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Abstract

This article focuses on individuals working on innovation developments during the unfolding of innovation streams. Innovation streams include both exploitation- and exploration-oriented projects. Those projects imply different temporalities and can be conducted at different paces. This research examines how different temporalities within a single innovation stream are managed first at the level of projects and then among projects. We collected data on an innovation stream in the semiconductor industry. We explain how teams and organization develop processes and tools to address different temporalities. The results show that the process of learning occurs first within projects and then among projects. Our research offers new understandings of the transition of organizations towards a project-based structure by demonstrating that changes in practices can occur first as a reaction to external events, then as the results of new arrangements triggered by management and finally as the consequences of the team's proactive actions.

Keywords: Innovation; Temporality; Project; Exploration; Exploitation

1. Introduction

Continuous development of innovation is a substantial source of competitive advantage and a crucial factor in organizations' longevity (Eisenhardt and Brown, 1998; Tushman et al., 1997). Most innovations are based upon other innovations and may become foundations for additional technological development (Podolny and Stuart, 1995). In this article, we focus on streams of innovation, which are defined as '*patterns of innovation that are required for sustained competitive advantage*' (Tushman et al. 1997, p.5). Specifically, we understand innovation streams as including both activities to prepare for future activities and activities to expand a company's existing knowledge base (March, 1991) through the development of new products.

Simultaneously creating new competences for future expansion and while continuously developing existing knowledge is particularly challenging. In fact, exploring new pathways and exploiting the existing knowledge base are based on different temporalities (March, 1991). As exploring involves experimentation, search and discovery (Ibid), its returns are based on long-term engagement (Arthur et al., 2001). Furthermore, reinforcing deadlines may not be conductive to exploratory activities (Amabile, 1985, 1998). On the contrary, exploiting a company's existing knowledge base is associated with short-term returns, and meeting deadlines and maximizing the use of existing resources are key objectives (Arthur et al., 2001).

However, innovations are increasingly developed by project teams. Projects can bring competitive advantages for companies in terms of the reuse of existing knowledge or the development of new knowledge (Brady and Davies, 2004; DeFillippi, 2001). Thus, individuals can be involved consecutively in simultaneous projects with different temporalities that can be conducted at different paces within a company. However, few studies have linked the two processes of the exploration of new activities and the exploitation of the existing knowledge base and time perceptions in project-based organizations (Swan et al., 2010;

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Bakker et al., 2013). Our research explores how different temporalities within a single innovation stream are managed. It is grounded in a stream of research demonstrating that projects are the locus for the development of new capabilities at the organizational level (Söderlund and Tell, 2009). It provides new insights by focusing on projects within their context and in their interrelation (Engwall, 2003). Our research focuses on temporalities both within and between projects.

We collected data on an innovation stream in the semiconductor industry and performed a qualitative analysis using the 'event structure analysis' (ESA) method. The innovation stream was composed of 10 hybrid projects (Schwab and Miner, 2008). We explain how teams and organizations develop processes and tools to address different temporalities.

This article is structured as follows. Section 2 presents the theoretical background and objectives of this research. The research settings and methods are described in Section 3. Section 4 presents the results. The last section includes a discussion and the conclusion of the paper. The results show that the process of learning occurs first within projects and then among projects. During the first stage, the project structure gains legitimacy in the organization. Then, team members deploy the new practices, particularly concerning time pacing, and finally, synchronization within projects and the external environment is enhanced.

2. Theoretical background

2.1. Innovation projects and temporality

Most works on technology innovation focus on the development of a single innovation, although in certain highly dynamic domains, the innovation paths are formed by several innovation trajectories, which sometimes overlap or go in different directions (Boland et al., 2007). Innovation streams are characterized by both the exploitation of current knowledge and the exploration of new futures (Tushman et al., 2010). Companies need to enhance the development of these streams to both shape technological change in their market and sustain competitive advantages (Tushman et al., 1997). Thus, they need to develop an ability to address the strategic challenges of managing different innovation types both consecutively and successively (Gupta et al., 2006; Bodwell and Chermack, 2010).

Those activities can be performed in projects. As projects are temporary structures that are oriented towards a specific objective, they are particularly helpful in exploring or exploiting knowledge to be applied in a particular context (Sydow and Staber, 2002; Grabher, 2004). Projects assemble people with a diversity of profiles and past experiences. Thus, projects provide diversity and enhance the development of new activities (Hargadon and Sutton, 1997; Fleming et al., 2007). Moreover, project members move from one project to another and cross-pollinate a company's knowledge base (Takeuchi and Nonaka, 1986; DeFillippi and Arthur, 1998) and exploit previously generated knowledge. Thus, during innovation streams, projects are performed simultaneously and are interrelated with continuous flows of new innovations (Eisenhardt and Brown, 1998), which is called synchronization (Halbesleben et al., 2003).

The temporality of projects affects how people interact in a team and organize their work (McGrath, 1991; Hernes et al., 2013). In this research, we particularly focus on the capacity of the organization and individuals to pace innovations, focus simultaneously on different timeframes and build ties between those timeframes (Brown and Eisenhardt, 1997). Time frames relate to the project teams' 'anticipation of the termination of their project that is more or less imminent' (Janowicz-Panjaitan et al., 2009). Orlikowski and Yates (2002) note that in most research, time is either conceived as an objective measure, which exists independent of human actions, or as socially constructed by human action. Time has a subjective capacity (Ancona et al., 2001, Bakker et al., 2013). Thus, timeframes relate to the fact that time is experienced by individuals and play a major role in how people become involved in projects and learn from them. Teams that perceive a project as a short-term engagement, after which their relationships with other team members will be dismantled, focus more on the immediate present (Bakker et al., 2013), which may impede the further diffusion of newly created knowledge (Grabher, 2004) and the unfolding of innovation streams.

Time frames relate to projects in isolation. However, innovation projects are embedded in larger social aggregates (McGrath, 1991), and moreover, certain organizations schedule product innovations at regular time intervals (Gersick, 1994; Brown and Eisenhardt, 1997). When individuals are involved in a continuous flow of projects, as in innovation streams, they perceive that their collaboration with other team members is likely to recur in the future, and they develop long-term relationships and a long-term orientation (Cattani et al., 2011). Repeated collaborations with similar others favours knowledge dissemination but would constrain the innovation stream regeneration process (Granovetter, 1973). The transition between long-term and short-term orientations needs to be managed at both the individual and team levels. Thus, we also focus on the synchronization of transitions within projects to provide a tempo for change. Synchronization also occurs between the project group and "external events" (McGrath, 1991). Those synchronizations are keys to time-pacing innovations. Time pacing allows for the coordination of innovation activities (Dougherty et al., 2013). Brown and Eisenhardt (1997) demonstrate that the ability of managers to link current product development to future development and to synchronize transition between projects determines the ability of the organization to generate a continuous flow of innovations.

Several studies, which link temporality to projects, have been performed that consider stand-alone projects in which people do not expect to collaborate on other projects in the future (McGrath, 1991). However, projects should also be understood in the context of the more permanent organizational structures in which they are embedded (Grabher, 2004; Schwab and Miner, 2008; Cattani et al., 2011; Manning and Sydow, 2011). Innovation streams provide a particular context, as groups have shared pasts and can expect to have shared futures. Individuals can also interact on several projects at the same time. Finally, groups, which are involved in different projects, innovate at different rates and times during the innovation streams (Boland et al., 2007). Although each group has its own logic and tempo (Galison, 1997), it has to overlap with other projects to transfer knowledge and to create collaborations among projects (Boland et al., 2007). Two main temporalities need to be balanced during innovation streams: an exploration-oriented and an exploitation-oriented temporality.

2.2. Balancing between the contradictory requirements of exploration and exploitation projects

Exploration-oriented projects are intended to create new futures (March, 1991; Smith and Tushman, 2005; Yang et al., 2014). Top management can form project teams to develop new capabilities and explore new business opportunities (Davies et al., 2010). New knowledge is thus generated to adapt to changing environment conditions (Middleton, 1967), and companies need to unlearn their past knowledge and create new routines (Yang et al., 2014). Those projects are characterized by involving non-routine and complex tasks (Grabher, 2002). They are usually associated with the creation of ad hoc teams, in which the members have no prior relationships, as the company gathers together people with different backgrounds (Fleming et al., 2007; Ruff, 2014). They have a finite end but one that is generally agreed upon by members of the team without external constraints (“carte blanche”) (Grabher, 2002; Ruff, 2014). They usually involve a long-term engagement, as they are characterized by experimentation and searching for new solutions (March, 1991; Eisenhardt and Tabrizi, 1995).

Dougherty and her colleagues (Dougherty et al. 2013, p. 235) differentiate between clock-time pacing and event-time pacing: ‘clock-time pacing marks beginnings and ends of activities with clocks and calendars, whereas event-time pacing marks beginnings and ends of activities with learning events, the timing of which is unpredictable.’ This dichotomy is similar to the distinction between objective time, which can be measured and used to coordinate activities (Orlikowski and Yates, 2002), and subjective time, which relates to events.

During an exploratory project, event-time pacing predominates, as planning and rewarding for schedules are inefficient (Garud et al., 2011; Eisenhardt and Tabrizi, 1995). In that type of project, the team needs to cope with unfamiliar activities and develop new capabilities. These exploratory projects may be perceived as an opportunity to enhance one’s learning and build one’s future career (Arthur et al., 2001; DeFillippi and Arthur, 1998). As Dougherty et al. (2013) note, scientists who are involved in discovering new drugs pace their time according to learning events. They cannot predict when those events will occur, but they set their milestones according to them. The focus and criteria for success are on the learning created and not particularly on meeting deadlines.

On the contrary, exploitation-oriented projects involve clear deadlines and schedules. Team members focus less on personal learning than they do during exploratory projects. Projects turn to a “logic of consequentiality”, with the objective of producing the quickest acceptable outcomes (Swan et al., 2010). Projects are replicated with few differences from one project to another (Engwall, 2003) and offer only incremental learning (Arthur et al., 2001). As projects are quite standardized, the management team reinforces precise deadlines because it is easier to forecast the amount of time needed to complete the project. Team members also know what expertise is needed and who has the required skills. Consequently, individuals develop their collaboration activities according to the success of prior projects (Schwab and Miner, 2008; Soda et al., 2004; Grabher, 2002). Thus, they increase their probability of working with the same collaborators again. Exploitative projects are short-term engagements in terms of personal learning, but they can provide support for long-term relationships. Teams involved in the development of successive exploitation projects know that if they are successful in their tasks, they may contribute again to subsequent projects. The temporariness of a project is balanced by a flow of continuous projects. This impacts both types of time perception, insofar as the continuous flow of projects provides long-term collaborations (Tempest and Starkey, 2004).

Consequently, one of the challenges of managing multiple projects during innovation streams is to synchronize the temporality of the different projects, which are based on completely different logics, as shown in Table 1, such that exchanges of practices can occur across multiple teams (Bresnen et al., 2004). Several studies highlight a tension between the two temporalities described above (Dougherty et al., 2013; Garud et al., 2011) but simultaneously recognize that individuals must be able to engage in different projects with their own temporal rhythms. Garud and his colleagues (2011) explain how engineers at 3 M manage different temporalities to achieve both exploration and exploitation at the individual level. Similarly, Dougherty (Dougherty et al., 2013) proposes ideas to overcome the tension between groups of people who have different approaches to time pacing. However, Brady and Davies (2004) propose a model for articulating the exploration of new knowledge and the exploitation of existing knowledge on a longitudinal basis. Companies moving to a new customer base or exploring new technologies go through three consecutive phases. During the first phase, firms move through a “vanguard project phase” to explore new practices. During the second phase, the firms use the learning obtained in the first phase by transferring it from project to

Table 1
The different logics of exploitation and exploration projects.

	Exploitation projects	Exploration projects	References
Constraints and planning	Clear deadlines and schedules, short-term objectives	Few time constraints, long-term objectives	March (1991)
Relationships	Existing relationships	New relationships	Fleming et al. (2007)
Time pacing	Logic of replication	Event-time pacing based on learning events	Dougherty et al. (2013)

project. Finally, the knowledge is used to develop new routines and capabilities, and the firm is able to execute a growing number of projects. This relates to the notion of projectification (Midler, 1995; Packendorff and Lindgren, 2014), defined as changes in the organizational and governance structures to increase the primacy of the project process (Maylor et al., 2006). Projects are then institutionalized in the organization (Packendorff and Lindgren, 2014), which involves a high level of autonomy for project managers with a decentralized decision system, a customer-oriented organization and the standardization of practices and routines to manage a portfolio of projects.

However, we know little about the individuals and the teams involved in the process. Specifically, we should develop a better understanding of how individuals learn during the different phases and adapt their practices to transition from one temporality to another over time. Consequently, we study the unfolding of an innovation stream in a semiconductor company to understand how different temporalities within a single innovation stream are managed.

3. Research settings and methods

3.1. Research settings

This research was conducted for one of the world's leading semiconductor producers. This organization employed more than 30,000 employees and had a turnover of 5 billion euros in 2008. It was part of the Philips group and was sold to a venture capitalist in 2006.

We signed a research contract with an R&D centre at that company and worked there for 4 years (2007–2011). One of the main innovations, developed at the beginning of the 2000s, was chips for receiving TV channels, or tuners. That research centre included a business line (BL) dedicated to the design of tuners.

We had access to the design records of various products from 2000 to 2010. We identified an innovation stream that began in 2000 with the development of 'silicon tuners.' These tuners are highly integrated circuits that receive radio frequency signals and convert them into a frequency that displays images or plays audio on a device such as a television.

At the end of the 1990s, televisions used 'can tuners' — ten-centimetre-long metallic boxes that contain various electronic components. Can tuners were not convenient to use. First, their size did not allow them to be integrated with small devices or into flattened televisions. Second, these electronic components had to be manually tuned to match other components in the TV. Consequently, they were costly to integrate.

From 2000 onwards, engineers in the R&D centre began to use chips to integrate several features of tuners. Philips was then the leader in designing and producing systems for can tuners. Marketers and researchers decided to design an initial prototype for 'silicon tuners' (tuners that are integrated into chips) to keep the company at the leading edge of the market. Over 10 years, several generations of tuners were launched in different markets. In our study, we focus on that innovation stream, which lasted from 2000 to 2010 and included the launch of six different new products.

3.2. Methods

Our study addresses the engineers involved in developing an innovation stream. We conducted a single case study, as we had the opportunity to explore a significant phenomenon under rare circumstances (Eisenhardt and Graebner, 2007). The innovation stream that we study took place over a long period of time (10 years) and involved a notable number of projects associated with 10 teams. Consequently, we could assess changes in team dynamics over time. The unfolding of that project stream also embodies the transition from an organization based on the management of single projects to the management of a portfolio of concurrent and consecutive projects (Packendorff and Lindgren, 2014).

We analyse the relationships among engineers employed by the semiconductor producer and their relationships with internal and external partners (management, marketing, customers, universities, industrial partners, and others). The engineers worked primarily at two R&D centres, one located in France and one in the Netherlands. Our method follows a logical sequence through the following four steps:

Step 1: We conducted 24 interviews on innovation streams related to the development of silicon tuners from 2000 to 2010. Appendices 1 and 2 summarize the positions of the interviewees and the years of interviews. As certain interviews relate to events that occurred a few years earlier, we cross-checked information with secondary data. Thus, we had access to 100 documents (meeting reviews, internal presentations, press releases) and gathered data on 77 patents that were filed during the development of the innovation stream.

The interviews consisted of open-ended questions on the programme history, technological developments, the different innovations that were generated, the type of innovation, targeted markets and the type of information and knowledge that individuals exchanged through the innovation stream. We wrote a monograph on the ten years that were studied.

We assessed the level of the technological disruption of the different generations of products (incremental, architectural, or discontinuous innovation) and the level of novelty in the market (current customers, new customers in defined markets, or emerging markets), according to Smith and Tushman's (2005) innovation map (Table 4). We determined the different levels of market novelty and technological disruptions based on the opinions of engineers working on the innovation streams. Key historical elements are presented below (Section 3.2), as is a table summarizing the new products that were launched during the period studied (Table 4).

Step 2: We used a method similar to Stevenson and Greenberg (2000). First, event structure analysis (ESA) (Griffin, 1993) allowed us to use the temporal order of events to organize information about the innovation stream. ESA uses historical narratives and 'an inferential logic that is systematic, largely non-probabilistic, and procedurally replicable' (Griffin and Ragin, 1994, p. 4). It allows for imputing the underlying structure of a causal argument (Brown, 2000). We used ETHNO (ESA's interactive computer programme) to map the causal flow of events that occurred during the innovation stream (Fig. 1). The innovation stream was composed of 10 main projects that lasted 2–4 years. Next, we distinguished three main periods that corresponded to different brokerage logics: P1 — 2000 until the end of 2003; P2 — 2004 until the beginning of 2007; and P3 — 2007 to 2010. We defined the different phases according to the disruption in the paths that were followed. For each phase, we identified main events that triggered changes in engineers' practices and whether those events occurred in the external environment or in the team. According to Morgeson et al.'s (2015) work, we characterized events according to three dimensions to identify whether the event is:

- disruptive, which means that it reflects a discontinuity in the environment;
- critical, which means that it is essential or important for the team;
- novel, which means that it represents a new and unexpected phenomena.

The shape of the ESA diagram (Fig. 1) indicates when a main path divided into two (or more) different streams of new product development (such as at the beginning of the first phase) or when different streams merged, as in the beginning of the third phase. The first phase is characterized by two main paths (one involving improvements in existing products and the other one intended to explore new technology). The phase ends when the two paths merge. The second phase is characterized by one main path, which is divided into two directions as new market opportunities emerge (PC market, TV market). It ends when the management decided to establish different teams to study different markets and technologies.

Step 3: To determine whether individuals were focused on exploration or exploitation during the three phases, we used patent data and an analysis of interview content. Patents are considered a formalization of knowledge; the higher the number of citations a patent has, the greater its role in the innovation stream (Fleming and Sorenson, 2001). Therefore, we calculated the number of patents issued by the teams of the R&D centre on the innovation stream during the three periods. For each patent, we computed whether other patents were cited and whether other inventors had cited the patent. Inventors often cite patents that relate to technological subjects that are related to their own research (Sampat and Johnson, 2002; Criscuolo and Verspagen, 2008). We assumed that a low number of citations indicate that the technological field of the patent was new and characterized exploration. Conversely, a high number of citations demonstrate that the team was exploiting existing knowledge. Similarly, we stipulated that a patent that was referenced by another inventor is a key patent in the innovation stream.

We extracted sections of the interviews relating to exploration and exploitation, as well as passages related to time perception and the perception of relationships as being short-term or long-term engagements. The interviews were

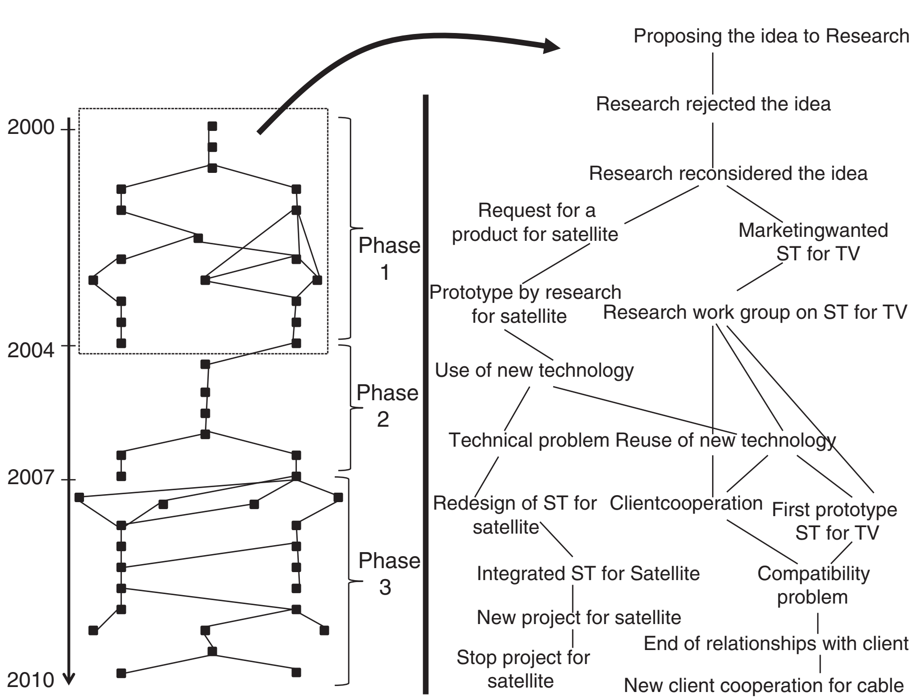

Fig. 1. Event structure analysis (with a focus on Phase 1).

coded using Atlas.ti to understand the different conditions of knowledge development and time perception (Lincoln and Guba, 1985). We used passages to illustrate our results, which are described in Section 3.2.

Step 4: We identified members who stayed in the set of relationships (network) composed by the innovation streams, whether they left the network, and whether new actors joined the network. To identify all of these actors, we created an initial list of persons from patent ownership lists. We interviewed persons from this list, which then was modified based on the interviews. We contacted the persons who were added to the list and considered it to be complete when three interviewees agreed that it was (Kadushin, 1968). Actors were included in the network during one of these periods if they were working on an innovation during the period or if they filed a patent during the period. We sent the list of persons to each actor and asked them to indicate the names of the other actors with whom they had worked (number of ties – see Table 2). We also gathered information on whether they knew one another previously ("existing ties" — see Table 2) and whether they were in close relationships ("strong ties" — see Table 2) (Granovetter, 1995). We then differentiated the three periods to define a team representation for each phase (Table 2).

4. Results

First, we identified whether each phase was characterized by exploration or exploitation. Then, we described the three different phases in terms of market and technological outcomes, and for each phase, we differentiated how time was perceived by the team, whether there were objective deadlines that were reinforced, how the work was paced (rhythm), the consequences for learning activities, the perception of relationships as short-term or long-term engagements, and whether learning systems were developed.

4.1. Exploration and exploitation in the three phases

Table 3 describes the patents for each period and the proportion of patents with citations.

The patent data (Table 3) demonstrate that the first period was characterized by exploration. Few of the registered patents cited other patents (30.4%). Eleven patents (47.8%) registered during this first period were cited later, with 21 occurrences. A more detailed analysis of the dates of those patent proposals shows that 8 out of 11 of those patents were proposed before 2002. The first phase is thus characterized by exploration, as depicted in the following quotation:

> '*At the beginning, I was very interested in this project because it was a breakthrough, a major innovation in our field and I was interested in achieving that, structuring the design*'
>
> [(the project manager)]

The analysis of patents during the second period shows that 43.5% were based on registered patents, which is more than during the first period. Furthermore, only 17.4% of the patents would be used (a total of seven times) in the future. Those scores indicate that more patents were using the knowledge base of the company during the second phase than during the first phase. During the second phase, individuals were exploitation-oriented.

Finally, the third period was characterized by the highest number of patents registered, and only 41.9% of the patents included citations. The third period was also characterized by the greatest co-ownership of patents by individuals from different sites, which demonstrates that there were embedded relationships with researchers from other entities (Lahiri, 2010). Thus, the third period is typified by exploration and transfer, as depicted in the following quote:

> '*When we began to work on the second-to-last generation of the product, we looked at things that already existed and we tried to reuse them as much as possible. We did this much more than previously. There were also many elements of that product that were only a technological transfer*'
>
> [(a project member)]

Patent and interview analysis indicates that the first phase is characterized by exploration, the second phase by exploitation, and the third phase by exploration. The first two phases are consistent with Davies and Brady's work (2004). However, during the third phase, we observe both knowledge transfer and exploration, as if a new cycle were beginning.

Table 4 describes the six new products launched between 2003 and 2010. It includes only "new generations" of products. In the semiconductor industry, once a new generation is

Table 2
The evolution of the networks of actors.

Measures	P1	P2	P3
Number of actors	23	30	29
Number of new members		22	11
Number of members from P1		8	6
Number of ties	114	186	169
Percentage of existing ties	46%	53%	58%
Percentage of strong ties per existing ties	62.5%	35%	37.5%

Table 3
Patents registered during the three phases.

	P1	P2	P3
Number of patents	23	23	31
Number of patents with citations (% compared to the total number of patents)	7 (30.4%)	10 (43.5%)	13 (41.9%)
Total number of citations	42	47	54
Number of patents of the period that are cited later (Proportion of the number of patents that are cited later)	11 (47.8%)	4 (17.4%)	2 (6.5%)
Number of future patent citations	21	7	2

launched, several improved versions of the same product are sold.

4.2. The production of successive innovations in three phases

From 2000 to 2010, we identify 10 main projects, which are associated with a specific team. Fig. 2 presents those successive projects and the launch of the different generations of silicon tuners. Dedicated teams were tasked with managing these projects. We numbered the teams according to the project on which they worked (team n°1 for the first project, team n°2 for the second project, etc.). As teams achieved different results and there were changes in the business unit's objectives, certain teams merged (for example, at the end of the first phase, teams 1 and 2 merged into team 3) or were split into several teams (for example, at the end of the second phase, team 4 was split into three teams, n°5, 6 and 7). The objectives of the team also sometimes changed (at the end of the first phase, the objectives and resources of the third team were adjusted, and the team became team n°4). During project development, actors seek support or technical skills outside their team both within and outside the business unit. Individuals can move from one team to another. Consequently, we included in the analysis descriptions of the networks of relationships among actors, which go beyond specific projects because all actors were working in the same open space (Table 2).

4.2.1. 2000–2003: developing exploration-oriented projects

4.2.1.1. Number and types of projects. The first phase began in 2000, as a business unit was dedicated to the development of silicon tuners. In that unit, two teams worked on concurrent projects. Team n°1 (Fig. 2), which was an existing team, sought to develop silicon tuners for satellite TV by improving existing components. The objective of team n°2 was to design a product that could address the different TV markets (cable and terrestrial TV, as well as emerging markets) and would be as efficient as can tuners. The initial team n°2 was essentially composed of young graduates and a few experienced people who wanted to transmit their expertise. Consequently, relationships inside the team were mainly new.

4.2.1.2. Time pacing within projects and synchronization among projects. Different temporalities prevailed within the two teams, which contributed to the emergence of tension among the teams. Team 1 had strict deadlines assigned to the project and relied on the stage-gate process that was implemented in the company to monitor project development. Team members had little autonomy to schedule the project, and managers took most decisions. As the team improved existing knowledge and practices, team members were able to plan the project progresses accurately and meet deadlines.

Time pacing was organized completely differently for team 2. The management had established broad deadlines, but they were not strongly enforced, as shown by the following quote:

> '*Well in the beginning of the project, (…) there were deadlines between brackets, but these were not real deadlines. But they were deadlines that had a tendency to shift, and then during the years, as the project progressed, it was more important to have a real deadline and to have a fixed date for the release of IC.(…) The desire was to have the first silicon tuner within six months, but we did not set up milestones like this. It is not a real date. But after the first generation, there was a real need to have those dates fixed to stick to these dates.*'
>
> [(a researcher)]

Although team n°2 had autonomy to schedule its time, the project was perceived as a "race" against the competition because the team wanted to be the first to launch a product on the market. Several interviewees highlighted the word "run", as in the following quote:

Table 4
Different versions of silicon tuners developed for different markets.

		Version	Level of market novelty	Level of technological novelty	Output
P1	2002	Silicon tuner for cable TV	New client for the team but known in the market	Disruption	Success
	2003	Silicon tuner for satellite TV	Existing clients in the market	Incremental innovation compared to the previous version	Success
P2	2004	Silicon tuner for PC and set-top boxes	New clients in the market	Incremental innovation compared to the previous version of the silicon tuner.	High market share, but the market was not as large as expected
	2007	Silicon tuners for decoders with new integrated features	Targeted clients did not adopt the innovation, and the product was finally sold to PC manufacturers	The product system is innovating.	The cost of the product is too high for the targeted market, but the product allows for the generation of the subsequent version of silicon tuners.
P3	2008	Silicon tuners for mobile devices	New clients on the market	The technological innovation did not come to a successful conclusion, and an incremental innovation was generated.	Gradually cancelled
	2009	Fully integrated silicon tuner for terrestrial and digital TV	Existing and new clients	Disruption	Sales gradually increased.

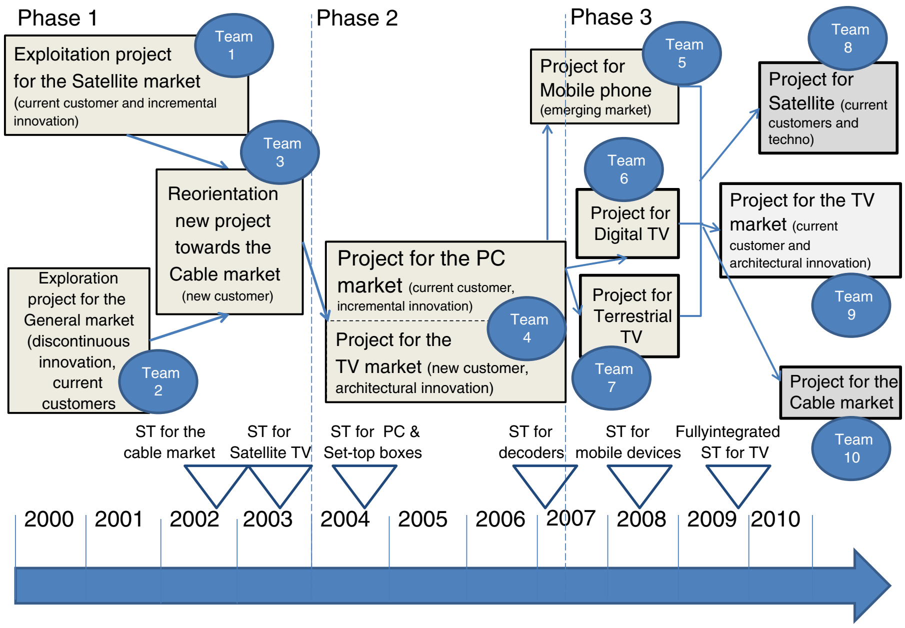

Fig. 2. The unfold of different projects from 2000 to 2010.

> '*We wanted to be the first ones so it was challenging. We thought that we could have a very high profit thanks to that new architecture and with all the market that we could target. So we needed to run, run, run; everything was due the day before (…) but we manage to handle it.' 'We never stopped, we ran like hell.*'
>
> [(a project manager)]

As a consequence, the engineers developed their own times and ways of functioning:

> '*Certain behaviours were above the norm in terms of involvement, certain persons were working until 2 o'clock in the morning, 4 o'clock, one engineer even fell asleep in the bathroom. It was epic.*'
>
> [(a project manager)]

The vague deadlines and intense competition with outside groups enhanced the group's ability to define future activities for the company (Amabile, 1996), as shown by the number of patents without citations (only 30.4% of patents with citations in phase 1 — Table 3). However, team n°2 was unable to reuse knowledge from other projects.

4.2.1.3. Team dynamics and relationships with external partners. Once the decision was made to conduct research on silicon tuners, the engineers on these two teams activated their relationships with researchers from other R&D centres of Philips semiconductors and contacted existing customers to develop an initial prototype. However, the two teams were not communicating and did not exchange knowledge. Tensions even arose between the two teams.

First, members of team n°1 were disappointed not to have been chosen to work on the exploration-oriented project. Several interviewees told us that project team n°1, which was working on improving the company's existing products, was frustrated because project n°2 was always given primacy, and they felt that they never received support from management for their own project. Furthermore, members of team n°2 were primarily young graduates who were hired to work on the project and researchers. Consequently, the percentage of existing ties during the first phase was lower than during the two other periods (46% — Table 2). Most members of team n°2 did not know one another. Although the team lacked experience, they did not rely on prior expertise, which had been developed in team n°1 as stated in the following quotation from a member of team n°2. This increased team n°1's resentment of team n°2.

> '*We were not really open to looking at what others had done and to reuse their know-how. The people who had to work on the evolution of existing products were frustrated.*'
>
> [(a designer)]

Note that the proportion of strong ties is high during that period (62.5% of existing ties were strong during phase 1 — Table 2). Different explanations can be highlighted: First, team n°1 relied primarily on strong relationships and mobilized contacts with former colleagues to carry out its projects. Second, concerning team n°2, it seems that the prospect of working together on other projects may have contributed to the strengthening of relationships on the team. Another explanation may be that the engineers and researchers regarded project n°2 as an outstanding opportunity to learn. Their motivation to learn led them to interact more and to develop strong ties within team.

However, the relationships with other teams (including team n°1) and with senior management were characterized by opportunistic behaviour. As project n°2 was highly regarded by top management, certain people perceived that they should become involved in this project. However, they did not contribute to the output. Surprisingly, a human resources manager told us that they were always attempting to attract those types of people called "mercenaries" to explorative projects. This type of person played a key role in promoting the project to top management. However, they were unable to become involved in subsequent projects because their motivation rapidly decreased:

> '*For* [*the phase of exploration*], *you have a specific profile*, *those whom I call mercenaries. Those individuals do not monitor their time*, *they come during Christmas Eve…They also have a different way of functioning.* (…) *Those people do not go the distance when projects are more structured and as time unfolds*, *so you need to have people who were there at the beginning of the project so that they keep the project memories and will stay for 3*, *5*, *10 years.*'
>
> [(a person in charge of human resources)]

Thus, it seems that the project n°2 was orchestrated by people who intended to work only on exploratory projects and had short-term relationships with projects and other individuals who worked on subsequent similar projects. Two temporalities were at stake during the same project (project 2), and there was no synchronization with project 1.

Consequently, the level of tension within teams n°1 and n°2 reached a level that had never been experienced in the company. An unsigned letter of complaint expressing those tensions was even sent to the CEO. This led to high turnover among projects at the end of the first period.

Project managers were aware of the lack of common practices and tools to manage both projects. Consequently, they attempted to develop knowledge-sharing tools, but time pressure prevented the team from using them, as shown by the following quotation:

> '*We developed several tools. It was one of the difficulties because deploying those tools required time from the project manager but also from the team and it was not easy to balance it. We required of them a lot of innovations*, *designs*, *time to develop products quickly*, *and we also asked them a lot of things in terms of project management*, *reports*, *and regular technical proceedings*, *and they spent a lot of time in meetings.* (…) *When you are developing innovative products*, *you need time. You should not wander into diverse and ancillary tasks.*'
>
> [(technical project manager)]

4.2.1.4. Events that shape practices. Events that shaped project 1 came from the external environment. A manager presented a paper on the technology developed during the project at a colloquium. An American client then contacted him to develop applications for cable TV. This client was the leading US provider, and the potential sales volumes were substantial. Furthermore, the product for cable TV was easier to develop because there were fewer constraints in terms of noise filtering compared with terrestrial TV. Cooperation then began between partners who had never before collaborated. The new relationship with the cable TV broadcaster gave the team a deep understanding of how to interface their products with clients' products. Thus, the team developed knowledge of a new market and progressively changed its practices.

Similarly, relationships with prospective customers changed dramatically during the first phase for team n°2. The team was developing a prototype with a prospective customer. However, as the client tested that prototype, the client realized that it had to change its own system to adapt it to the new chip. As the client did not wish to make any changes, the relationship ended. This client's withdrawal encouraged the team to realign the target market to products that were easier to develop.

Events related to the facts that prospective customers were determined to participate in the co-development of the projects or, on the contrary, quit the projects are both critical for and disruptive to the teams' practices and the paths of the innovation streams (Morgeson et al., 2015). Those events forced team n°2 to work with team n°1 and to exchange knowledge. It also shaped how the project was managed, as the project manager was forced to work for another business unit.

Consequently, at the end of the period, intermediate managers (project managers) had to leave the project because they felt pressured and could no longer address the tensions. As the first generation of products was developed, numerous actors chose to work in other groups. Top management also changed because managers took advantage of the project and went to work on other emerging projects where they could obtain greater recognition. During the first period, there were 23 actors who were recognized as having brought creative output or support to the project; eight of them (out of 30 — Table 2) were still involved during the second period, but only six of them remained during the third period. They perceived their involvement in the project as temporary.

In 2002, the two teams (n°1 and n°2) were merged to work on the cable market (Fig. 2). A press release announcing the launch of the first silicon tuner for cable TV was distributed. That product was described as a technological discontinuity preparing the way towards digital integration and 'the connected house.'

At the end of 2003, engineers from team n°3 attempted to integrate filters to isolate signals from the noise when receiving TV. A first silicon tuner was proposed for satellite TV. This chip integrated filters and a signal conversion system. It also covered a broad range of frequencies. This project involved new actors (compared with the previous project), and these actors contributed new ideas or support.

4.2.2. 2004–2007: several innovations exploiting the existing knowledge base to conquer new markets

4.2.2.1. Numbers and types of projects. One main project was conducted during this phase, and another project was launched at the end of the period. At the beginning of 2004, individuals were working on the same team (Team n°4 — Fig. 2). That team sought to develop silicon tuners for two markets: the PC and TV markets. Twenty-two actors who were cited as bringing new insight to the project joined the network during the second period (Table 2), and nine of those actors became very connected to the others because they belonged to the core of the team. In 2004, silicon tuners for receiving analogue TV on personal computers (PCs) were launched. The design team was attempting to exploit knowledge developed for the first generation of silicon tuners by adapting it for clients who were new to the team but familiar to the semiconductor industry. A second generation of products for analogue and digital TV was then developed. Silicon tuners with a reduced size were also integrated into set-top boxes. Team n°4 managed to create knowledge (23 patents were filed during that period — Table 3). We consider this phase to be exploitation-oriented because knowledge that had been developed previously was reinforced. Furthermore, the new products, which have been launched, are new versions of previous development and target at existing customers of the business unit. Learning was also enhanced throughout the organization. For example, actors focused on implementing management practices to synchronize their work with cycles in the environment (specifically, the launch of new generations of TV every two years). Project managers of that business unit also established a committee with other project managers in the company to share best practices such as practices to motivate the team to meet schedules.

4.2.2.2. Time pacing within projects and synchronization among projects. Team members work sequentially by focusing on the design of specific components without having a general perspective:

> '*It was a big project. Subsequent projects involved five or six designers*; *10 designers worked on this one.* (…) *We had many ideas*, *but they were not integrated in the architecture. Finally*, *we implemented blocks one after the other*, *but we did not know whether we would achieve the global specification*'.
>
> [(a designer)]

In fact, from the beginning of the period, management fixed and reinforced strict deadlines. These deadlines were established according to customer plans to develop new platforms. Time became cyclical, with new projects launched every two years at the beginning of the second period.

> '*We go through cycles of 2 years* (…)*. If we know that Sony and Samsung are going to produce new TVs*, *at that date we need to be ready at that time. If not*, *we need to wait for the next generation*, *and it can take up to one or two years.*'
>
> [(an engineer)]

However, these new projects involved even shorter development timeframes, as computer makers renewed their platforms annually. The team n°4 could not meet such short timeframes, as shown by the following quote:

> A designer explains that there were tensions in the team: '*and it was also because of the time pressure and resources*, [*that*] *we had a hard time convincing the management that we could not complete that project in less than three years*, *and at that time we had management who wanted us to launch a new product every year.*'
>
> [(a designer)]

Several interviewees raised concerns that the too-short project deadlines decreased the quality of their work and impeded knowledge development. As development times were shrinking, team n°4 had no other option but to reuse existing knowledge (which they had avoided up to then). Consequently, project managers developed several tools and practices to share knowledge.

4.2.2.3. Team dynamics and relationships with external partners. At the beginning of the period, members of the team were relieved to work together. They felt that every individual was valued at the same level, whatever chip they were working on, and there was less competition among individuals. Relationships among team members became more cohesive. Collaborators of the business unit formed a single team, but it was divided into two groups that worked on the same products. Thus, this project organization enhanced exchanges among team members. In terms of relationships, fewer engineers left the innovation stream from the second period to the third than from the first period to the second (only 11 new members in phase 3 — Table 2). Although the projects were depicted as very short-term engagements, the engineers felt that they would work with the same collaborators from time to time. Consequently, we did not see any instance of opportunistic behaviour, and the tension among team members decreased.

Developments were planed essentially according to the technical difficulties of each component, and customers' needs and requirements were not a central focus of the team. Consequently, several versions of the products were designed and proposed to clients. However, clients did not place orders. At the end of the period, certain members of the team were demoralized because they had to cope with strict deadlines to launch products, which were not accepted by the market. They felt that their efforts had been in vain.

4.2.2.4. Events that shape practices. The development of the projects was shaped by both the relative failure of solutions that had been proposed by the team and emerging opportunities in the market. PC manufacturers integrated silicon tuners into their machines to allow the receipt of TV signals. Contacts with mobile telephone manufacturers were also initiated. Those markets were new for the business unit and triggered changes in how it handled relationships with clients.

In terms of event characterizations, the changes in the market were neither novel nor disruptive during this period, as they occurred gradually and on a regular basis. The team could partly anticipate new market opportunities, and the persistent refusal of clients led team members to question their target market. However, those events were critical for the team, as they had consequences for the team's ability to generate revenues. Consequently, project managers attempted to develop methods to improve team practices, but they did not intend to revolutionize those practices (as in the first period).

In 2007, the company sold more than 100 million silicon tuners. Successive generations of silicon tuners were launched in different markets (cable TV, satellite TV, and for PC and set-top boxes), and a fourth generation of tuners for PCs was designed. As products designed for cable TV became successful, new designs began for terrestrial TV.

4.2.3. 2007–2010: the involvement of new actors and a new technological discontinuity

4.2.3.1. Numbers and types of projects. The period comprises 6 projects, which were conducted both successively and consecutively (Fig. 2). In 2007, the objective of the management team of the business unit was to develop new products for emerging markets such as receiving TV on mobile telephones. Similarly, products for notebook computers and mobile multimedia drivers were designed in 2008. Three teams were created to simultaneously develop versions of a silicon tuner for mobile devices, terrestrial TV and digital TV. These teams were formed as research groups and knew that they were short lived. However, those markets did not emerge as expected. Consequently, members of those teams were split in 2009 into three project teams: cable, TV and satellite (Fig. 2).

4.2.3.2. Team dynamics and relationships with external partners. During the third period, the manager of the department orchestrated a project turnover, which enhanced knowledge breakthroughs (31 patents in phase 3 — Table 3) (authors, xxxx). The human resource manager, the department manager and the project manager continued developing new tools and systems to share information and knowledge, as shown by the following quote. The human resource manager explains that they are deploying a "plateau meeting".

> '*It is an informative meeting, which should not last more than half an hour for the department. It takes place in an open space and allows for the exchange of information on business and projects every week, and everybody is invited, everybody stands up and receives information on customer feedback, bugs that emerged ….*'
>
> [(the human resource manager)]

4.2.3.3. Time pacing within projects and synchronization among projects. Time pressure still made it difficult to focus on knowledge development tools and practices, as shown by the following:

> '*Our main difficulty is to keep the pace over the long term. It is my impression, we are struggling with every day activities, we have a lot of things to do, and when it comes to keeping our nose to the grindstone, thinking outside of the box and bringing people together, we have difficulties.*'
>
> [(the human resource manager)]

The project managers attempted to develop a new system to address the widening gap between the expectations of managers and the team regarding deadlines. They created two deadlines, one that marketing and the managers would have liked to achieve (the stretch target) and one corresponding to what the designers thought they could achieve. Then, the project managers promised a bonus if the team completed the project by the stretch target. Ultimately, team n°9 was unable to complete the project before the stretch target, but it nevertheless finished four weeks earlier than expected. As team n°9 was disappointed to have missed the stretch target and was not focusing on its success, the project manager told us he would not renew that practice. However, this shows that selecting an optimal project deadline with an incentive for the team to reach the deadline is part of the learning process:

> '*We are making progress, and the processes that we implemented on the* [*last version*] *of the product and which are working well, we are going to transfer them to other projects, and we will add a layer.*'
>
> [a project manager)]

Synchronization occurred among projects, and as members of the team were embedded in long-term relationships, they shared planning tools and systems developed to pace time and managed to negotiate and impose their timeframes on management.

4.2.3.4. Events that shape practices. The main event that occurred during this period was the signing of an agreement with a can tuner manufacturer. TV manufacturers began to insert silicon tuners into can tuners to acquire after-sales service and support from can tuner makers. Consequently, marketers activated existing relationships with can tuner makers and developed a strong collaboration Thus, this event was the consequence of proactive efforts on the part of engineers who attempted to influence the environment. This event was critical for both the team and customers and allowed for the successful launch of products on the market.

At the end of 2008, 200 million silicon tuners were sold. A low-cost solution was proposed in 2009 for terrestrial digital TV, and several prototypes were created to integrate multiple silicon tuners for cable TV. In 2010, more than 400 million silicon tuners were sold, and sales of silicon tuners for terrestrial TV took off.

5. Discussion and conclusion

Time pacing and time monitoring are key activities for managers during the development of innovative projects (de Falco and Macchiaroli, 1998). In this research, we contribute new insights by understanding how engineers in a company move across projects that have different timeframes, temporalities and expectations concerning the future of existing relationships and learn how to coordinate different types of projects. Thus, we answer Hobday's (2000) call for further studies on the human side of project management and the changing nature of projects over time. Consistent with Hobday's (2000) results, we demonstrate that the project organizing takes different forms according to the needs of New Product Development. The structure was first characterized by heavyweight project management (Clark and Wheelwright, 1992), and it gradually transitioned to a project-based approach.

The model that we propose also expands works by Brady and Davies (2004) and Lindkvist (2004), which describe how organizations build a project-capability. We offer explanations for how teams can learn to address different project structures and types through three successive phases.

During the first phase, team members experience new ways to pace time and focus on establishing new relationships. Transformations of practices occur both as the result of learning from the team and reactions to events. The mechanisms of changes during that period are similar to those described by Gersick (1988) with a succession of phases of inertia and brief moments of transition.

Furthermore, our research demonstrates that managers can overcome resistance to change in project practices (Bresnen et al., 2004) by orchestrating turnover within projects and mixing team members' profiles. Hence, management appointed certain individuals to the first phase of the innovation stream to conduct exploratory projects. Those individuals perceived their involvement in team relationships as a short-term engagement and were able to work with vague deadlines and no strict planning of activities. They would not be involved in the next phase of the innovation stream but instead moved to other exploratory projects. These individuals act as leaders, prevent the team from being pressured by organizational routines, and promote a timeframe that is specific to the team. As the team is in a complete "vacuum," it has an enhanced ability to transform processes and change time pacing. During this first period, the adoption of new practices was carried out primarily at the individual level, and synchronization and sharing of knowledge among projects did not occur.

Tensions among teams led management to reconsider the project structure. The business unit was then reorganized as a single-project team. This restructuring demonstrates that managers became aware that they needed to address the challenge of learning through projects and within projects (Scarbrough et al., 2004). Thus, the organizational context in which projects emerged had changed as a result of prior failures. Managers proposed various arrangements to facilitate the deployment of tools to monitor and pace time and to reuse knowledge. Thus, during this period, changes occurred gradually and were orchestrated by management.

During the last period, synchronization is orchestrated, as are turnover and cross-pollination among projects. Thus interrelations among projects were considered to facilitate the sharing of knowledge and new methods. The number of projects increased considerably, demonstrating the ability of the business unit to manage a portfolio of projects. This period was also characterized by both exploration and knowledge transfer, which demonstrate that the unit had developed new capabilities such as trading-off between different temporalities and knowledge exchanges. Changes in project structure and practices were then considered an on-going process and occurred through experimentation. Thus, the business unit had learnt how to resolve the tension between the autonomy required by the project team and the need to disseminate knowledge and practices within projects (Sydow et al., 2004). To conclude, our research offers new understandings of the transition of organizations towards a project-based structure (Packendorff and Lindgren, 2014) by demonstrating that changes in practices occur first as a reaction to external events, then as the results of new arrangements triggered by management and finally as the consequences of the team's proactive actions.

Our research also provides new insights to the literature on networks within project teams. This literature has either emphasized the persistence of relationships in project organization (Sydow, 2009) or the benefits of membership flexibility in project teams (Cattani et al., 2011). We demonstrate that as successive projects within the same innovation streams are carried out, management relies on the reproduction of past ties to enhance knowledge accumulation within projects. Relationships become stronger as actors develop long-term relationships and trust is enhanced. Actors are then willing to take risks and exchange complex knowledge (Cattani and Ferriani, 2008; Hansen, 1999), which facilitates the diffusion of new ideas. However, turnover among different project teams also provides opportunities for new insights and new information, which enhances the emergence of new ideas (Granovetter, 1995; Burt, 2004).

This research has two main limitations. First, the analysis of a single case study, despite being carried out over a long time period, limits the generalizability of the results. A comparison of different cases could produce more robust results. Second, this research is based on a comparison of three periods and their respective networks. Consequently, this analysis is not a 'correlation' (of the relationship between network and innovation) but rather a comparison of periods for drawing proposals.

Conflict of Interest

There is no conflict of interest.

Appendix 1. Position of interviewees

Position	Number of actors who were interviewed
Marketers	2
Designers	10
Managers (project managers and middle management)	6
Partners (actors who worked on a different site of the company or customers)	4
Human resource manager	1
Site manager	1
Total	24

Appendix 2. Year of interviews

Years	Number of interviews
2006	3
2007	4
2008	2
2009	12
2010	3

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