels of entrepreneurial dynamics and enabled the acceleration of the commercialization process (O'Connor and DeMartino, 2006). Such dynamics were perceived as critical in order to compete in a newly emerging field populated not only by larger incumbent firms, but also with smaller technology based, entrepreneurial firms. Separation made it possible to act as agilely as a small entrepreneurial firm, free from the requirements, interests, and practices of major business units. At the same time, separation was not absolute and can be characterized by semi-permeability: corporate, complementary capabilities have been sourced selectively. They instantaneously received a large group of engineers when they needed them for the development of ASDL, and the forward pricing models have been inspired and supported by senior management outside the virtual company. Furthermore, development efforts profited from the in-house technological capabilities (e.g., the chip division) to develop a total infrastructure, while their competitors had to rely on external partners, introducing additional complexity and longer throughput times.

As such, these findings highlight the interplay between organizational design choices and the presence and relevancy of complementary resources. First, it becomes apparent that neither complete separation, nor an organizational design of an ambidextrous nature accounts for the observed dynamics in a satisfactory manner. Rather, our findings reveal the effectiveness of a 'hybrid' structure characterized by semi-permeability which allows the simultaneous presence of entrepreneurial autonomy and the enactment of complementarities. Second, the presence of complementarities as well as the adoption of this semi-permeable structure does not provide a complete account of the observed dynamics. Entrepreneurial behavior – labeled by Burgelman (1991) as autonomous strategic processes – present itself as a third, constitutive, ingredient. Both the initial research on the ADSL technology and the creation of the virtual company stem from entrepreneurial, bottom-up initiatives which have been allowed and supported by senior executives. Paraphrasing Chandler (1962), one could

state that structure 'follows' strategy, including its autonomous, entrepreneurial part. Combined, these findings strongly suggest the relevance of combining simultaneously insights stemming from the fields of strategic management, entrepreneurship and organizational design theory to arrive at more comprehensive accounts of the complex and challenging processes of reconciliation that incumbent firms face within dynamic environments.

NOTES

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4. Appendix A provides a schematic overview of the ADSL architecture.

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APPENDIX A

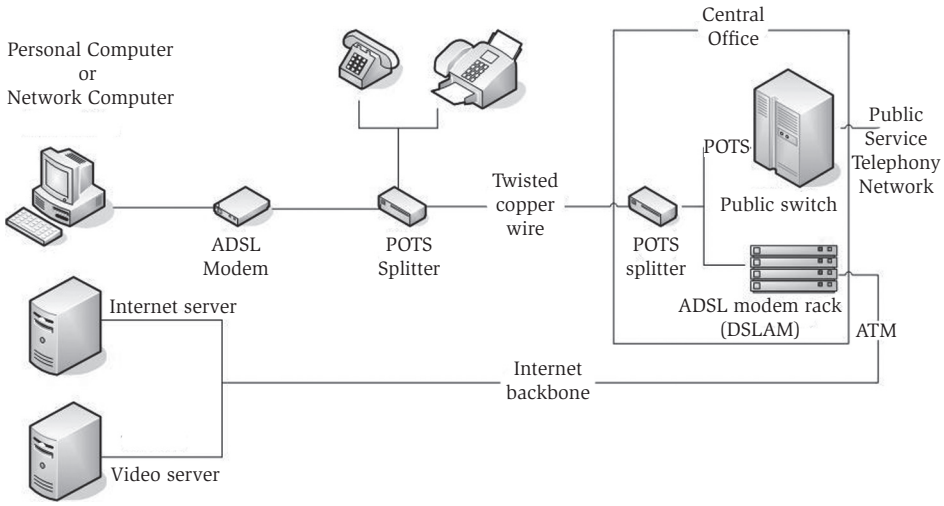

Figure 1. The ADSL Architecture.