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Abstract

New entrants very often spin out from established firms and because they set on a course at founding, their learning and capabilities become inextricably linked to their organizational and technological heritage. But while this heritage may provide an initial advantage, it can also generate inertia and resistance to change, unless the new company is able to unlearn some practices from the parent company and learn something new in order to establish its own sources of competitive uniqueness. This tension between inherited path and new trajectory, imprinted past and search for newness is the object of this paper. Building on an in depth case study of Acorn Computers and ARM semiconductors we show that while there are strong influences from the parent company on the spinoff, these imprinted organizational effects can be overridden. We use the term *deprinting* to stress the reversible nature of this process in contrast with the irreversibility embodied by the classic imprinting notion. This is followed by a phase of intense learning efforts whereby the spinoff establishes its competitive identity based on a blending of retained routines, repeated improvisation and feedbacks from the market. We refer to this process with the term *reimprinting*, to emphasize the metamorphosis experienced by the spinoff as it sets on a new distinctive trajectory.

1. INTRODUCTION

There is considerable evidence indicating that some of the most radically innovative products and technologies are often developed and commercialized not by incumbent companies, but rather by entrepreneurial ventures. However, contrary to the popular image of solitary entrepreneurs starting from scratch and seizing venturing opportunities, many of these ventures trace their origin back to pre-existing incumbent firms or academic institutions (Christensen, 1993; Klepper, 2001; Klepper and Sleeper, 2005). These ventures are usually referred to as spin-offs that is, entrants founded by employees of established organizations in the same industry.

In this literature, spin-offs represent a distinctive class of industry entrants that have a clear parental heritage (Klepper and Sleeper, 2005). Because spin-offs are incubated within an organizational setting with established routines, practices, and culture, their learning trajectory and capabilities become profoundly intertwined with those of their parents'. Spin-offs may inherit from their parent companies blueprints and models in the form of established routines, technologies and capabilities that are likely to shape not only the founding process of the new venture but its long term behavior and success, thus leaving a lasting stamp on its development (Agarwal et al., 2004).

In recent years an increasing number of studies have drawn on biological analogies to describe the parent company and its influence on its progeny (spin-off) as a form of imprinting (Stinchcombe, 1965). The fate of the spin-off is held to be determined by the conditions at founding and the characteristics of the genetic heritage received by birthright. This aura of inevitability is not surprising given that the primal inspiration for theories on organizational imprinting is to be found in the seminal work by Konrad Lorenz (1970), who argued that once developed, imprinting is irreversible[1]. But just as organisms are not clones of any of their parents, spinoffs also differ from their parents. Spinoffs need to deviate from their parents' trajectory to establish their sources of uniqueness and succeed[2] (Klepper 2006). This tension between inherited path and new trajectory, imprinted past and search for newness is the object of this paper. How do spinoffs come to grip with their past in order to build their future? How does the

[1] For instance, if a bird was imprinted to a bird of another species, later contact with its own species would not eliminate effects of early experience.
[2] Pushing the evolutionary metaphor further, more fit members of the species – industry - have higher rates of reproduction, which bears on the fitness of the entire species (Klepper, 2006).

inherited resources and capabilities become combined in order for the spin-off to establish its own idiosyncratic advantage? While this organizational heritage may provide an initial advantage, it can also generate inertia and resistance to change, unless the new company is able to discard some practices from the parent company and experiment and learn something new, more consistent with its own domain. How does such an internal selection process unfold? Can the spin-off set itself free from its imprinted make-up?

Although there is much research linking incumbents' initial conditions to their long-term performance (Cockburn et al., 2000; Helfat and Lieberman 2002; Cattani, 2005, 2006; Winter et al., 2006) only relatively few studies have extended this approach to the *parent-progeny* dyad (Phillips, 2002; Agarwal et al., 2004; Klepper and Sleeper, 2005) so as to investigate the extent to which the imprinting phenomenon may unfold through experience of the progeny and materialize in the form of a long-term competitive advantage. However, because most of these studies place a predominant emphasis on the continuity that shapes the relationship between spin-offs and their parent, very little is known about the critical juncture when the offspring deviates from its parent's trajectory to establish its own competitive identity. While in this stream of research it is generally conjectured that entrepreneurial offspring may inherit routines and key resources from their parent organizations, we lack a micro-founded understanding of the organizational conditions under which such processes occur and a clear specification of the actual practices that are the object of such intergenerational transfer. For instance, in a study among Silicon Valley law firms by Phillips (2002) the transfer of capabilities and resources from parent to progeny is inferred from evidence on the migration of employees across organizations. It is however unclear precisely which (and to what extent) blueprints are retained and which are released in the process. As a result little is known on what exactly the progeny is inheriting from its parent and the extent to which it does actually exploit such legacy.

To address these themes we followed a longitudinal case study design across two organizational settings, that of Acorn Computers (the parent company) and ARM (the spin-off). In the early '80s Acorn Computers was one of the most successful of pioneering UK technology enterprises. However in 1984 it ran into serious difficulties and was taken over by Olivetti. Acorn had (before takeover) started developing in-house know-how which would enable the company to be more self sufficient. The capability originating within Acorn later formed the basis for a 1990 spin-off, Advanced Risk Machine (ARM), which developed billion dollar assets and became the worldwide leader in low power consumption RISC based processor technologies. Based on prior literature and our initial observations we developed a preliminary conceptual framework, which we applied to detailed case evidence. The evidence leaded us to refine our initial conceptual framework to take into account the subtleties of the evidence uncovered.

The paper is organized as follows. We begin by looking at prior work and compare this with our initial observations. On this basis we construct a preliminary conceptual framework. We then present the methods summarizing the research design, the setting, and the data. We go on to focus on the case evidence to illustrate how ARM capitalized on its organizational heredity while at the same time departing from the practices of its parent, Acorn. Next we interpolate extant theory with key insights from the case evidence and abstract our revised model of parent-progeny transfer and spin-off entry. We conclude by discussing the implications and the limitations of this study and identify important topics for future research.

2. PRIOR KNOWLEDGE AND PRELIMINARY CONCEPTUALIZATION

Our approach to theory building in this paper involves iteration between conceptualization and evidence in a variant of Eisenhardt's case methodology (1989). The concepts we developed on the basis of preliminary observation and literature review guided us towards relevant case material. Once we had assembled detailed case evidence, anomalous findings that were not addressed by our original conceptualization called for re-examination of our conjectures. This led to a refined conceptualization, supporting greater depth and richness of interpretation.

In the simplest terms, we started by questioning the concept that imprinting is irreversible, conjecturing that reflexive agents may critically revise their organizational inheritance as Popper had argued in the case of human agents (Popper 1965). This process is effectuated in order to filter out unwanted practices and routines and retain only those that are more consistent with their new objectives and the demands of the progeny's market environment. In delineating our perspective on intergenerational learning we build upon a body of knowledge that combines literature on organizational founding conditions with ideas on the role of individual agency and deliberate learning in shaping the trajectories of spin-off firms. Taken together, these strands of literature offer original angles from which to appreciate the learning processes associated with the spawning of new firms from parent organizations.

In the following section we distil key ideas and observations from the literature and suggest a preliminary conceptualization of parent progeny influence and spin-off entry. Next we present our case history and analysis thereof.

2.1. Parent-progeny imprinting and spin-off entry: A stylized model

Research on organizational imprinting provides empirical evidence of the formative influence of early choices, as well as some explanation of the processes that generate persistence. This literature holds that over time imprinted organizations become increasingly committed to early strategies, reinvesting their resources in employees with consonant skills, building sets of norms, practices and routines that promote the original vision, and refining policies to support the goals arising from their original strategies. Two main factors shape the imprinted organization: the initial conditions (Stinchcombe 1965) and the founders (Kimberly 1979; Schein 1983; Boeker 1988).

While the original imprinting hypothesis of Stinchcombe (1965) was mainly concerned with wider institutional and societal founding conditions as carriers of lasting influence, at a more micro-level of analysis the founding contexts of a majority of new ventures is represented by other firms. These new firms, usually referred to as spin-offs, trace their initial founding conditions to incumbent firms where they typically undergo a gestation period before entering the market. Spin-offs are legion in various high-technology industries such as semi-conductor (Braun & MacDonald, 1978), disk drive (Christensen, 1993), and laser (Klepper & Sleeper, 2000), as well as in the legal services (Phillips, 2002). Because the initial conditions of spin-offs - the "available social technology" (Stinchcombe 1965) - can be traced to other firms, and because "what an organization knows at its birth will determine what it searches for, what it experiences and how it interprets what it encounter" (Huber 1991, p. 91), the imprinting process suggests that spin-offs' early choices and strategies will become tightly intertwined with their parent's trajectory. Knowledge, culture and routines embodied in the organizational context of the spawning company imprint the spin-off's organizations, affecting its developmental course and leading to continuity in strategy and culture already developed at the parent level.

Initial organizational and strategic conditions, however, are not the only source of parent-progeny persistency for spin-off firms. Another source of continuity is the influence of employees who exit the parent company to found the progeny, carrying with them previously accumulated experience and know-how (Klepper and Thompson, 2006). Founders are highly consequential in setting the course of a new firm because of the way their experience, cognitions and beliefs, shape a firm's orientations (Boeker 1988). But in the case of spin-offs such biases and mental models are likely to be the result of experience that matured within the parent company. In fact, when employees leave a parent organization to found a new spin-off venture, they walk out with blueprints in the form of tacit knowledge, routines, and heuristics. As suggested by Agarwal et al (1994): "Very much like the inheritance of biological genes (Winter 1991), organizational blueprints consisting of unique insights and decision rules used to transform resources into action, cognitive dimensions of competency (Fiol 1991), specific knowledge and information (Boeker 1997), can all be transferred through founders from parents to progenies".

Thus, whether it unfolds through imprinting via initial conditions, or employees transferring blueprints and rules of actions, the parent-progeny relationship suggests a strong entanglement between the competitive trajectory of the spawning firm and its spin-off. In either case, according to the imprinting literature, early choices at the parent level are likely to persist in the progeny because changing course is costly and investments are difficult to reverse, early practices quickly become taken for granted, and choices are elaborated into interconnected systems (Eisenhardt and Schoonhoven 1990). As noted by Argawal et al. (2004), because the spin-off is set on a course at founding, its learning capabilities and performance "become inextricably linked to their organizational and technological heritage".

Figure one provides an appreciative representation of the parent-progeny influence model that can be distilled from this literature. The figure summarizes the two imprinting influences that shape the spin-off formation. The initial conditions' imprinting is embedded in the organizational environment of the spawning firm; the founders' imprinting is embodied by the employees that move across organizational domains. Together these two imprinting forces may leave a lasting impression on the spin-off, engendering persistence in the competitive and technological trajectory from parent to progeny.

Figure 1 here

This stylized characterization of the entry of spin-offs and their subsequent trajectory as being strongly pre-influenced by conditions that ensue at the level of the spawning incumbent is aligned with evidence building up on spin-off entry and performance. For instance, in Klepper and Sleeper's study on the laser industry, it is shown that nearly all the spin-offs initially produce a type of laser their parent had produced, thus suggesting that spin-offs exploited competencies inherited from their parents. Using evidence from the disk drive sector Agarwal et al. (2004) demonstrate that both technological and marketing know-how can be passed from parent to progeny. In a study of Silicon Valley's law firms Phillips illustrates how personnel outflows increase similarity of routines and resources across organizations (Phillips 2002) and, by implication, their competitive interdependence. Using a comprehensive dataset of Danish start-ups Dahl and Reichenstein (2006) similarly suggest that spin-offs whose founders have a long tenure with the spawning firms are more likely to replicate and adapt blueprints established at the parent's level. Gompers et al. (2005) also shows that spin-offs use knowledge and practices developed in the parent firm to exploit entrepreneurial opportunities.

Research on imprinting and the related evidence on parent-progeny interorganizational relationships have provided rich support for the idea that critical knowledge and routines may be imprinted on spin-offs at birth and that this legacy is central to the understanding of the strategic course and success of spin-offs. But while this evidence is persuasive in demonstrating the continuity that underlies this relationship, it falls short in explaining whether and how, at some stage, the spin-off will reshape its imprinted trajectory and develop its own sources of distinctiveness and competitive identity. In fact, most of this literature appears to be premised on an untested assumption that the interorganizational heritage is imprinted somehow irreversibly in the offspring, thus resulting in a strong causal relationship between the quality of the parent company and the survival of the progeny. So, for instance, it is assumed that "healthy" parents are more likely to spawn smart progeny (Agarwal et al. 2005, p. 505). Because spin-offs from successful parents are more likely to inherit fit routines it is argued that they will perform better than other spin-offs, and other start-ups. As noted by Dahl and Reichenstein (2005): "Spin-offs with better performing parents are based on better routines, which positively increases their chances of survival". Along a similar line, it is suggested that offspring from failing parent organizations should be less likely to succeed due to inheritance of faulty routines and inadequate resources. As expressed by Phillips (2002): "progeny that arose in the wake of their parents' failure were more likely to fail […] rather than benefiting from the failure of the parent law firms, progeny assume the same resources and routines that led to the failure of their parents".

This deterministic depiction of spin-off entry and performance based on parental imprinting raises several issues. First, if the imprinted influences were as enduring and consequential as this literature seems to imply, spin-offs which are very different from their parents or on a very different strategic path would not be in evidence, or if they were, as the exception rather than the norm. Nor should we expect to observe highly successful offspring originating from failing incumbents, as this would not be consistent with the irreversible nature of imprinting. However there is also contrary evidence. Swaminathan (1996), for instance, shows that organizations founded in adverse environmental conditions will have high initial mortality rate but higher survival at a later stage. The study does not distinguish the founding context based on whether or not the firms are spin-off or start-ups, yet it does suggest that unfavorable initial conditions may give rise to high performance firms (the fittest firms are likely to be those forged under unfavorable initial conditions). Other studies indicate that spin-off entry is often triggered by internal conflicts and disagreement (Klepper and Thompson 2006), thus suggesting some kind of departure or rupture from the parent's path. 'Fairchild semiconductors', for example, was a sinking ship when it spawned some of the firms (sometimes known as the Fairchildren) that would establish the foundations for Silicon Valley and lead the semiconductor industry to new glory.

These observations suggest that the irreversibility of imprinting may have been overstated and point to a series of questions that extant theory on parent-progeny heritage and spin-off entry does not seem able to fully account for: What is the relationship between spin-offs' evolutionary trajectory and imprinted influences ? What processes and conditions shape the critical juncture when the spin-off departs from the parent company to establish its own competitive identity? How do spin-offs evolve their own capabilities while at the same time building on experience in the parent company ?

3. METHODS

3.1. Research setting

Our research questions suggest a topic in need of theory building, prior to hypothesis being framed or test. Case research based on in depth evidence is a suitable method for studying processes that span long periods and under-researched complex phenomenon (Eisenhardt 1989). The method requires rich field data and using the research questions to guide data collection and iterative refinement of initial concepts. In developing theory, the richness of data used is more important than the number of cases. Using an extensive archive of interview, internal documents, newspaper articles and other secondary sources on Acorn Computers (parent) and its spin-off ARM (progeny), we wrote a comprehensive case of parent-progeny transition spanning more than two decades. We generalize from a set of key events in the case to develop process theory explanations and revise our initial model accordingly (Van de Ven 1992).

Research setting

Acorn Computers was one of the most successful of pioneering UK technology enterprises Though Acorn itself was not a commercial success, it gave rise directly or indirectly to more than thirty start-ups including ARM, just as Fairchild gave rise to Intel and other start-ups in Silicon Valley. However in 1984 Acorn ran into serious difficulties and was taken over by Olivetti. Among the reasons for Acorn's problems were the delays and defects in the microprocessors supplied by Ferranti. Acorn therefore started developing in-house know-how which would enable the company to be more self sufficient. The technology and capability originating within Acorn then formed the basis for a 1990 spin-off, Advanced Risk Machine (ARM), which established itself as a world leader in semiconductor IP and became a major success story.

We chose Acorn and ARM as the field for our inquiry for several reasons. First, Acorn and ARM represent a unique occurrence in the history of European high tech industry. Acorn is probably unequalled in spawning new high tech ventures in the U.K. while ARM is the most prominent European company in microprocessors design and worldwide leader in low power consumption RISC based processor technologies. Given its long history as a highly innovative and R&D-oriented company as well as a breeding ground for new ventures, Acorn represented a fruitful context for evaluating the impact of a firm's existing knowledge base on spin-off emergence. We needed a case for which we could track key processes in parent-progeny transition as accurately as possible without it being too old to prevent us from interviewing people who were directly involved in the transition. Finally, due to the success of Acorn during the eighties and the subsequent dramatic take-off of ARM in the nineties (despite the parent company decline), both Acorn and ARM have received extensive media coverage throughout the last two decades. This has generated a large amount of secondary data that we could use in the analysis to complement the data we collected during our interviews.

3.2. Research Design

The study was based on a longitudinal case study design across two organizational settings (Yin, 1994). We collected both interview and archival data on the origins of the two companies and the transition from one to the other. We began by writing short case studies of the two organizations, updating the cases based on our successive interviews. We gathered data primarily through semi-structured interviews of key personnel involved in the transition process and engineers responsible for developing RISC technology in ARM. Throughout this phase we built on findings, evidence and sources accumulated over almost 20 years by the first author on Acorn and ARM, as part of a research project aimed at investigating issues of new firms growth and technology management (Fleck and Garnsey, 1987; Garnsey, 1999; 2002; 2004; Garnsey and Fleck, 1988).

Acorn was first approached in 1986 by the first author, when the aim was to understand the origin and evolution of the company. A second group of interviews was conducted in 2001, following the spawning of ARM. Finally key people from both organizations were contacted again and interviewed in 2005 and 2006, in order to clarify data patterns and processes that emerged from the analysis of the accumulated evidence. This abundance of sources, the repetition of key interviews over subsequent time points and more generally the opportunity of tracking the events as they unfolded over time helped us reduce the risk of our retrospectively imposing meaning on historical events from our knowledge of outcomes (Aldrich, 2000).

3.3. Data Collection

All the authors performed data analysis. Our analysis followed an iterative process of moving back and forth between our emerging framework for assessing the process of spin-off entry, theory on parent-progeny transfer, and our growing body of data. For Acorn, data and interviews gathered during the '80s and '90s were combined with historical sources, the company having ceased to exist in 1999. For ARM retrospective data were combined with current information collected during the research.

3.3.1. Personal interviews

We interviewed people at multiple levels, some of them on multiple occasions. Informants were selected among key contributors to Acorn and ARM. They were individuals from different functional areas who made crucial decisions and critically shaped the genesis and development of the two companies. Some of them only contributed to Acorn or ARM while others where directly involved throughout the gestation and spawning event. Taken together they represented a wide range of expertise, training, and experience within the two companies. Since the interviewees were present at different times and moments in Acorn's-ARM history, we could reconstruct more accurately how the parent-progeny influence process unfolded (for a similar approach, see Cattani, 2004).

We conducted open-ended interviews with all informants. We asked them different questions depending on their role and degree of involvement in the spin-off. Our goal during these encounters was threefold: First, we were interested in understanding the knowledge conditions conducive to the creation of a new company. We thus asked informants questions about the general context in which research was conducted and knowledge managed inside Acorn. These questions helped us characterize the internal "selection environment" at Acorn. Second, we were interested in tracking the origins of the entrepreneurial opportunity leading to the foundation of ARM. Accordingly, our second set of questions dealt more specifically with "how'' the RISC[3] technology was encountered and the choices that were made in order to pursue it. We sought to understand the motives behind the spin-off decision and the links between such motives and the competencies Acorn had been developing over time. How well did the stock of available skills and knowledge match the requirements of the RISC opportunity? Was Acorn deliberately promoting the spin-out of ARM as a means for better exploiting the RISC

[3] A Reduced Instruction Set Computer (RISC) chip is a microprocessor that is designed to perform only the most common types of computer instructions, so that it can operate at a higher speed. By using only the most common instructions, RISC chips can perform the majority of tasks more efficiently.

opportunity? Was it aware of its potential? Third, we wanted to identify ARM's inheritance from Acorn and its offspring. To this end we asked informants to identify the key traits of the ARM business model and technological base and to reflect on the role of initial conditions and antecedents in shaping the spin-off entry process and the competitive behavior of ARM.

To delve deeper into key issues, the interviewers followed up on responses with questions such as: Could you elaborate further on this aspect? Would you add something else to the picture? Are there any other questions you think we should have asked?

3.3.2. Archival data

We need secondary sources from research literature and internal documents on Acorn and ARM. Additional data were obtained from industry publications, financial analysts' reports, and press reports about Acorn and ARM. Other sources provided background information on the role of Olivetti in rescuing Acorn from the financial crisis that had befallen the company in the mid '80s (Ciborra, 1994; Piol, 2005) on the career histories of Hermann Houser and Robin Saxby, founder of Acorn and CEO of ARM respectively (Langdon and Manners, 2001) and on the technological transition that marked ARM as providing the leading architecture in the low power consumption embedded processors (Atack and van Someren, 1993).

These sources helped us to clarify the internal as well as environmental conditions under which the Acorn-ARM transition took place. We used these sources to cross check interview data and control for biases in retrospective accounts of past events. Wherever incongruity between secondary sources and interview data emerged we were challenged to rethink of our conceptualizations and revise our questions. This variety of data sources provided a basis for triangulation and may alleviate some of the concerns associated with retrospective data (Burgelman, 1994; Golden, 1992). Indeed, the crucial benefit of using several sources of evidence is the development of "*c*onverging lines of inquir*y*'' (Yin, 1994: 92).

4. FINDINGS

The analysis of the data suggested that the transition from Acorn to ARM and the key events and decisions underlying the parent-progeny transfer could be understood in terms of three sequential phases. (In phase one the parent company develops its own distinctive traits and capabilities. The culture, practices and routines that crystallize during this phase set the initial conditions under which the progeny is to emerge. Phase two is the gestation period that culminates with the spawning of the new firm. This is the phase of congenital learning and inheritance. The spin-off draws on parent's lessons to make sense of the external environment and rapidly set on a developmental course. Yet, this is can also be a phase of rebellion as the offspring tries to develop its own identity and override its imprinted parental influences. We suggest that such impetus towards deviation increases to the extent that the parent experienced severe failures or crises. Negative events may indeed serve as powerful stimuli for the progeny to critically revise its heritage. We characterize this second phase with the term *deprinting,* to stress the reversible nature of this process in contrast with the irreversibility embodied by the classic imprinting notion. The deprinting phase is followed by a third phase of intense learning efforts whereby the spin-off establishes its competitive identity based on a blending of retained routines, repeated improvisation and feedbacks from the market. We refer to this third phase with the term *reimprinting*, to emphasize the metamorphosis experienced by the spin-off as it departs from the parent's path and sets on a new distinctive trajectory.)

These transition phases roughly reflect three key periods in the Acorn-ARM transition. The first period (1978 – 1985), coincides with the initial years at Acorn, when the company accumulated technical know-how and establishes an organizational culture strongly dedicated to technical excellence. In this period Acorn first came across the RISC opportunity and started to probe and learn about its potential. During the second period (1986 - 1990), corresponding to the deprinting phase, conditions emerged at Acorn that led to the decision to spin out the new technology and found ARM. ARM inherited from its parent the RISC technology together with distinctive cultural traits and complementary resources, yet the crisis looming large at Acorn and the arrival of new external investors also triggered the unlearning of inappropriate practices from the parent company and new efforts to learn what is more consistent with the new emerging strategic agenda of the founding team. During the third period (post 1990), ARM's technological know-how in Reduced Instruction Set processors is combined with the competencies of a new CEO coming from a different environment and with strong marketing experience. This combination of continuity with new drive (reimprinting) shaped the emergence of a radically new intellectual property and partnership-based business model business model that fueled new investments and innovations, and set the spin-off on a highly idiosyncratic competitive track.

4.1. Phase one: The rise of Acorn Computers. Founding conditions and imprinting

In 1978 Herman Hauser, a PhD in Physics at Cambridge University, founded CPU limited together with Chris Curry. He and Chris Curry founded CPU to pursue the opportunity they could see opening up for a low cost micro-computer that would be very powerful by the standards of the time. Hermann knew how to find the people who could design a high performance machine that could be sold at a price reflecting low overheads while Chris Curry during his years at Sinclair had learned the benefits to a start-up company on the mail order model which required minimal capital. The novice entrepreneurs invested only £100 in their new company and in 1979, using the income from its design-and-build consultancy CPU, financed the development of a 6502-based microcomputer system. This system was launched in January 1979 as the first product of Acorn Computer Ltd, a trading name used by CPU to keep the risks of the two different lines of business separate.

Acorn was at the forefront of micro-computer ideas because it was able to tap expertise from the Computer Lab of the University of Cambridge. Hermann's persuasive skills were soon apparent. As Hauser recalls:

> *"They called me a 'Hoover of Talent' – I used to go out to the University Microprocessor Group and find out who were the smartest designers and hire them to design our computers. So really, right from the start I was the person who articulated the vision and found exceptionally talented people to do the design. And they were outstanding designs" (Langdon and Manners 2001 p. 112).*

Knowing that they were at the leading edge technically gave Acorn the confidence to compete with better resourced rivals like Commodore and Apple.

In 1981 Acorn was placed on the list of companies invited to tender for a BBC contract which would allow the selected computer to carry the BBC emblem in return for royalties. There was a visit from the BBC at the start of a week to look at their designs which were viewed as promising. Hauser succeeded in persuading a group including chief engineers Roger Wilson and Steve Furber, to build a working prototype in four days, in time for the next meeting about the BBC contract. He says he did this by telling each of the team that the others thought this was possible. Together they achieved what they individually thought to be impossible. As recalled by Steve Furber:

> *"I built the first prototype by hand and Sophie looked at it and said 'I could do better than that!' and went away and did so. I thought the System 1 was entirely designed over an Easter vacation…. I do recall that Sophie produced the monitor program by hand (hand assembly of 6502 code), we blew it into a PROM and it worked straight off. There may have been a minor bag or two but basically it run first run, previously untested".*

The favorable report of the BBC's technical advisors and energy of the young team with its strong university connections led the BBC group to select Acorn's prototype as the demonstration model for their computer literacy series. The still precarious new venture was now endorsed by the BBC, and with this came brave new prospects. Acorn's reputation grew with their innovative R&D and high quality standards. New product design and development were a priority. Creativity was viewed as a strategic need, the view being that a leading company had to be ahead of its rivals on as many fronts as possible. Hauser enthusiasm for ideas helped give Acorn the buzz of a leading research lab. In the early 1980's the company was developing products which were very new at the time but to become familiar ideas ten years later, including modems, other telecommunications products for satellite and cable broadcasting, interactive video and an operating system to rival UNIX (The Guardian, March 8, 2001). Despite Acorn's eagerness for technical excellence, it became soon apparent that too many senior managers were more interested in technology than in the day-to-day mechanics of running a business. By 1983 many of these R&D projects were not relevant to Acorn's core business of microcomputers nor to well identified market needs. Few developed into marketable products, and few of those produced sold well. Yet, this propensity to experiment and innovate remained over the years a distinctive trait of Acorn, turning it into an extraordinary forerunner of technological change. As one of the senior engineers told us: *"Acorn always did things that were challenging conventional way"*

In 1983 Acorn was growing fast and floated on the stock market. In order to maintain the edge and prevent any further delays in the launch of the Archimedes, the next generation computer, a group responsible for chip design was set up in late 1983 with the task of looking around for new microprocessor designs to replace the existing 8 bit 6502. Yet, none of the existing architecture seemed to fit with Acorn's vision:

"We looked at National's 16032 and Motorola 680000 but they did not suit our design style. They had very complicated instruction sets giving poor interrupt response. Basically they were too slow." (interview with Steve Furber)

At some stage Acorn also planned to use Intel's 286 chips in its Archimedes computer. But because Intel would not let it license the 286 core and adapt it, Hauser eventually decided to give the R&D group free rein (though no new resources) to stretch their expertise by creating their own 16-bit chip for the Archimedes computer. At that time, starting from scratch to design a 16-bit microprocessor *"would simply appear insane to most of the people in the microprocessors business" (Herman Hauser, interview)*

Yet, the design team were enterprising enough to get themselves to the Western Design Centre in Phoenix and discover that other small teams were designing their own chips using early RISC techniques pioneered at AT&T.

"We knew that it had taken National 200 years of development time for the 16032 and Acorn could not afford that – we only had 300 people at the time", recalls Furber, "then we came across the Berkeley RISC.[4] *A group of graduate students had built a microprocessor with only a tiny percentage of the resources used by National. It was simple, it addressed the interrupt problem and it seemed something worth looking at".*

One again Acorn proved it could match up to extraordinary technical challenges and create new competencies from scratch.

"The general view was that microprocessors had a mystique - that they were designed by very special people. I'd never designed a microprocessor and everything I knew about computers I'd learned at the Cambridge University Processor Group where people met to make computers for fun…but we were confident […] Our mentality was let's have a go at building a microprocessor" (Steve Furber, quoted on …)

So, whereas at IBM were simulating RISC instruction sets on powerful mainframe computers, at Acorn, Steve Furber, Sophie Wilson and their small team of engineers managed to designed a RISC chip using their own brain power. Having limited resources and a limited group of people they succeeded in coming up with a highly efficient architecture which capitalized ingeniously on their previous core technology. As explained by one of the engineers in the original team

[4] A Reduced Instruction Set Computer (RISC) chip is a microprocessor that is designed to perform only the most common types of computer instructions, so that it can operate at a higher speed. By using only the most common instructions, RISC chips can perform the majority of tasks more efficiently.

> *"One of the reasons it is very low power is that we had no idea how to do it … We wanted it to go into a plastic package because that's much cheaper than a ceramic package and there were power limits so we did everything we could to minimize power. Not because we had this far sighted view that we're going to be the portable products of the future. It was small because we kept it simple. It was essentially reusable because we were a very small design team with no resources and we had to reuse our own core design".*

The Acorn RISC Machine (ARM) was designed in 18 months by the same people who worked on the first computer and the pattern was the same; it worked sufficiently well the first time to be debugged using the system itself. The chip had 30,000 transistors that is, the same number as a Z80 or the 6502 that Acorn used in its BBC Micros, but it was twenty times faster and it had exceptionally good power consumption. It was also the world's first RISC processor. According to Hauser

> *"ARM was part of a policy decision that a computer should be deigned on silicon rather than cobbled together out of third party components. This focus made Acorn one of a small, select group of genuine computer companies (Apple being the most obvious) that own their own technology from the ground".*

Indeed, having learned how to build an entire computer system from scratch Acorn had generated know-how in all computer specialties, including among others, silicon chip design, operating system design, computer architecture and local area networking. ARM's first sample was delivered in 1985 and was manufactured by VLSI which also gained the right to sell chips using Acorn's new chip design.

The ARM microprocessor emerged in a period when Acorn was experiencing financial difficulties. The main problem for Acorn since its inception had been increasing output to meet demand. The Electron had been launched in 1983 but problems with the supply of its ULAs meant that Acorn was not able to capitalize on the 1983 Christmas selling period – a successful advertising campaign, including TV advertisements, had led to 300,000 orders but the suppliers were only able to supply 30,000 machines. The apparently strong demand for Electrons proved to be illusory: rather than wait, parents bought Commodore 64s or Sinclair Spectrums for their children's presents. Ferranti solved the production problem and in 1984 production reached its anticipated volumes, but the contracts Acorn had negotiated with its suppliers were not flexible enough to allow volumes to be reduced quickly in this (unanticipated) situation – supplies of the Electron built up. By the end of the year Acorn had 250,000 unsold Electrons on its hands, which had all been paid for and needed to be stored – at additional expense. Acorn was also spending a large portion of its reserves on research and development. The BBC Master was being developed; the ARM project was underway; the Acorn Business Computer entailed considerable development work but ultimately proved to be something of a flop, with only one version ever being sold. Obtaining Federal approval for the BBC Micro in order to expand into the United States proved to be an ultimately unsuccessful drawn-out and expensive process. The expansion devices that were intended to be sold with the BBC Micro had to be tested and radiation emissions had to be reduced.) Around $20m was sunk into the US operation but the NTSC modified BBC Micros sold barely at all. By January 1985 one third of the Christmas stock remained unsold; sales were about 35% below the April forecast and the pressures on Acorn made it necessary to cut staff numbers from 450 to 250 by early in 1985. Suppliers' demands for payment became pressing and by early February 1985 a winding up petition was issued. Acorn had to cease trading.

4.2. Phase II: The crisis of Acorn and the spin-off decision. Deprinting and learning shift.

Unexpectedly, when Acorn was about to cease operations and no British company seemed to be willing to enter into an arrangement with Acorn, Elserino Piol from Olivetti made an approach. On 20 February 1985, after a short period of negotiations, Curry and Hauser signed an agreement with Olivetti giving the Italian computer company a 49.3% stake in Acorn for £12 million. The money went some way to covering Acorn's £11 million losses in the previous six months. Sales targets were agreed, which depended on Olivetti distributors selling Acorn stock. This did not occur. (Distributors were attributing the fall in sales of Acorn computers to their proprietary operating system which was not compatible with the emerging industry standard, DOS. When Bill Gates had offered a license on favorable terms, Hauser had rejected the idea of moving to an inferior operating system.) As a result, sales targets were missed over the summer of 1985, and a second round of refinancing was eventually implemented. In September 1985, Olivetti took ownership of 79% of Acorn. They paid under £15m for the company, which had been valued at £100m in the previous year.

Olivetti had acquired an R&D team which was at the forefront of developments in operating systems, microchip developments and user-interface. Major projects underway included development work on the still novel RISC chip technology, a new micro-computer operating system with wide applications and interactive video development. “In accordance with Olivetti's partnering policies, Acorn had originally been acquired to gain market share in the UK and a strong foothold in the education market. After the acquisition, both of these objectives lost their importance because of the very troubled financial situation of the company. However, it came as a surprise that Acorn's labs contained a wealth of people, skills and on-going projects that turned out to be of strategic relevance, putting the company (Olivetti) on a new track, at least as far as corporate R&D was concerned; more precisely, they envisioned for Olivetti the option to be a world leader in workstation technology instead of just being a follower of IBM (Ciborra 1994)

Before leaving the company, the founders had appointed a managing director facing the new task of integration after the acquisition. The key issue in Acorn was to realize a transition from an independent company into a subsidiary and benefit from Olivetti’s international access and resources. Yet, Olivetti's own financial performance in 1987 was disappointing and pressures on Acorn to keep out of the red increased. The timing was bad: capital investment was urgently required for the launch of Acorn’s new personal computer, and for development of a UNIX workstation designed as competition for the highly successful SUN Microsystems product. In 1988 Olivetti started pursuing several avenues to sell ARM’s core technology:

> *“The first option was to sell it internally but Olivetti was already using Intel; then we tried to sell it to ST Microelectronics, but they were already linked to another chip manufacturer, then we approached Siemens, but they became skeptical because we were using Intel rather than ARM, at some stage we also approached Lerry Ellison but he declined too” (Elserino Piol, personal interview).*

By late ‘80s it became clear that the great potential of the ARM micro-processor was being stifled within Acorn and that the liaison with Olivetti product planning branches was not forthcoming. At the same time most computer companies were unwilling to buy a microprocessor that was owned by a competitor. As observed by one of the top managers at Acorn:

> *“We had lots of go’s at spinning out the technology and selling it to others, but none of these had worked. In 1990 we were feeling pretty demoralized and had become used to failure. We were downtrodden.”*

In that period Apple was defining a new architecture for handheld devices, known as “Newton”, and densing the first products to feature this new hardware and software architecture.

Apple believed there would be a market for the "personal digital assistant" (PDA) amongst the traveling business community. Having concluded that the ARM chip design was powerful enough to be portable, the Apple vice president of Advanced Projects Group, Larry Tesler, then played a key role in initiating the launch of an independent company to develop the full potential of the ARM technology. John Stockton at VLSI Technology was also instrumental in initiating ARM's foundation. VLSI had licensed the first designs from Acorn and could see the potential to extend their applications. However Acorn, as a primarily computer manufacturer, had little incentive to provide wider support for the technology. After intensive interaction by Acorn managers and Board members, backing for the decision to spin off ARM in 1990 was obtained from Olivetti. A joint venture was undertaken with VSLI and Apple Computers. The new company was now free to fully leverage the extensive expertise it had inherited from Acorn, where the market potential of the RISC microprocessor was inhibited by the many organizational and competitive pressures Acorn was subjected to. As managing director Sam Wauchope explained in the wake of the spin off decision:

> *"It is a bit of a wrench to separate what has been an integral part of Acorn, but we have decided that ARM and Acorn are best served by the creation of a separate company. The deal opens up many possibilities in terms of product development which we probably would not have been able to afford."*

The bulk of the Advanced Research and Development section of Acorn that had been developing the ARM CPU for seven years and was composed of 12 engineers formed the basis of ARM Ltd when that company was spun off in November 1990. From the outset, ARM inherited a precise business model template that it could follow, as well as the technical expertise required to design the processor. Acorn and Apple were the clients, and VLSI provided the manufacturing capability. The initial business idea was to replicate externally what they had been doing for Acorn before spinning out. They were now free to approach other computer manufacturers, who could implement the ARM core without the fear of using a component controlled by a competitor who could block them out. While this seemed the logical and easiest avenue to pursue, ARM had also learned important lessons from the mistakes that led to the downfall of Acorn. These suggested the need for a critical revision of strategic direction. Acorn's major problems had always been production volume and lack of market focus. The proliferation of promising research projects with no market follow through had demonstrated the crucial importance of establishing tight links with customers and listening to their needs before venturing into costly explorations. Moreover, Acorn had made the mistake of maintaining an essentially inward looking strategic stance, insisting on proprietary systems when it was becoming apparent that in order to compete successfully in the computer industry firms had to aim for compatibility and open standards. Attempts at exporting had been unsuccessful. As ARM's CEO noted:

> *"The lesson had been learnt from failures at Acorn that, in order to succeed, a product had to succeed on the world stage and to do that, it had to become a global standard, which meant it had to be used by many companies." (Langdon and Manners, 2001 p. 121).*

ARM's learning process benefited from these lessons, which mapped very quickly onto a radically new business model.

4.3. Setting on a new track: reimprinting and metamorphosis

With ARM established as a new company, the team set about recruiting a CEO with the right skills. From his 12 years career with Motorola in the US and the Far East, Robin Saxby brought new kinds of experience to ARM. In addition to a mix of technical and business expertise, Saxby's infectious optimism also gave the new-born company high hopes. With significant experience in the industry Saxby immediately sought to maximize the company's very limited resources. From his first involvement with ARM Robin Saxby recognized the importance of managing relationships. Before accepting the job as managing director he arranged to meet the twelve engineers from Acorn, who had come from different teams within Acorn,) to establish a rapport with them. Within the company Saxby quickly developed an open culture. He played an active part leading weekly management meetings and, right from the start, he involved everyone in ARM in identifying its strengths and weaknesses.

In comparison to the US$2-3 billion capital investment that a silicon wafer factory requires, ARM's resources were laughably modest. But although fabrication was clearly not an option, there were other ways of entering the microprocessor market. Jamie Urquhart, one of the 12 founders, explained how he, Saxby and other two members of the early team made a SWOT analysis that made the case for ARM (led towards) becoming an IP company:

> *"We got everyone into one room and reviewed the options. We had already successfully licensed technology to VLSI. So we built on strengths we had. We also avoided weaknesses – no expertise in the company in the backend product/shipping logistics required in a chip business."*

Other companies had already taken the IP route by becoming “fabless” chip companies contracting out the manufacture of their chips. ARM took this one step further and decided that they would be a “chipless, chip company”. As a pure intellectual property firm, ARM would license its chip designs to semiconductor companies. In this way partners would take the ARM enabling technology, add their own application specific technology onto it, and use their silicon plants to manufacture the chip. ARM’s declared goal was to become the global standard and licenses were the only way for a small company with no resources. As explained by Saxby:

> *“To be the world standard, we had to get partners everywhere in parallel. And to get partners everywhere in parallel, we had to license the technology. That’s the order of thinking”.*

In order to pursue this strategy ARM had to develop new relational capabilities that were not in the repertoire of its founders. Given the scarcity of resources, rather than recruiting specialized marketing personnel Saxby chose to promote three of the twelve Acorn engineers to positions of sales and marketing. He believed that it was quicker and easier to teach engineers to sell than teach salesmen to understand ARM's complex technology. Then he hired a part time external consultant to train his team in sales and customer management. As one of the founders told us:

> *This guy taught us the SPIN approach […] essentially the first thing you do with a customer is you work out the Situation. How big is the company? How many chips do you design? How many chips do you manufacture? Then the P is problems. What sort of problems exists? Because getting a customer to take your product, if there are no problems it is very difficult […]. And they had problems because they had to design a different chip for every different application (it) goes into. You then work by Implied Needs. If you can have one chip, you develop the theme of how you can absolutely make the customer think and realize the cost of having to design lots of chips vs. the benefit of having one chip that can do several things, saves a lot of money […] A number of people went through that training and we were speaking a common language internally […] The main lesson was listen to what’s going on […] listen to what’s happening in the market place, understand it, don’t put your own interpretation on it, try to really understand what’s happening […] the culture was to learn and to understand, to assimilate and to see what works.*

In November 1991 ARM launched its first products, the ARM6 family of chips including the ARM600 power efficient microprocessor, at the Microprocessor forum in San Francisco VLSI Technology offered to manufacture the new processors customized to users' requirements. During this first year of operation, ARM focused on its immediate source of revenue from licensing agreements. In January 1992, ARM announced that GEC Plessey Semiconductors

(GPS) had become their first independent licensee to manufacture ARM chips and incorporate ARM features into application-specific microcontrollers. ARM now had their first independent partner with whom to work on the basis of the licensing model. Indeed the relationship with Plessey turned out to be ripe with learning opportunities. As a former Design Manager at Plessey (now Principal Staff Engineer at ARM) explained:

> *"At Plessey we were looking around for a micro processing core and then […] we picked ARM […]. The thing that was different about ARM was that they were not just providing a core technology […]. They were also excellent listeners […] they were willing to learn because they knew we were on the same boat. So they said to us, 'We've got this core. It must be useful to people for something. We don't really know how you might want to use it but we're prepared to work with you to understand it." And I think it was so refreshing from our point of view because, at the same time, we knew we needed a core, and we didn't know how to do it. We knew there were more questions that we knew answers to but didn't know what the questions were. When ARM came to us and approached us, they were in the exact same position. They had a capability, and they knew what they would like to do, but they knew that there were so many questions that they knew answers to. And this made us a very good fit because we were both going to learn out of this exercise. We were going to learn what a CPU was and how to use it, and they were going to learn what it meant to be able to supply something into an environment like Plessey They had this opportunity to work very closely with us, to learn about modularizing an ARM, about using an ARM core in an ICs environment and we, at the same time, were trying to understand how to sell this to our customers, how to put it into our product offering […] We had to design products around it which was a very difficult thing to do. And we learned. It was a teacher-student thing"*

Saxby and his colleagues concentrated on the 'brain' side of the chip business", and at the same they made sure their company also benefited from a deep understanding of manufacturing 'muscle' by establishing a very strong, customer-oriented approach towards its licensees.

> *"We need to have an intimate understanding of the manufacturing process and work with our partners in areas like test, de-bug, yield and performance enhancement […] We really treat our customers as partners involving them in agreeing specifications and taking joint risk and benefit on projects."*

Saxby also introduced a new business discipline to the group that had originated in an unstructured environment as Acorn. As one of the founders stressed:

> *He (Saxby) can be very structured…So every year, we would have business plan. We would have strategy review, an operational plan and a tactical plan. And these were not huge documents, but they were important documents. They were important in that they built on what we had been learning. They aligned everybody in the right direction. They gave us focus and made us challenge what we were doing.*

This disciplined approach of focusing on maximizing available resources to deliver the technology and nurture key relationships proved to be very effective as the small and fast moving

ARM became self-sustaining by only its second year of operation, without the need for further financing. In 1993 Sharp became the third licensee to manufacture and market ARM processors. As experience increased, ARM offered further services to its clients such us consultancy, feasibility studies, training and prototypes supply. The degree of learning and experience that ARM was able to gain through these partners was dramatic.

In May 1993 when Texas Instruments took out a license. ARM's business strategy as independent chip designer was thus endorsed by another major player. After VLSI and Plessey, this was the first licensee not signed through Apple's contacts. TI pushed the boundaries of ARM's contractual discipline further and provided further inputs to its learning effort. :

> *TI imposed us new level of discipline. Contracts would contain all of the deliverables; they'd have all of the timing specified. They were very professional and it was hard. They were demanding but they taught us a great deal in terms of helping to regularize the set of deliverables that we would then license on to our licensing partners (James Urquhart).*

At the time TI was trying to win the mobile phone business of Nokia. Through TI had deep expertise in one of the key technologies required, Digital Signal Processing (DSP), it was relatively weak in the complementary technology for central processing units (CPUs). They needed a CPU design that would work reliably in the background, use minimum power, and be well supported with design tools, models and applications. Based on this platform, they could focus on using their skills in DSP to make a chip that was uniquely attractive to Nokia. ARM's CPU technology promised to provide that platform, so TI decided to package the ARM design it into its overall offer to Nokia. Nokia came back with a list of problems: the ARM processor needed too much memory because the software code was too large, making it too expensive. But Nokia also recognized that there wasn't another product on the market that provided the required performance and that the solutions to these problems weren't obvious. ARM was breaking new ground.

ARM took up the challenge. In response to Nokia's feedback and an understanding of the necessary interfaces with TI's DSP technology, ARM worked with TI to set and then meet ambitious targets for power consumption and code size. The outcome was an important, significant innovation that became known as the "Thumb" architectural extension. By creating a subset of the most commonly used 32-bit instructions; ARM's engineers found they could compress these into smaller 16-bit code without any degradation in performance. Not only did Thumb turn out to be very popular with ARM's other partners, but the connection with Nokia meant that ARM shared in Nokia's success. The Thumb experience reinforced ARM's approach of working closely with market-leading OEMs, in addition to their direct licensees—the semi-conductor companies like TI. With an ARM chip running in the background, the OEMs could use their own proprietary technologies on top of the ARM platform to make their end product (such as a mobile phone) different and more attractive to users. To pull off this balancing act, ARM had both to understand the technologies and needs of different semiconductor manufacturers and OEMs and then to find the right trade-off between their competing priorities and demands to come up with a design that would suit the most important requirements of all. ARM at that time had 50 employees and £10 million in revenues; £3.5 million chips were endowed with ARM technology.

The endorsing effect of TI and the growing success of Nokia benefited ARM, attracting increasing numbers of licensees and fueling an outstanding rate of growth and innovation. After a decade of expansion, ARM had, by the end of 2001, 65 partners located in Europe, the US and Asia and about 800 employees. Four year later it had market capitalization of £1.6 billion and with ARM chips in an estimated 77% of the embedded RISC processor market. ARM had become the de facto global standard.

ARM's new business model distinguishes it from Acorn, but at the same time the technical standard developed at ARM has a lineage tracing back to its parent. This interplay between imprinted know-how and the new organizational impetus shaped ARM trajectory in a unique manner. The spin-out of ARM made it possible for the inherited technology to respond to the specifications and needs of a new market for low consumption applications, and triggered the emergence of a novel IP-based business model.

4.4. Lessons from the case evidence

The three windows in table 1 pinpoint the salient elements distilled from the case evidence to facilitate understanding of the evolutionary process that shaped the genesis of ARM and the development of its competitive identity. We use these categories to stylize the essential features of the parent-progeny metamorphosis, with imprinting and reimprinting being the two ends of this process and deprinting an intermediate transition phase.

Table 1 here

As is apparent from the figure, key elements alter across phases as elements and behaviors that emerge as decisive in certain phases disappear from others. For instance, in the imprinting phase there was a noticeable lack of reference (to plans or strategies for) setting a global standard based on partnerships and international agreements. In contrast, this dimension heads the strategic agenda during the reimprinting phase. Similarly, none of our sources suggested the pursuit of a patenting strategy at Acorn. Acorn did not file a single patent during its existence while ARM started very quickly to patent as a requisite condition for the sustainability of its emerging business model. ARM's ensuing know-how, however, was not just technology-based but encompassed a whole spectrum of support capabilities. As pointed out by James Urquhart: "We are not a licensing patent, we are licensing a complete design that works, along with the test patterns, along with the software that makes it work, along with the ability to persuade customers that it will work" (personal interview). Elements of this approach were to be seen in Acorn's early relationship with VLSI, but were not formalized into routines. Moreover, while imprinting and reimprinting both rely on the engagement of visionary champions who commit themselves to a business idea, they are also very dissimilar in terms of prior experience. Champions did not clearly emerge in the deprinting phase, where the stage is populated by several significant actors but with no single individual standing out from the group. Though the role of champion remained important, incumbents changed and the challenge was to select the new champion to pass the baton to without gaps in the process.

The comparison also reveals a marked difference between Acorn and ARM in the ability to move from improvisation to routines to capabilities. ARM was very rapid in the way it encoded learning from experiments with customers into routines and collective practices. These built on feedback as well as involving deliberate efforts at establishing an IP based business model. The IP strategy did not emerge fortuitously but as the result of targeted actions and deliberate choices informed by an ongoing learning interaction with lead clients. These were explicitly referred to as "teacher customers" by some of our informants. These clients provide useful feedback on how to craft highly customized services and at the same time imposed a rigorous work discipline in terms of timing and relationship management.

The contrast between the companies is marked at the extremes of the continuum while the intermediary (deprinting) phase consisted of "unlearning" and the preservation of knowledge that was at risk of being lost. During deprinting constraining practices are relinquished, allowing for a more accurate matching between prior capabilities and emerging market opportunities. The main challenge in this phase is to select the most promising know-how and resources that could otherwise dissipate rapidly. From this perspective, it is not surprising that Acorn turned into a hotbed for entrepreneurial initiatives as the deprinting phase frees slack and opportunities for the progeny to take up and pursue.

The reimprinting suggests a radical change in capabilities' development. The capabilities previously developed in Acorn underwent a fundamental renewal on the basis of multiple enabling conditions. These included the contribution of expertise from external consultants who trained the internal team in new marketing and customer relation practices; the arrival of Saxby as new CEO, with his distinctive background and strategic orientation; the learning approach to clients and clients' customers, providing ongoing feedbacks on how to customize and improve the technology. These were combined by means of rapid internalization and sharing of know-how throughout the organizations. So, as one of ARM founders explained to us, ARM's emerging capabilities were being nurtured by an "incredible intelligence machine" tapping a large amount of information and competencies through his numerous partnerships with clients:

> *ARM, when it's operating properly, should be able to assimilate information about what's happening in the market much more quickly than most companies because bizarrely, it will work with hundreds of competitors […] not competitors to ARM, but competitors to each other and with their customers so (ARM) has an incredible intelligence machine.*

5. Theorizing Interorganizational Learning and Spin-off Entry

Consistent with prior theory on organizational imprinting and parent-progeny transfer, the case illustrates the way ARM inherited important blueprints and cultural elements originated in the parent company. These elements provided the basic template for the new company's learning process, guiding early patterns of organizing. Yet, in the light of the evidence assembled, it was also evident that a refinement of the simple notion of imprinting was required. We saw, for instance, that it was not only the company of origin that provided strong influences. Key individuals coming from outside were a critical influence and brought with them ways of organizing with which they were familiar from their own prior organizational experience. At the same time the feedbacks from the environment proved learning cues that contributed crucially to steering the spin-out's strategic direction. The intertwining of the imprinted past and the emerging path we called deprinting. During *deprinting,* we conjectured that the progeny undergoes an unlearning-retaining tension (somewhat akin to Kurt Lewin's (1947) psychoanalytic concept of unfreezing). Some elements from the inherited past are selected and retained, others are dropped and substituted for or transformed. Inherited blueprints are subject to skeptical scrutiny and revision based on critical appraisal of parent's mistakes as well as novel signals from learning trials.

In particular, the case evidence showed how it was that emerging learning opportunities were essential to explaining what occurred. The reason why critical reappraisal proved possible was in no small part the outcome of influences from prior failures at Acorn which provided potent learning stimuli to avoid potential threats and embark on a winning track. By building on selected expertise, while diverging from the parent's strategic pattern, ARM developed an idiosyncratic combination of resources which mapped better onto the selection criteria of the new market for low power consumption processor architectures. This process in turn paved the way for the *reimprinting* phase, when the spin-off set out on a new trajectory as a result of the combination of retained know-how and development of new capabilities and organizational routines in response to market feedback and successful improvisation. Taken together the three phases of imprinting-deprinting-reimprinting offer a perspective on interorganizational learning and emergence that highlights the benefits of focusing on the parent-progeny dyad as the relevant unit of analysis. Based on our findings figure 2 provides an enriched stylization of our initial conceptual model of parent-progeny transfer and spin-off entry.

Figure 2 here

The new model highlights deprinting and reimprinting as additions to the original model. It also identifies the change of strategic trajectory that characterizes the parent-progeny transition, in contrast with the continuity implied by previous theory. Below we summarize the main theoretical insights that can be drawn from this revised model.

5.1. Deprinting

The literature on imprinting suggests a highly determinist model of parent-progeny influence and spin-off entry. Based on our evidence we argue that the risk with this way of portraying the parent-progeny relationship is that it overlooks the possibility that the inherited practices may be subject to critical reappraisal and revision by reflexive agents in the spin-off organization. Such a possibility seems especially plausible in those situations where the parent has experienced severe failures or crises that may serve as signals or lessons for the progeny on what to retain and what discard from the past. This may be less true in the case of successful parents since previous successes are more likely to enable self reinforcing dynamics and sustain past practices (Levinthal and March, 1993; McGrath, 1999), But, not uncommonly, spin-offs arise out of disagreements and crises that provide initial impetus to the spawning event. Evidence also indicates that successful spin-offs sometimes originate from failing incumbents.

Negative outcomes and critical events represent powerful learning stimuli, not only for gaining confidence and knowledge, but also in terms of reflecting on the consequences of one's actions and actively trying to ensure that such events do not reoccur in the future (Cope, 2001). As Smilor (1997) states, entrepreneurs "learn from what works and, more importantly, from what doesn't work" (p. 344). Not all failures however are equally adept at enabling constructive learning. Sitkin (1992) refers to failures that foster learning as "intelligent failures"; these are failures that provide a basis for altering future behavior through new information. These failures are of sufficiently large scale to attract attention yet not such as to bring about radically negative outcomes (firm exit, etc.). “Intelligent failures” can promote willingness to take risks and foster resilience-enhancing experimentation (Lounamaa and March, 1978). Progeny whose parents have experienced failures or near-failures have therefore an opportunity to critically reflect upon their failures, unlearn faulty practices and address uncertainties that could be disregarded by progeny of successful parents. This impetus stimulates reflexive agents to engage in exploratory search for new possibilities. Thus, learning through experimentation and bricolage (Baker et al., 2003) becomes a central learning technique (Sarasvathy, 2001; Sitkin, 1992). In this respect, the protracted learning efforts of ARM with its partners, the development of new marketing capabilities almost from scratch, and the many teacher-customer relationships are exemplars. As a result of this process not only part of the initial, inherited knowledge endowment was selected through critical revision but new practices were encouraged, that are distinct from the ones to which the spin-off had been exposed during parental incubation. It is this new orientation built on inherited practices that we refer to as the process of deprinting.

5.2. Reimprinting

The process of deprinting presents a signal challenge to the new firm that must undergo considerable learning efforts in order to break with imprinted practices and set on a new developmental track (Garud and Karnoe, 2001). To cope with the requirements of the ensuing trajectory, the spin-off needs to acquire new skills and establish novel routines that encode lessons from its search and experimentation. These are critically evaluated, with those yielding positive feedbacks being reinforced. In such a process, initiatives or traits that are favored by the business environments are incrementally reinforced in the course of market activity. The selection unfolds through a process of positive feedback. Positive signals from the market environment lead to greater commitment of resources which eventually make it increasingly difficult to return to the critical juncture where the entrepreneurial agents deviated from their previous trajectory (Sydow et al. 2005). There are deliberate efforts on the part of managers to refine and replicate selected traits by means of intentional interventions. As the signals from these experiments cumulate into consistent patterns they become increasingly codified into routinized behaviors that provide the basis for the new organizational make-up of the spin-off. ARM's new strategic direction was set very early but it was only through ongoing feedback arriving from the emerging market for low consumption embedded devices that it became a strategic trajectory[5]. Thus, the deprinting process paves the way for a gradual metamorphosis that culminates in the adaptation of the spin-off to the new niche environment and the creation of a new path. We referred to this process as reimprinting to emphasize the consolidation of the new trajectory. This occurs through exposure to new external and also internal selection regimes that re-shape its organizational and technological path in ways that were unforeseeable ex-ante (Garud and Karnoe, 2001). We suggest that reimprinting occurs in a fashion akin to the biological process of technological speciation (Adner and Levinthal, 2002; Cattani, 2006). The spin-off develops as new organizational species that shares a prior lineage with its parent. It develops radical new features as a result of its exposure to new selection criteria in the markets where the spin-off's core competences are evaluated according to the resource structure of distinctive niches. To the extent that the resources available in the new niche domain are sufficiently abundant to support the business efforts associated with the spin-off's new trajectory, this process may result in a metamorphosis with dramatic consequences. The re-imprinted spin-off develops a highly idiosyncratic combination of resources and capabilities with significant strategic potential.

6. CONCLUSIONS

The prevailing tendency to look at the spawning company and the spin-off as two separate entities obscures the complex interplay of intended and coincidental occurrences that may

[5] As a similar illustration of such a phenomenon also consider Burgelman's account of Intel's shift from memory business (Burgelaman, 1994). The firm was gradually pulled by market feedbacks and middle managers allocation resources decisions away from the memory business, engendering a whole new set of routines and practices. Initially minor efforts were reinforced and ultimately fundamentally altered the organization's business.

crucially characterize the transition from one company to the other. Our dyadic focus allowed us to identify a long span of incubation for ARM technology in Acorn. The project to develop a new microprocessor started at Acorn in the early 1980s and the team dedicated to the RISC technology had ten years to experiment and work with prototypes and to test and improve their designs for Acorn's computer products before spinning out. By tracing the spin-off's organizational and technological heritage back to its parent company we were able to illuminates the role of antecedents in incubating a new technology and shaping its trajectory. While this approach rests on an already robust stream of research that emphasize the effects of spin-offs' origin on their subsequent survival rate and performance (Agarwal et al., 2004; Cooper and Gimeno-Gascon, 1992; Klepper, 2001), little attention has been paid to the relationship between a spin-off's organizational and technological heritage and the exploitation of its innovative potential. We have found it essential to focus on dyadic processes and to trace them as they unfold over time in order to elucidate the evolving nature of the micro processes that shape the link between the past and the future. The dyadic perspective provides longitudinal depths and illuminates the interstices between the imprinting-deprinting-reimprinting phases. Had we not focused on the processes unfolding over a long span of time, Acorn would have been labeled as case of missed opportunities and failure. At the same time the dyadic focus provides compelling addition to the understanding of the role of prior experience in shaping new firm formation. It illustrates the transformation processes that occur in order for this imprinted 'heritage' to be adapted to the needs of the new venture. The transition between imprinted, deprinted and reimprinted knowledge illuminates the nature of the intergenerational learning processes and helps explain the intensity of parent-progeny change. Moreover, the examination of two sequential growth initiatives with strong underlying links reveals nuances and idiosyncratic elements of each trajectory, which would be difficult to capture on the basis of a generic comparison. It would be hard to understand ARM, its evolutionary trajectory and its achievements without knowing its roots in Acorn, at the same time we could not fully appreciate Acorn and the limitations of its business model – the lack of standard, alliances and marketing capabilities – without the enlarged interpretative framework made available by examining the history of ARM.

ARM was fortunate in gaining appropriate expertise from leading companies; this is not always the experience of spin-offs. The case also reveals that it is through the agency of particular people that learning takes place and is embedded in the new firm's routines and business model. The success of the spin-off rests on the quality of the parent organization but it also depends on serendipity and individual expertise that drive technological advance.

Figure 1

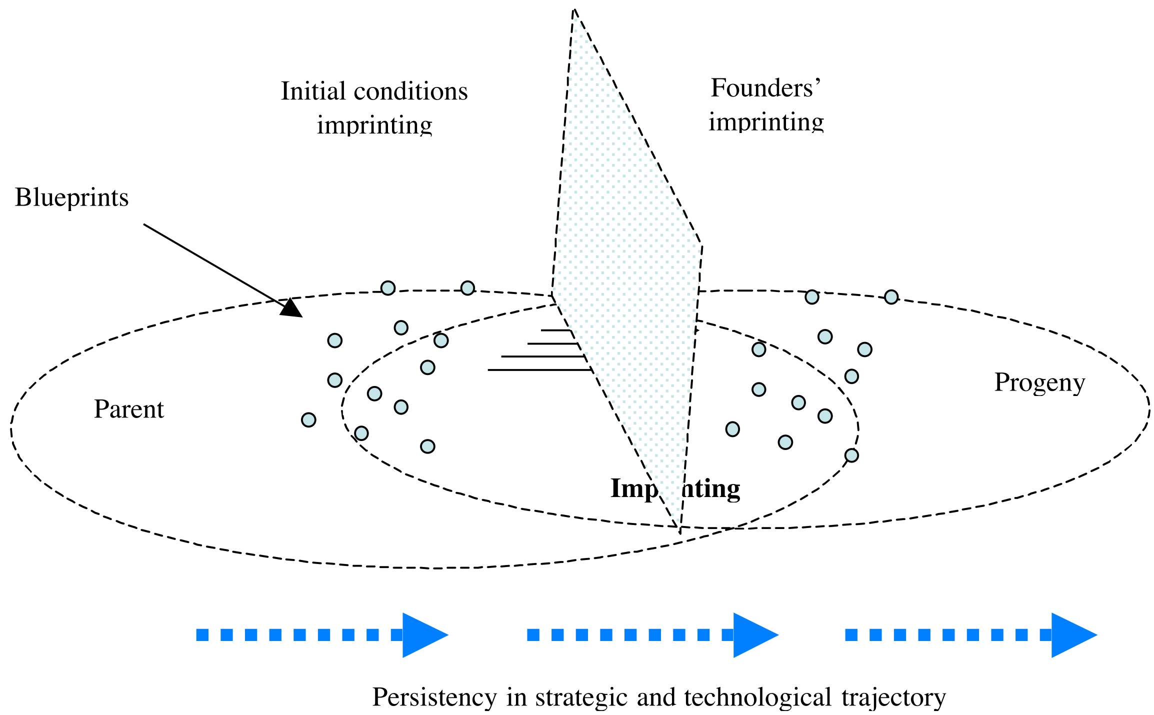
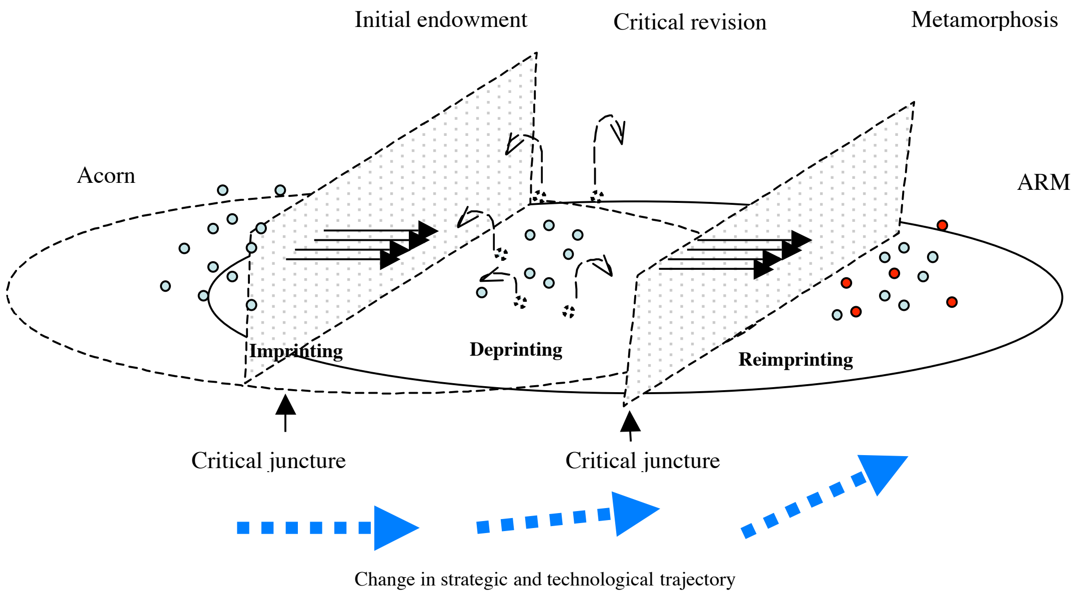


Table 1

Imprinting (1979-1985)	Deprinting (1985-1990)	Reimprinting (1990-)
•Rich scientific environment •Bricolage capabilities (design and rapid execution) •Passion for technical excellent •Weak marketing •R&D discretion and autonomy •Resource constrain – *less is more* •Champion	•The new embedded in the old •Search for a buyer •Spin out as a emerging unplanned activity •Olivetti-Apple-VLSI •Missed opportunities become apparent •Internal slack	•Patents •Technology Standard •Partnerships •Key clients and market understanding •Articulated and collective learning process •IP business model •Less is more •Bricolage (design and rapid execution)

Figure 2



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