Inter-Firm Co-Operative Strategies In The Context Of Discontinuous Technological Change

The Case Of The Uk Optical Communications Systems Industry

Simona Spedale

ERIM REPORT SERIES *RESEARCH IN MANAGEMENT*	
ERIM Report Series reference number	ERS-2002-112-STR
Publication	December 2002
Number of pages	29
Email address corresponding author	sspedale@fbk.eur.nl
Address	Erasmus Research Institute of Management (ERIM) Rotterdam School of Management / Faculteit Bedrijfskunde Rotterdam School of Economics / Faculteit Economische Wetenschappen Erasmus Universiteit Rotterdam P.O.Box 1738 3000 DR Rotterdam, The Netherlands Phone: + 31 10 408 1182 Fax: + 31 10 408 9640 Email: info@erim.eur.nl Internet: www.erim.eur.nl

Bibliographic data and classifications of all the ERIM reports are also available on the ERIM website: www.erim.eur.nl

ERASMUS RESEARCH INSTITUTE OF MANAGEMENT

REPORT SERIES

RESEARCH IN MANAGEMENT

BIBLIOGRAPHIC DATA AND CLASSIFICATIONS		
Abstract	At times of discontinuous technological change co-operation represents a viable strategy for both incumbents and new-entrants, provided that the choice of co-operation is consistent with the firm's business strategy (market-pull vs. technology-push) and with its degree of organizational and technological flexibility. Evidence from the UK fibre-optics industry identifies two ideal-types of co-operation, namely *structured co-operation* - associated with market-pull strategies and lower levels of flexibility – and *unstructured co-operation* – associated with technology-push strategies and higher levels of flexibility.	
Library of Congress Classification (LCC)	5001-6182	Business
	5546-5548.6	Office Organization and Management
	HD 69.S8	Strategic alliances
Journal of Economic Literature (JEL)	M	Business Administration and Business Economics
	L 20	Firm Objectives, Organization and Behavior: general
	L 20	Firm Objectives, Organization and Behavior: general
European Business Schools Library Group (EBSLG)	85 A	Business General
	270 A 100 G	Strategic Management Organizational Growth
	270 A	Strategic Management
Gemeenschappelijke Onderwerpsontsluiting (GOO)		
Classification GOO	85.00	Bedrijfskunde, Organisatiekunde: algemeen
	85.10	Strategisch beleid
	85.10	Strategisch beleid
Keywords GOO	Bedrijfskunde / Bedrijfseconomie	
	Strategisch management, organisatievernieuwing	
	Samenwerkingsvormen bedrijfseconomie, strategische keuzebepaling, technologische ontwikkeling, marketing	
Free keywords	Inter-firm relationships, Co-operative strategy, Technological discontinuity, Incumbents, New-entrants	

INTER-FIRM CO-OPERATIVE STRATEGIES IN THE CONTEXT OF DISCONTINUOUS TECHNOLOGICAL CHANGE

The case of the UK optical communications systems industry

SIMONA SPEDALE
Erasmus University Rotterdam
Rotterdam School of Management
P.O. Box 1738
3000 DR Rotterdam
The Netherlands
Phone: (+31) 10 408 1941
Fax: (+31) 10 408 9013
sspedale@fbk.eur.nl

Acknowledgements

This paper is based on research carried out by the Author during the course of her Ph.D. at City University Business School. The Author wishes to acknowledge the contributions of the Fibre-optics Industry Association and of many industry experts, practitioners and managers who participated in the study. Some financial support to the research came from City University Business School. The Author is also indebted to Chris Hendry, Charles Baden-Fuller, Peter Ring, Frans A.J. van den Bosch and Henk Volberda for their support and their comments during her studies and in the drafting of the present paper.
A different version of this paper has been submitted for publication to Long Range Planning.

INTERFIRM CO-OPERATIVE STRATEGIES IN THE CONTEXT OF DISCONTINUOUS TECHNOLOGICAL CHANGE

The case of the UK optical communications systems industry

Introduction

Technological discontinuities such as biotechnology and digital wireless communications shake the competitive environment, destroy the basis of established competitive advantages for incumbents, and open up opportunities of strategic renewal by building new competitive positions[1]. However, they do not necessarily imply the demise of incumbent firms. A growing body of evidence indicates that, in their battle against aggressive new-entrants, incumbents can and do survive[2]. In some cases, such as in the case of high-tech multi-technology industries, the end result of discontinuous technological change is a "symbiotic co-existence" of old and new firms[3].

The co-existence of incumbents and new-entrants can be partially explained in terms of the impact of discontinuous change on both technological and 'complementary' competences within the same industry[4]. More specifically, technological discontinuities can simultaneously have competence destroying and competence enhancing effects for incumbent firms[5]. Christensen, for example, found that trajectory disruptive architectures tend to be developed in new, emerging market segments, whereas trajectory-sustaining technologies are first used within mainstream markets[6]. Rothaermel found that in high-tech multi-technology industries, radical technological change destroys competences that relate to an incumbent's upstream value-chain activities while enhancing competences that relate to its downstream value-chain ones, especially those that are necessary to successfully commercialize the new technology[7].

This paper analyses the role of co-operative strategies for both incumbents and new-entrants in shaping the industry competitive context in the wake of a technological discontinuity. As shown by Rothaermel, discontinuous technological change can also initiate a process of 'creative' co-operation. Incumbent firms use co-operative strategies – typically with new-entrants - to establish their technologies as the dominant standard and expand their consumer base. At the same time, some of the start-ups specialize into new sub-fields, so that the

industry splits into quite separate competitive arenas. Incumbents and new-entrants end-up coexisting within the same industry in different networks of co-operative relationships[8].

Rothaermel's most recent work concentrates on incumbents' performance and on co-operation between incumbents and new-entrants[9]. But the issue of co-operative strategies as firm-level responses to technological discontinuities is wider. The contribution of this paper is to develop our understanding of the relationship between radical technological change and co-operative strategies by providing an answer to two fundamental questions:

1. What types of co-operative strategies emerge in the wake of a technological discontinuity?
2. Are there any similarities (or differences) in the behaviors of incumbents and new-entrants with respect to the type of co-operation?

This paper presents the results of a research study on co-operative strategies in the UK fibre-optics industry between 1992 and 1997. It shows how the competitive flux created by the emergence of fibre-optics as potential substitute to copper-based technology in communications is compounded by the slower than expected progress of the new technology. In the midst of this unresolved technological battle, both incumbents and new-entrants adopted co-operative strategies of one of two types, respectively labeled here as *structured* and *unstructured* co-operation. Structured co-operation is characterized by the development of highly engineered partnerships at the inter-organizational level, whereas unstructured co-operation is highly dependent on the development of personal relationships between individuals in different organizations.

The paper highlights two key findings. First, not only old and new firms co-exist within the same industry – albeit in quite different competitive arenas - but also old and new technologies can (and often do) co-exist within the same firm. This has major implications for the type of market strategy pursued by individual firms. A second, counter-intuitive finding is that being an incumbent or a new-entrant does not entirely explain the type of co-operative strategy adopted by a firm. Two interrelated factors appear relevant for this choice. The first is the strategic driver of the firm, which distinguishes between demand-pull versus technology-push strategies[10]. The second is the degree of flexibility of the firm, which includes both technological and organizational dimensions[11].

In the following section the theoretical background for the study will be briefly introduced. I then proceed by illustrating the fundamental characteristics of fibre-optics that make this industry an interesting field for addressing the research questions. After presenting the research methodology I illustrate the major findings and discuss them in the light of the existing theoretical and empirical contributions. Finally, I reflect on the implications of the study for both managerial practice and theory.

Exploring the relationship between technological discontinuity and co-operative strategies

Three bodies of literature mainly contribute to our understanding of the relationship between discontinuous technological change and firm-level responses, in the form of co-operative strategies – namely, the economics of technological change, innovation studies, and strategic management.

In the field of the economics of technological change, early contributions by Freeman and by Rozenberg show that discontinuous technological change is not homogeneous in terms of its nature and impact for existing firms and their strategies[12]. The subsequent realization that a technological discontinuity can have both competence enhancing and competence destroying effects constitutes a fundamental step forward for analyzing how incumbent firms can survive the 'gales of creative destruction'[13] that sweep industries from time to time.

Building on Henderson and Clark's classification of innovations – based on the degree to which innovations reinforce or make obsolete firms' expertise – many contributions in the fields of the economics of technological change and innovation studies have tried to understand and clarify the options available to both new-entrants and incumbents[14]. For example, works by Mitchell, Pavitt and Rothaermel have shown how incumbents, in particular, can rely on enhanced competences and architectures to defend their competitive positions and take advantage of radical technological changes[15]. Rothaermel's work also highlights the importance of co-operation in shaping competition in the wake of a technological discontinuity. Incumbent firms, in particular, use co-operative agreements with new-entrants to establish their technologies as the dominant industry standard and, consequently, to expand their consumer base. At the same time, some of the start-ups

specialize into new sub-fields and concentrates on the most advanced niches of the market, so that the industry ends up split into quite separate competitive arenas[16].

These findings are consistent with Christensen's analysis of the rigid disk-drive industry[17]. Christensen shows how the leading disk drive manufacturers reacted to radical changes in technology and the markets and points out that the most successful incumbents were those who developed the new technologies to address their (traditional) mainstream customers' needs. New entrants, on the other hand, concentrated on emergent market segments, with significant implications for the future development of the technology, and the industry as well.

From the strategic management point of view, a firm's survival in the long term is dependent on the sustainability of its competitive advantage in the face of a changing environment. The analysis is here limited to the more adaptive perspectives in the strategy field, and, more specifically, to the Resource Based View[18]. The main argument of the Resource-Based-View of the firm states that a firm's resources and competencies are the basis of its competitive advantage and that isolating mechanisms are the pillars of sustainability[19]. But capabilities have a dark side, and core rigidities make change a difficult task[20]. The more radical the change, the more difficult the task for incumbents because of core-rigidities effects. As Grant points out, in responding to a radical change in an industry "whereas new firms are faced with the challenge of acquiring entirely new capabilities, established firms are faced with the dual challenge of acquiring new capabilities and dismantling existing obsolete capabilities"[21].

However, although faced with a very difficult task, incumbents are by no means doomed to failure. How can they survive? In the field of strategy, a perspective that complements the Resource Based View in understanding firms' options in the face of radical change and explaining long-term survival has recently developed under the name of Relational View of the firm[22]. The Relational View of the firm is based on the key assumption that a firm's critical resources can span its organizational boundaries and be embedded in *interfirm* relationships. The recognition that competitive advantage depends on inter-organizational relationships contributes to our understanding of firms' survival in the face of radical technological change. It, in fact, highlights how the typical advantages associated with co-operative strategies[23]– such as increased flexibility, access to complementary resources, and learning – might be relevant for both incumbents and new-entrants and could partially

explain the predominance of one or the other in the face of radical technological change. Co-operative strategies, in other words, contribute towards the sustainability and the creation alike of competitive advantage. The former is crucial for incumbents; the latter is crucial for both incumbents and new-entrants.

To summarize, all of the three theoretical perspectives above - the economics of technological change, innovation studies and strategic management – do not discount the possibility that incumbents and new-entrants might co-exist in the wake of a technological discontinuity, and that co-operative strategies play a potentially significant role in achieving this outcome. Starting from this recognition, the present paper concentrates on the types of co-operation adopted by incumbents and new-entrants as firm-level responses to radical technological change, and on their similarities (or differences) with respect to co-operation.

Fibre-optics: substitute or complementary?

Opto-electronics is a revolutionary technology, an example of "scientific fusion" which "exemplifies the merging of optical and electronic properties at the atomic level"[24]. It is also a classic example of major technological discontinuity. In terms of end-markets, opto-electronics is a core technology for a number of different industries, notably communications, information systems, consumer electronics, aerospace, military and medical. In general terms, however, it is possible to distinguish between two main types of applications. The first is industrial and consumer electronics, which has dominated in countries such as Japan; the second is optical communications, which has constituted the main driver for technological development in the UK. It is this second area of application that lies at the centre of the present study.

The development of opto-electronic technology in communications has been characterized by two 'technological bottlenecks' – increasing transmission capacity and increasing transmission distance – and four main phases. The first phase (1960s and first half of the 1970s) coincides with the emergence of optical communications as a potential reality. The difficulty in producing low-loss (that is, high-quality) fibres is paralleled by steady progress in the development of suitable sources of light. During the second phase (mid-1970s to mid-1980s) this bottleneck is removed thanks to the development of successive generations of fibres. Progress in the development of other components – particularly sources of light – is

also achieved and optical communications becomes a reality. The third phase (mid-1980 to early 1990s) is mainly characterized by issues related to the commercialization of the technology in the market. Great emphasis is also put on lowering the manufacturing cost of key components in order to enhance diffusion.

This becomes the dominant theme for the fourth phase. In theory the fourth phase should coincide with the emergence of fibre-optics as the dominant technology in the industry and the complete demise of the old copper-based technology. The reality, however, shows a different picture, one that has been recently depicted as "the slow progress of fast wires"[25].

From a technological point of view, the fundamental difference between optical and copper-based communications is that in fibre-optic cables information is carried by means of light beams whereas electrical current is the carrier in conventional copper cables. The decisive advantage of optical communications over more conventional forms lies in the different carrying capacity of optical and metallic cables. Other advantages follow as shown in Table 1. Judging on the basis of pure technological characteristics, there is little doubt that fibre-optics should entirely replace copper-based technology in communications. In the early stages of the diffusion of fibre-optics in the marketplace, the technological superiority of the new technology above traditional copper generated a strong expectation that 'fibre-to-the desk' would become a reality in a not-so distant future. Substitution was not in question, and it would happen soon. But a few years down the line a different picture has emerged. 'Fibre-to-the desk' has not become a reality, and some people have started doubting that it will in the near future. More than that, some have started doubting that it should.

[TABLE 1 ABOUT HERE]

What has provoked this significant change in the expected outcome of the technological battle between copper and fibre-optics? On closer scrutiny, a combination of factors have delayed the diffusion of fibre-optics and prevented its emergence as the new industry standard[26]. Fist of all, the intrinsic complexity of the technology, and the presence of significant 'interdependencies'[27] constitute natural obstacles to rapid commercialization.

The second factor is connected to cost and infrastructure problems. For fibre-to-the desk to become a reality, a few pre-requisites need to be met. One is cost-related. There is a linkage between the rate and pace of diffusion of the new technology and its cost. If the cost does not

come down significantly with volume increases, the diffusion may come to a halt as well. In the case of fibre-optics, the cost of some components has decreased significantly (for example, fibre-optics cables are in themselves a mature product) but in other areas costs are still relatively high. This is partly related to the second pre-requisite. A capillary diffusion of optical communications systems needs huge investments in infrastructure. For example, for Local Loop or Subscriber connections to be available, wider networks (LANs, MANs, and like-such) need to be put in place. Delays and cost-related problems at the infrastructure level affect the economic viability of more localized systems.

The third factor is that firms with huge investments in copper-based technology have reacted to the substitution threat on two fronts. On one hand, they have intensified their efforts in innovation in the traditional copper-based technology. Metallic cables, for example, have dramatically improved their performance and can still benefit from cost and infrastructure-related types of advantages. On the other hand, incumbent firms have diversified into opto-electronics with the dual objective of controlling the diffusion of the new technology and, at the same time, avoid rapid cannibalization of the old.

In brief it is possible to summarize the situation of the UK optical communications systems industry at the time of the study as follows. Optical communications is by any means a technological discontinuity, and the theoretical advantage of the new technology is so strong that it might be considered as a substitute. In reality, however, a combination of factors - technology-related, infrastructure and cost-related, and, firm-related ones - have halted the emergence of fibre-optics as the dominant standard in the industry. Fibre-to-the-desk is not a reality, and the majority of optical communications systems are based on a combination of copper-based and optical technology. For example, in a typical LAN application such as providing access to an industrial park, fibre-cables could be used to connect different buildings, and metallic ones could be used to extend the network to each individual terminal or desk within the a building. In other words, these two potentially substitute technologies have become complementary.

Methodology

The research focused on the development of co-operative inter-firm relationships in the UK communications systems industry. The emergence of opto-electronics constituted the

technological discontinuity at the center of the study. This included both incumbents and new-entrants[28] and, more specifically, analysed co-operation between manufacturers and installers of optical communications systems. A schematic structure of the industry supply-chain at the time of the study is in Figure 1.

[FIGURE 1 ABOUT HERE]

The target population for the empirical research consisted of all UK firms involved in manufacturing and/or installation of optical communications systems. These are firms whose core activity is to provide end-customers with the necessary 'hardware' for fibre-optics communications. The big systems operators, who provide end-customers with the actual service, were therefore excluded alongside firms exclusively involved in distribution of hardware components. Formally independent firms, UK subsidiaries of multinational groups, as well as divisions of bigger companies for which it was possible to collect specific data, were included in the sample. The sampling frame was obtained combining three existing lists – respectively provided by the Fibre-optics Industry Association (167 corporate members), the Fibre-optics, Lasers, and Opto-Electronics Directory (126 companies), and the list used by Brown and Hendry [29] for their comprehensive survey of the UK fibre-optics industry. The total sample consisted of 132 firms.

The choice to concentrate the study on co-operative relationships between manufacturers and installers of optical communications systems is justified both theoretically and empirically. The theoretical rationale lies in the idea that the process of creative co-operation that follows a technological discontinuity is related to the relevance of up-stream and down-stream activities in the incumbents' value chains[30]. The empirical one lies in the fact that the relationships between manufacturers and installers is particularly critical in this industry, given that installers represent an essential link-pin between demand – that is, customers' needs – and supply – that is, available technology and offer.

Data collection included both secondary and primary data. Secondary data consisted of extant literature and publicly available data on the industry. Primary empirical data were collected by means of survey and interviews, mainly carried out in the year 1998. A total of 53 questionnaires were returned, of which 41 usable for analysis purposes giving a response rate of 31%. A preliminary analysis indicated no major bias in favour of specific categories of

respondents in terms of size (measured by means of annual revenue and employees) or primary activity (that is, manufacturing or installation).

The survey instrument was adapted to capture the different perspectives of manufacturers and installers - the two ends of the relationship under study - but the questions covered identical fields and mainly concentrated on the nature of inter-organizational relationships at this particular level of the supply-chain. A number of indicators were used to measure co-operation. Some were empirically based, such as the length of the relationship, the number of suppliers/distributors, and the use of practices that limit access to suppliers and distributors. Others were more theoretically based. An extensive analysis of the new institutional economics, strategy and organization theory literatures[31] on the development of co-operative inter-organizational relationships led to the identification of six 'critical' areas. These broadly relate to aspects of co-ordination, commitment and information exchange, and governance – in particular, control and conflict resolution - and are summarized in Table 2.

[TABLE 2 ABOUT HERE]

These measures were used to create an initial map of the different types of co-operative behaviours adopted by manufacturers and installers in their reciprocal dealings. Subject to further analysis, they also provided the basis for the identification of more general patterns of co-operation between manufacturers and installers in the industry. This led to the identification of two main approaches to – or strategies of - co-operation, which are described in the following section.

The results

The analysis of the research data led to two main results. The first is empirical evidence to confirm how old and new technologies can co-exist within the same industry - in different organizations - but also within the same firm - if not always in the same proportion. This has important implications for firms' strategies. The second is that two ideal-types of co-operative strategies can be identified at the level of the industry supply-chain under study, respectively labeled here *structured* and *unstructured* co-operation. These findings will be illustrated in detail in the remaining part of this section.

The co-existence of copper and optical technologies

What impact did the fibre-optics revolution have on firms' strategies and, more specifically, in terms of their choices of markets and core technology? What were its implications for the industry supply-chain? When fibre-optics emerged as a potential substitute for copper-based technology, the incumbents reacted by diversifying into the new technology. Incumbent manufacturers were typically large firms, with huge investments in copper technology that could not be easily re-deployed. A radical change in strategy was very difficult, and, given the opportunity, these firms adapted by concentrating their efforts on serving their old market – the market for standard applications characterized by large volumes, high rates of growth and mainly large, non-sophisticated customers – with a combination of old and new technologies. They became 'general manufacturers'. In terms of technology development, these firms put a lot of effort in improving copper technology, and this stimulated a series of innovations that made copper significantly more competitive. On the other hand, they rapidly developed new competencies in fibre-optics, and tried to strike a balance between the two so that the new would not cannibalize the old too quickly.

Incumbent installers, on the other hand, could change their strategy more easily. They did not have the strain of huge non re-deployable investments in copper and with this stronger flexibility came the possibility to redefine their overall strategy in terms of both markets and technologies. Some firms actually kept faith to the old ways, more specifically to their old markets, and became 'general installers'. Others decided to concentrate more heavily on the new technology and specialized in the more sophisticated types of applications. In other words, they reinvented themselves as technology-driven, 'specialist installers'.

Significant differences were also observed amongst new-entrants. These were soon confronted with the difficulties encountered by fibre-optics in its diffusion in the market, and with the defensive reaction of the incumbents. New-entrant manufacturers mainly directed their efforts towards specialist niches of the market, whereas new-entrant installers chose one of two alternatives. They either concentrated their efforts on the mainstream market for standard applications – therefore becoming 'general installers' – or pursued a very focused niche strategy – therefore becoming 'specialists'.

These developments can be summarized in a matrix (see Figure 2) that classifies manufacturers and installers of fibre-optic communications systems in terms of two

dimensions. On the one hand, their intrinsic nature of incumbents or new-entrants, which crudely summarizes both organizational and technological competencies; on the other hand their choice of strategy. Even if a combination of old copper and new fibre-optics is still necessary for keys-in-hand communication systems, individual firms' strategies can differ in terms of the relative combinations of market/technology served. In other words, they can follow a predominantly demand-pull strategy centered on mainstream markets or, alternately, a predominantly technology-push one, concentrating on specialist niches.

[FIGURE 2 ABOUT HERE]

Structured and unstructured co-operation

The development of co-operative strategies between UK manufacturers and installers of optical communications systems is a response to the altered competitive circumstances brought about by the fibre-optics revolution. Incumbents and new-entrants both benefited from increasing levels of co-operation. Incumbent manufacturers and installers adopted co-operative strategies to take advantage of the enhancing effects of the technological discontinuity on, respectively, their downstream and upstream activities. For new-entrant manufacturers and installers co-operative strategies were part of a wider entry strategy, and played a significant role in overcoming the difficulties posed by the slower than expected diffusion of the new technology in the market.

By analysing the patterns of co-operative behaviour captured in the survey, two ideal-types of co-operative strategies were identified and named, respectively, structured and unstructured co-operation. A comparison between the two, based on the key six areas identified in the methodology section, is shown in Table 3.

[TABLE 3 ABOUT HERE]

At the time of the survey, relationships between manufacturers and installers of optical communications systems show many co-operative features, and specific questions in the questionnaire on the trend of the previous five years – between 1992 and 1997 - corroborate the idea that co-operation was on the increase. This is confirmed by qualitative data from the interviews and the case studies[32], which also support the view that the adoption of co-operative strategies is connected to the specific competitive circumstances following the emergence of fibre-optics and its co-existence with copper technology. In other words, the

slow progress of fibre-optics and the resilience of copper technology are strongly associated with the emergence of co-operative strategies at a critical level in the industry supply-chain.

Structured or unstructured co-operative strategies?

The results from the survey and the case studies are consistent with previous findings in suggesting that, in the wake of the fibre-optics revolution, UK firms tend to operate in two separate competitive arenas[33]. The first is the wide mainstream market for standard applications, characterized by large volumes; high rates of growth; non-sophisticated, mainly large, customers, and (primarily) price-based competition. The second arena is the realm of specialist applications and comprises a collection of niches where particular needs are catered for. These can be connected to special characteristics of the end-customers - for example in the case of small and medium firms with little knowledge of the technology - or to special characteristics of the applications – for example, when sophisticated applications are requested by equally sophisticated end-users such as the military and aerospace. In these niche markets, price is not so relevant whereas being at the leading edge of technological development is. The ability to provide tailor-made solutions, to advice and counsel uneducated customers in their technological choices, and to communicate with sophisticated users on an equal footing are all necessary attributes to be successful in niche markets and all require a strong focus on the technology. The constant expansion in the number of applications of optical technology across different fields provides ample opportunities for growth (and also new entries) in this arena, but growth in itself is not necessarily a strategic priority for individual firms.

The identification of structured and unstructured co-operative strategies answers the first research question, but what can be said about potential similarities (or differences) between incumbents and new-entrants with respect to co-operation? In other words, which firms adopted structured co-operation, and which choose unstructured co-operation instead?
The most counter-intuitive finding of the study is that the position of incumbent or new-entrant does not entirely explain the type of co-operative strategy chosen by UK manufacturers and installers of optical communications systems, neither does their own core activity – that is, mainly manufacturing or installation.

The type of co-operative strategy adopted by manufacturers and installers of optical communications systems is, instead, linked to two interrelated factors – namely, the key strategic driver of the firm and, its degree of organizational and technological flexibility. The key strategic driver of the firm spans between, on the one hand, growth in terms of volume in mainstream markets for standard applications – a strategy earlier defined as market-pull, and, on the other hand, growth in terms of diffusion of the technology across different specialist niches – a strategy earlier defined as technology-push. The degree of organizational and technological flexibility of the firm is only partially captured by the intrinsic characteristic of incumbent or new-entrant. Other structural factors – such as, for example, the importance of sunk costs and the possibility to re-deploy existing investments –play a fundamental role. Figure 3 summarizes the positions of different industry participants (manufacturers and installers of optical communications systems; incumbents and new-entrants) with respect to these two factors and highlights the types of co-operative strategies that emerge between them.

[FIGURE 3 ABOUT HERE]

Incumbent manufacturers, typically following a demand-pull strategy, entered highly structured co-operative relationships with 'general' installers to reinforce and expand control over mainstream markets and existing customers. New-entrant manufacturers, typically following a technology-push strategy, developed unstructured co-operative relationships with (mainly) 'specialist' installers. This type of co-operation had learning as main objective, and the development of leading-edge applications of fibre-optics technology also constituted an attempt to remove technical and cost-related obstacles to the wider diffusion of the technology in the market. As for installers, both incumbent and new-entrants could choose more freely than manufacturers between a demand-pull and a technology-push strategy. Those who preferred a demand-pull one entered more structured types of co-operative agreements with 'general' manufacturers, whereas the ones who opted for the technology-push strategy were more likely to develop unstructured co-operative agreements with 'specialist' manufacturers.

Finally, some firms - typically new-entrant installers –appear "stuck in the middle"[34] at the time of the study. These are typically firms with a strong initial focus on the technology but that, at some stage in their development, were allured by the possibilities for rapid growth offered by the standard applications market. These firms tend to have double strategies and

double systems of co-operation, but interview data reveal that the lack of focus and the tensions emerging from this duality negatively affect both performance and morale.

Summary and conclusions

The main purpose of this study was to analyze the types of co-operative strategies adopted by incumbents and new-entrants in the wake of a technological discontinuity. A secondary objective was to identify potential similarities (and differences) between incumbents and new-entrants with respect to co-operation. The context for the research is the UK fibre-optics industry, and specific attention has been devoted to the development of co-operative strategies between manufacturers and installers of optical communications systems in the years 1992-1997.

The study confirms previous findings that highlight the importance of co-operative strategies as firm-level responses to technological discontinuities for incumbents[35] and also as part of a wider entry-strategy for new comers[36]. It also contributes new evidence to the study of the development of new, disruptive technologies and their implications for firm strategies. In line with Christensen's and Rothaermel's contributions[37], it suggests that incumbent firms who adopt the new technology tend to apply it to their traditional mainstream markets (demand-pull strategy), whereas new-entrants tend to concentrate in specialist niches, where leading-edge applications are explored and developed (technology-push strategy). However, an original contribution of the study is to show how the choice between demand-pull and technology-push strategies is not directly associated with a firm's status of incumbent or new-entrant, but is also affected by other organizational and technological factors. For example, the importance of sunk-costs and the possibility to re-deploy existing investments can play a significant role, as the differences in strategies between incumbent manufacturers and installers in the UK optical communications systems industry show. This suggests that the impact of a revolutionary technology differs significantly between firms at different levels of the same industry supply-chain, and a more careful distinction is called for in future studies of incumbents' reactions to technological discontinuities.

The study also provides a valuable insight into the types of co-operative strategies that emerge after a technological discontinuity. The two ideal-types of structured and unstructured co-operation constitute distinctive alternatives, and the choice between the two depends on a

firm's long-term strategic objectives as well as on its degree of organizational and technological flexibility. Co-operative strategies are, therefore, related to what the firm *wants to do* in the long term as well as to what *it can do* given its organizational structure and capabilities, and its technology. Again, a firm's status of incumbent or new-entrant is only a partial explanatory variable, in that there is no immediate association between the position of a specific firm as incumbent or new-entrant and its choice of a structured or unstructured type of co-operative strategy.

As for the managerial implications of the study, the relevance of co-operative strategies in complex competitive environments is highlighted. In the context of discontinuous technological change co-operative strategies offer both incumbents and new-entrants the opportunity to shape the competitive game. Co-operation is, in other words, a useful strategy for the sustainability of old positions and the creation of new competitive advantage alike.

The study, however, shows that in the context of discontinuous technological change different types of co-operation suit different purposes. A better understanding of the factors affecting the choice – the strategic driver of the firm and its degree of organizational and technological flexibility – as well as of the alternatives available – structured versus unstructured co-operation - can benefit managers in their decision-making. Moreover, the two ideal-types of structured partnerships and unstructured co-operation offer a valuable insight and pave the way for further developments on issues such as strategy implementation and the long-term effects of co-operation on competition and firm performance.

Finally, a critical implication of the study is that the pattern of adoption of demand-pull and technology-push strategies in the wake of a technological discontinuity, combined with the development of consistent types of co-operation, have a significant impact on the direction of technological development and on the shape of the future competitive game. As Christensen highlighted in his study of the hard-drive disk industry[38], the tendency of incumbent firms to concentrate on mainstream markets pushes leading-edge developments of the technology in specialist niches, often far away from sight. This might pose a significant future threat for established firms, if 'hidden' technological developments pave the way to wider success in the market in the future. Managers of established firms are therefore alerted to these potential risks, and should accordingly provide adequate organizational and strategic solutions to keep an eye[39] on what is going on at the fringes of their industries.

TABLE 1. Technological advantages of fibre-optics versus copper-based technology in optical communications

BANDWIDTH AND CARRYING CAPACITY	Optical cables provide larger capacity and bandwidth than metallic cables, so that tens of thousands of simultaneous channels can be transmitted and received
TRANSMISSION LOSSES	Optical cables suffer lower transmission losses than metallic cables, and decrease the need for signal amplification
WEIGHT	Optical cables weigh far less than metallic cables, and also take up less space
ELECTROMAGNETIC INTERFERENCE	Optical cables are immune from electromagnetic interference (crucial in specialist applications, mainly for the military and aerospace)
SAFETY	Optical cables are safer than metallic cables (crucial in hazardous areas)

Sources: Charin (1983), Miyazaki (1995)

TABLE 2. Measures of interfirm co-operation

INTERORGANIZATIONAL PROCESS	**OPERATIONAL MEASURE**	**Description**
CO-ORDINATION AND CAPABILITIES INTEGRATION	Teamwork across organizational boundaries	The higher the degree of teamwork (across a wide spectrum of activities, from design to installation) the more co-operative the relationship
	Span of selection criteria	The wider the span, including criteria that go beyond past performance to include factors such as potential for innovation, technological capabilities, ease of communication, and managerial practices, the more co-operative the relationship
COMMITMENT AND INFORMATION EXCHANGE	Commitment to the relationship and information exchange	The level of commitment and information exchange is measured in terms of the adoption of practices such as exchange of strategically sensitive information, idiosyncratic investments in tangible and intangible assets, open books, and exchange of personnel
GOVERNANCE	Span of performance evaluation criteria and type of monitoring mechanisms	The wider the span, including criteria such as contribution to innovation, the more co-operative the relationship. As for mechanisms, aspects such as the degree of formality/informality of the evaluation are taken into account
	Role of the contract	Written down or in oral form, as a means to specify the expectations of the parties
	Conflict resolution mechanisms	Use of legal enforcement versus trust-based mechanisms. The higher the degree of 'voice' in conflict resolution, the higher the reliance on trust and the more co-operative the relationship

TABLE 3. Behavioral patterns of co-operation in supply relationships

	STRUCTURED CO-OPERATION	UNSTRUCTURED CO-OPERATION
Key areas for co-operation in supply relationships		
Teamwork across organizational boundaries	Suppliers are heavily involved at the early stages of the overall production process and co-ordination is mainly achieved by means of system integration	Suppliers are involved but the relationship is not formalized in structures. Their involvement is based on social interactions at the individual level that lead to high relational capital
Supplier selection	Selection is based on a wide range of criteria (expressing both past performance and future potential) in order to secure a high degree of organizational fit, promote efficiency and reduce control and conflict resolution costs	Selection is important but organizational fit is not the priority. A certain amount of diversity and non-complementarity is required to generate new knowledge. Criteria that express 'potential' are preferred to criteria based on past performance
Commitment to supplier and information exchange	High degree of commitment at the organizational level, that leads to high relation specific investments and the creation of idiosyncratic relationship knowledge	Low degree of commitment at the organizational level but high at the individual level, which leads to high relational capital
Supplier's performance evaluation	Predominantly formal and structured, based on a check-list of different criteria	Mainly informal and unstructured. The overall assessment of the relationship prevails on evaluation of performance in specific areas
Role of the contract	The relationship is between 'organizations'. The contract plays a fundamental role in defining the operational rules and making the expectations of the parties explicit. It is used as a safeguard	The relationship is between 'people'. The contract is relatively unimportant, whereas trust-based personal relationships are key elements
Conflict resolution	Heavily engineered integrative conflict management. Going back to the contract as the basis of re-negotiation is the norm	Informal integrative conflict management. Relational capital is the fundamental mechanism. The contract is typically 'left aside'

FIGURE 1. UK OPTICAL COMMUNICATIONS SYSTEMS INDUSTRY: SUPPLY-CHAIN (Sources: Frost and Sullivan, 1992)

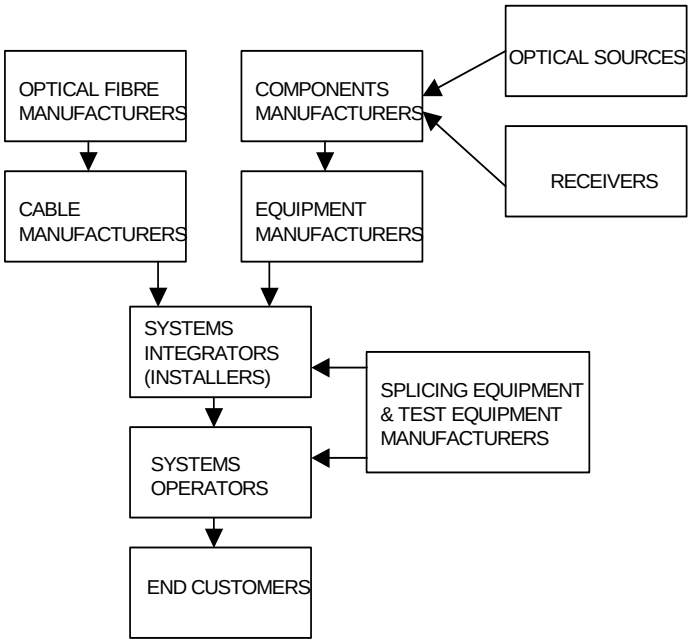


FIGURE 2. MATRIX: STRATEGY-POSITION

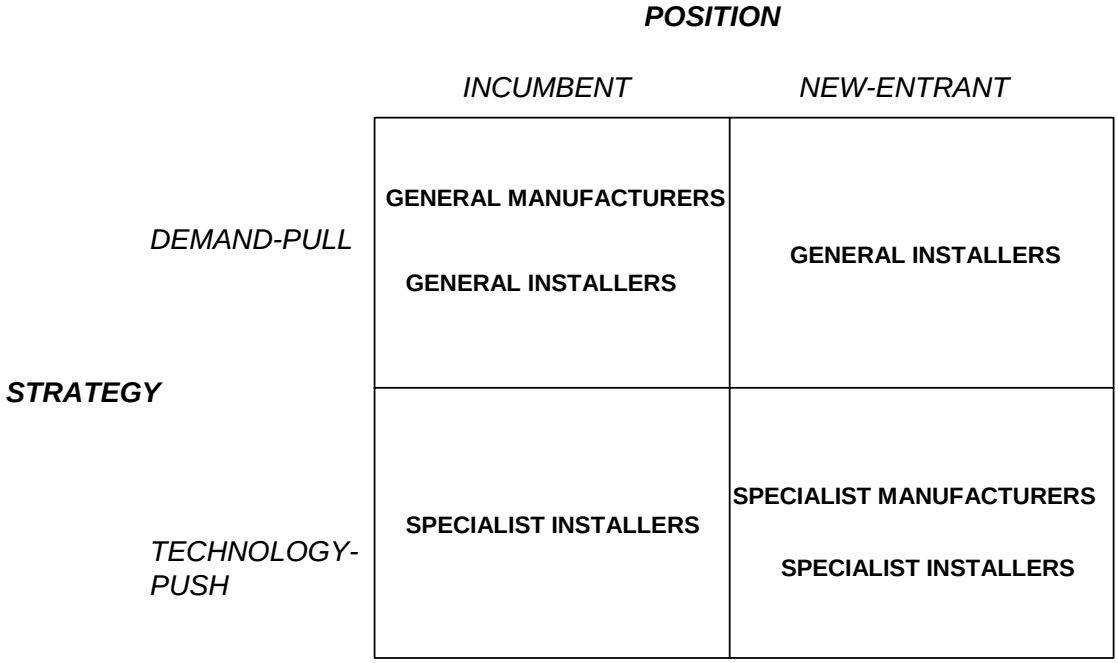
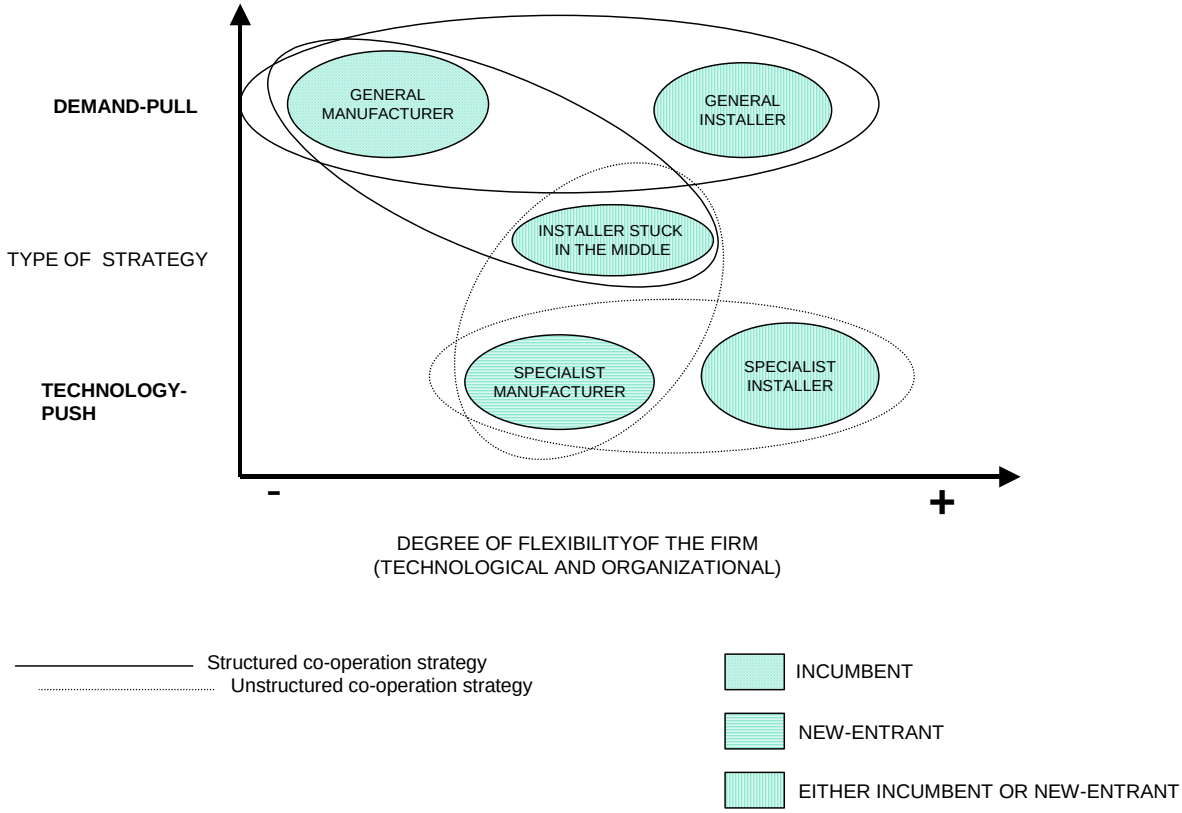


FIGURE 3. Co-operative strategies in the UK optical communications systems industry: a generalization



References

[1] W. Abernathy and K. Clark, "Innovation: Mapping The Winds of Creative Destruction" *Research Policy*, 3-22 (1985); Tushman, M. and P. Anderson, "Technological Discontinuities and Organization Environment", *Administrative Science Quarterly*, 31: 439-465, (1986); Tushman, M., Newman W. and E. Romanelli, "Convergence and Upheaval: Managing the Unsteady Pace of Organizational Evolution", *California Management Review*, 29/1: 29-44, (1986); C. Baden-Fuller and J.M. Stopford, *Rejuvenating the Mature Business. The Competitive Challenge*, London: Routledge (1992).
[2] C. Christensen, "The Rigid Disk Drive Industry: A History of Commercial and Technological Turbulence", *Business History* Review, (1993); C. Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, Boston MA: Harvard Business School Press (1997); W. Mitchell, "Are More Good Things Better, or Will Technical and Market Capabilities Conflict When a Firm Expands?" *Industrial and Corporate Change*, 1: 119-142, (1992); P. Patel and K. Pavitt, "The Technological Competencies of the World's Largest Firms: Complex and Path-dependent, but Not Much Variety", *Research Policy*, 2: 141-156, (1997).
[3] F.T. Rothaermel, "Technological Discontinuities and The Nature of Competition", *Technology Analysis & Strategic Management*, 12: 149-160 (2000); F.T. Rothaermel, "Incumbent's Advantage Through Exploiting Complementary Assets Via Interfirm Cooperation", *Strategic Management Journal*, 22: 687-699, (2001).
[4] D.J. Teece, "Toward and Economic Theory of the Multiproduct Firms", *Journal of Economic Behaviour and Organization*, 3/1: 39-63, (1982); D.J. Teece, "Profiting from Technological Innovation", *Research Policy*, 15: 285-306, (1986).
[5] C. Christensen, (1993) op. cit. Ref. 2; R. Henderson and K. Clark, "Architectural Innovation: The Reconfiguration of Existing Systems and the Failure of Established Firms", *Administrative Science* Quarterly, 9-30, (1990); D.J. Teece (1986) op. cit. Ref. 4.
[6] C. Christensen (1993) op.cit. Ref. 2.
[7] F. Rothaermel (2000) op. Cit. Ref. 3.
[8] F. Rothaermel (2000) op. Cit. Ref. 3.
[9] F. Rothaermel (2001) op. Cit. Ref. 3.
[10] C. Freeman, *The Economics of Industrial Innovation* (2nd ed.) London: Frances Pinter, (1982); J. Langrish *et al*., *Wealth from* Knowledge, Macmillan, (1972).
[11] H. Volberda, *Building the Flexible Firm*: *How to Remain Competitive*, Oxford, UK: Oxford University Press (1998).
[12] C. Freeman (1982) op. cit. Ref. 10; N. Rosenberg, *Perspectives on Technology*, Cambridge University Press, (1976).
[13] D.J. Teece (1982, 1986) op. cit. Ref. 4; J.A. Schumpeter, *Capitalism, Socialism, and Democracy*, Harper, New York, (1942).
1942
[14] R. Henderson and K. Clark (1990) op. cit. Ref. 5.
[15] W. Mitchell (1992) op. cit. Ref. 2; K. Pavitt, "Technologies, Products, and Organization in the Innovating Firm: What Adam Smith Tells Us and Joseph Schumpeter Doesn't", *Industrial and Corporate Change*, 7: 433-452, (1998); F. Rothaermel (2000, 2001) op. cit. Ref. 3.
[16] F. Rothaermel (2000, 2001) op. cit. Ref. 3.
[17] C. Christensen (1993) op. cit. Ref. 2.

[18] H. Aldrich, *Organizations Evolving*, London: Sage Publications (1999); E. Penrose, *The Theory of the Growth of the Firm*, New York: Oxford University Press (1959); M.A. Peterlaf, "The Cornerstones of Competitive Advantage: A Resource-Based View" *Strategic Management Journal*, 14: 179-192, (1993); B. Wernerfelt, "A Resource-Based View of the Firm" *Strategic Management Journal*, 5/2: 171-180, (1984); J. Williams, "How Sustainable Is Your Competitive Advantage?" *California Management Review*, Spring (1992).
[19] S.L. Lippman and R.P. Rumelt, "Uncertain Imitability: An Analysis of Interfirm Differences in Efficiency Under Competition" *Bell Journal of Economics*, 13/2: 418-438, (1982); R.P. Rumelt, "Toward a Strategic Theory of the Firm" in R. Lamb (ed.) *Competitive Strategic Management*. Englewood Cliffs, NJ: Prentice-Hall, (1984).
[20] D. Leonard-Barton, "Core Capabilities and Core Rigidities", *Strategic Management Journal*, Special Issue: Summer, 111-126, (1992).
[21] R.M. Grant, *Contemporary Strategic Analysis.* MA: Blackwell Publishers Grant, p.127, (1998).
[22] J.H. Dyer and H. Singh, "The Relational View: Cooperative Strategy and Sources of Interorganizational Competitive Advantage" *Academy of Management Review*, 23: 660-679, (1998).
[23] For a comprehensive review and analysis of Co-operative strategies see J. Child and D. Faulkner, *Strategies of Co-operation*, Oxford University Press, (1998).
[24] K. Miyazaki, *Building Competences in The Firm: Lessons from Japanese and European Optoelectronics*, London: Macmillan, p. 50, (1994); Charin, A.H. (1983) *Introduction to Optical Fibers*. New York: McGraw Hill.
[25] The Economist, February 5th 2001
[26] Various sources – mainly industry reports and press articles – confirm this analysis. See, for example, Frost and Sullivan Inc. Publishers, *The European Market for Fibre-Optic Communications Components* (1992) and The Economist (February 5th, 2001).
[27] H. Itami and T. Rohel (eds.) *Mobilizing Invisible Assets.* New York: Harvard University Press (1987).
[28] For the purposes of this study, incumbents are defined as firms that, quite independently from their current technological focus, operated in communications systems before the emergence of fibre-optics. Conversely, new-entrants are firms that have no past experience of communications systems exclusively based on copper technology.
[29] J. Brown and C. Hendry (1998) "Industrial Districts and Supply-Chains as Vehicles for Managerial and Organizational Learning" *International Studies of Management and Organization*, 27 (4): 127-157 (1998).
[30] F. Rothaermel (2000) op. cit. Ref. 3.
[31] See, among others, R. Dore, "Goodwill and The Spirit of Capitalism", *British Journal of Sociology*, 34, pp. 459-482; Dyer, J.H. (1996). "Specialized Supplier Networks as A Source of Competitive Advantage: Evidence from the Auto Industry", *Strategic Management Journal*, 17, pp. 271-291, (1983); J. Dyer, "Effective Inter-firm Collaboration: How Firms Minimise Transaction Costs and Maximise Transaction Value", *Strategic Management Journal*, 18/7, pp. 535-556, (1997); S. Helper, "An Exit-Voice Analysis of Supplier Relations - The Case of the United States Automobile Industry", in Grabher, G. (ed.), pp. 141-160. *The Embedded Firm. On The Socioeconomics of Industrial Networks.* London and New York: Routledge (1991); W.G. Ouchi, "Markets, Bureaucracies, and Clans", *Administrative Science Quarterly*, 25, pp. 121-141, (1980); W. Powell, "Hybrid Organizational Arrangements", *California Management Review*, 30, pp. 67-87, (1987); P. Ring, P. and A.H. van de Ven, "Structuring Co-operative Relationships between Organizations", *Strategic Management Journal*, 13, pp. 483-498, (1992); M. Sako, *Prices, Quality, and Trust Inter-firm relations in*

Britain and Japan. Cambridge, MA: Cambridge University Press (1992); H.B. Thorelli, "Networks: Between Markets and Hierarchies", *Strategic Management Journal*, 7, pp. 37-51, (1986); B. Uzzi, "Social Structure and Competition in Interfirm Networks: The Paradox of Embeddedness", *Administrative Science Quarterly*, 42, pp. 35-67, (1997); O.E. Williamson, *The Economic Institutions of Capitalism. Firms, Markets, Relational Contracting.* New York: Free Press (1985).

[32] Moreover, there is evidence that co-operative strategies are not confined to this critical level of the industry supply-chain, but spread downwards - between manufacturers and their suppliers - and upwards - between installers and end-customers.

[33] F. Rothaermel (2000, 2001) op. cit. Ref. 3; C. Christensen (1993, 1997) op. cit. Ref. 2.

[34] M.E. Porter, *Competitive Advantage: Creating and Sustaining Superior Performance.* New York: Free Press (1985).

[35] W. Mitchell and K. Singh, "Survival of Businesses Using Collaborative Relationships to Commercialize Complex Goods" *Strategic Management Journal* 17/3: 169-195, (1996); K. Pavitt (1998) op. cit. Ref. 15; F. Rothaermel (2000, 2001) op. cit. Ref. 3.

[36] B. Kogut, Walker G. and K. Dong-Jae "Cooperation and Entry Induction as an Extension of Technological Rivalry", *Research Policy*, 24: 77-95 (1995); G. Pisano, "The Governance of Innovation: Vertical Integration and Collaborative Arrangements in the Biotechnology Industry" *Research Policy*, 20: 237-249 (1991); T.E.Stuart, H. Hoang and R.C.Hybels, "Interorganizational Endorsementa and the Performance of Entrepreneurial Ventures", *Administrative Science* Quarterly, 44: 315-349 (1999).

[37] C. Christensen (1993) op. cit. Ref. 2; F. Rothaermel (2000, 2001) op. cit. Ref. 3.

[38] C. Christensen (1993) op. cit. Ref. 2.

[39] For example, by improving their capacity to absorb new external knowledge (see F.A.J. van de Bosch, H. Volberda and M. de Boer, "Coevolution of Firm Absorptive Capacity and Knowledge Environment: Organizational Forms and Combinative Capabilities" *Organization Science*, 10/5: 551-568, 1999).

Publications in the Report Series Research* in Management

ERIM Research Program: "Strategy and Entrepreneurship"

2002

Entrepreneurial Activity, self-perception and gender
Ingrid Verheul, Lorraine Uhlaner & A.R. Thurik
ERS-2002-03-STR

Gibrat's Law: Are the Services different?
D.B. Audretsch, L. Klomp & A.R. Thurik
ERS-2002-04-STR

Post-Materialism as a Cultural Factor Influencing Entrepreneurial Activity across Nations
Lorraine M. Uhlaner, Roy Thurik, Jan Hutjes
ERS-2002-62-STR

Value Creation and Value Claiming in Make-Or-Buy Decisions: Evidence from the Application Service Industry
Ernst Verwaal, Willem Verbeke, Harry R. Commandeur
ERS-2002-90-STR

Inter-Firm Co-operative Strategies in the Context of Discontinuous Technological Change, The Case of the UK Optical Communications Systems Industry
Simona Spedale
ERS-2002-112-STR

---

* A complete overview of the ERIM Report Series Research in Management:
http://www.ers.erim.eur.nl

ERIM Research Programs:
LIS Business Processes, Logistics and Information Systems
ORG Organizing for Performance
MKT Marketing
F&A Finance and Accounting
STR Strategy and Entrepreneurship