Why do firms change?

The role of business models, sequences of opportunities and changes of capabilities in bioscience firms'

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Why do Firms Change? The Role of Business Models, Sequences of Opportunities and Changes of Capabilities in Bioscience Firms

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Extended abstract

Our paper sets out to explain why bioscience firms change. We analyses the development of three bioscience firms and explains these firms by focusing on the relationship between the changes and experimentation of business models and the capabilities that firms develop over time. In particular we emphasize why capabilities are sustained, created or acquired. Theoretically we focus on events where the nature of the entire logic of the business model has changed as these firms act upon different opportunities over time.

We show that only by combining the initial technological and scientific capability with a more generic business capability, these firms were able to fully develop and pursue the initial opportunity. Our succeeding analysis of the three case firms also reveal that the linkages between the initial capabilities that these companies develop are only indirectly related to subsequent opportunities acted upon. As the initial opportunity increasingly becomes economically (or technologically) irrelevant, the more recently acquired generic capabilities provided the firms with the ability to act upon new opportunities. That is, the initial capability of the firm is not directly linked to the second opportunity, as these initial capabilities generally are very scientifically and technologically based and hence rather specific. Instead the link is by the creation of an additional and separate, and indeed a more generic, capability within the firm. As these firms 'add' or terminate capabilities over time, they are hence continuously leveraging only parts of their accumulated capabilities, meaning that they are both path-dependent and path-breaking in development.

The paper argues that a firm-based analysis of the development of capabilities and business models is warranted as a complement to the numerous sector-level studies of the biosciences. The internalist perspective of the co-evolution of capabilities and business models developed here cannot be substituted by industry or environmental explanations.

1. Introduction

Development of new, innovative, knowledge based firms and entrepreneurship increasingly occupies a crucial point within the modern society. While there are many theories that are helpful in explaining endogenous and ongoing changes of firms; including opportunity discovery and entrepreneurial alertness, scale and scope in production and distribution, market dynamics, organizational learning and innovations (Kirzner 1973, 1997, Chandler 1990, Teece et al 2000), the development and change of new firms is rather poorly understood. However, two recent promising bodies of literature are the capability based view of the firm and the business model literature. The capability based view of the firm characterizes the firm as a set of interrelated and evolving organizational capabilities. This approach attempts to explicitly characterize and explain what a firm does and can do for a given period of time (Dosi et al 2002). The business model approach entails the logic of how a firm creates value for a customer and how the firm goes about to appropriate returns from this created value (Morris et al 2005). While still at a relatively early stage, both approaches have begun in earnest to focus on changes in firm activities, which we argue is absolutely fundamental to an internalist explanation and analysis of firms.

Unfortunately, the capability literature does not directly deal with how firms act to create value or how capabilities are created, acquired or terminated. This is a serious problem in the sense that this is a core issue to be able to explain how a firm attempts to change and how well a firm manages to handle its changes. In a similar manner, very little is known why and how firms change their business models from the perspective of what they draw upon to do so and what they can do within certain resource and time constraints (Morris et al 2005). Interestingly, these two concepts are complementary in that one addresses the issue what a firm is able to do while the other addresses the issue of value creation. Thus, this paper suggests that a fruitful way is to analyse and explain changes within firms is to analyze them from the combined perspective of its business models and the change of its capabilities. Such an approach to analyse and explain the development of the firm will hence emphasize the co-evolution and interdependence between the development of capabilities and business models.

Consequently, this paper argues that the development of a firm should be explicitly understood in relation to how a firm can create and appropriate value in relation to its capabilities. Thus, by focusing upon the link between changes within business models and the development and accumulation of capabilities within firms our intention is not only to emphasize that such changes co-evolve, but that this co-evolution is frequently an outcome of the activities performed within these firms rather than just determined by factors outside the firm.

Our empirical focus is upon firms within the biotechnology industry. Biotechnology, besides ICT, has been described as one of the emerging general purpose technologies spurring future economic growth. From a societal perspective, the obsession with bioscience firms relates back to the huge public resources invested, the rising healthcare costs, and the potential to establish a local knowledge intensive industry. The development of bioscience firms can also be said to represent an extreme version of knowledge intensive firms which increasingly occupy a central position in the modern economy. A central tenet of the bioscience firm is that it tends to be of small size as well as a research and knowledge intensive venture compared to firms in other sectors. Perhaps the most distinguishing factor is the forward looking nature of the bioscience firm; at the time of market entry the firm generally lacks a and a long time may pass before it is able to (if ever) to earn returns on its investments. In this way, being an extreme case of a firm it can work as an empirical and theoretical contrast to large firms and small firms in other sectors. Thus, it is not difficult to understand why the activities of firms in biosciences have attracted so much attention. Recognizing theses issues, during the last three decades there has been a huge amount of conceptual, theoretical and empirical studies on both biotechnology as technology, on the emergence of bioscience firms and the structure of the industry. Indeed, while there are many studies that empirically analyse the emergence and development of biosciences on the sectoral level, there is strangely enough a distinct lack of studies that theoretically analyse the activities and changes within the individual firms. There are just a handful of studies of detailed developments of bioscience firms from a dynamic perspective (McKelvey 1996, Dodgson 1991). Yet, even a cursory look at public documents and industry discussions show that these firms tend to change quite drastically over time. This paper therefore argues that the change in what bioscience firms actually do is a largely overlooked empirical phenomenon that warrants

attention from a theoretical perspective to fully understand the resulting dynamics within the bioscience industry. Thus, the purpose of the paper is to demonstrate that many bioscience firms do change after their formation and explain how and why they change. Consequently, the paper will address empirically grounded research questions in order to explain how and why bioscience firms develop and change from a capabilities and business model perspective.

The paper is structured in the following way. Section 2 reviews the literature on business models, capabilities and opportunities and links these to the creation and appropriation of economic value. The section also outlines the relation between the three notions. Section 3 outlines the methodology of the paper and derives four distinct research questions. Section 4 presents the three case studies while Section 5 compares the three cases in relation to the four research questions. The final section draws some conclusions.

2. Literature

This section reviews the three notions business models, capabilities and opportunities. The aim is to capture the relation among the three notions in order to capture what these notions taken together explain firm changes. Thus, we firstly analyze and explain what a firm does and how it changes by focusing on the relationship among business models and opportunities. Then we go on to explain what capabilities are and how they relate to which opportunities the firm act upon and how they do it. Finally, we characterize the relationship between the business model and the capabilities of the firm.

The business model has been proposed as a theoretical framework that analyse the logic of the activities of a firm. There is however not yet a generally accepted definition of business models but scholars do agree that the business model at its most basic contains the issues of how a firm creates value, the internal source of the firm's advantage, and how the firm will make money (Morris et al 2005)[1]. The business model literature hence draws upon central ideas in business strategy research (Chesbrough and Rosenbloom 2002, Morris et al 2005), including the value chain and the value systems concepts (Porter 1985, 1996). Yet, the business model concept differ from strategy in that it does not deal with competition among different actors (firms) but only focus on how different aspects and activities of a business fit together in relation to bringing value to a customer. As such, the business model of a firm can be understood as a more concrete and detailed specification and choices of the firm in relation to the value creation and appropriation of an opportunity that a firm identifies and acts upon[2]. A way to analyse the activities of the firm is hence to characterize the constituent features of the business model. That is, the business model takes technical characteristics as inputs and converts them through customers and markets into economic outputs, and thereby connects technical potential with the realization of economic value (Chesbrough and Rosenbloom, 2002).

[1] A business model is a concise representation of how an interrelated set of decision variables in the areas of venture strategy, architecture and economics are addressed to create sustainable competitive advantage in defined markets (Morris et al 2005)

[2] Hence, the business model can be understood to be an answer to the Peter Drucker's questions "Who is the customer? And what does the customer value? … How do we make money in this business? What is the underlying economic logic that explains how we can deliver value to customers at an appropriate cost?" (Magretta, 2002, p. 4).

Central to the business model is how value is created for the customer and how the innovating firm appropriate economic value. From a dynamic and forward looking aspect value creation and appropriation is what the firm attempts to achieve. Value is a subjective notion that relates to the perceived wants or needs of a user and is thus here defined from the user(s) perspective (Menger 1871, Lepak et al 2007). The relationship between value and appropriation can be derived in the sense that a producer tries to appropriate or realize as much of the use value during the exchange of the ownership. This value is referred to as exchange value. The activities of the firm is thus to participate in forward looking value creation activities under uncertainty, and to appropriate and capture a part of the forthcoming value. The potential to appropriate such use value systematically differs between different technologies and activities (Levin et al 1995). The business model of the firm is further on neither naturally given nor static. For example, when firms improve their products the value for the firm of the new technology remains latent until it is commercialized. Sometimes a firm can successfully employ a business model to a new technology already familiar to it, but at other times the firm has to find a new business model in order to capture value from a technology. Failure to find an appropriate business model will cause the firm to yield less value than what might otherwise occur, this failure may even cause the firm to withdraw from its commitment or from the market altogether (Chesbrough and Rosenbloom, 2002).

While there is still a limited amount of work on how business models change, the business model can be viewed as a dynamic concept in the sense that it is to capture how managers, try our or experiment with an idea or hypothesis of an viable business, which then is tested and revised by entrepreneurial action (Murray and Tripsas 2004, Magretta 2002, Sanz-Velasco 2007). The business model of the firm thus evolves by adaptations to the feedback from the external environment in which the firm is active. This feedback can be very concrete and detailed in the sense that a particular product may benefit from an additional service, or the costs of manufacturing is too high relative to the price or there may be a need to change the distribution channels to reach other potential customers that are more likely to value the offerings of the firm. Hence, the business model does not need to be fully developed before it is tried out in relation to potential customers. A gradual change of business models thus aims to find

a better strategic ‘fit’ of the firm to its environment (Gavetti and Levinthal 2000). Strangely enough, very little is known why (and how) firms (radically) change their business models (Morris et al 2005). The answer may be trivial in that an existing business model does not work, for example in the sense that an existing business model has flawed assumptions of user preferences, which warrants the creation of a new model. From this it seems evident that core features of changes in business models include different forms of innovations, changes in economic value, and changes in appropriation or revenue models. A change in the business model thus includes the activities from making something to reaching customers, distributing the products, designing the revenue model and so on (Amit and Zott, 2001; Chesbrough and Rosenbloom, 2002; Magretta, 2002; Markides and Charitou, 2004; Morris et al., 2005). This suggests that to identify changes in business models should be a suitable way to analyse how firms change and experiment in order to reveal and verify their hypotheses of opportunities.

The business model of the firm is hence closely related to the opportunities that a firm subjectively identifies, discovers or acts upon. The business model outlines what a firm does, in terms of choices made, motivations and the set of activities undertaken while an opportunity outlines both what a firm perceives as feasible and what future businesses it may act upon. This means that some opportunities that a firm perceives and acts upon can result in a new business model for that firm. At any one time, it is quite likely that the firm has at most one or a couple of business models. However, the firm may very well imagine and perceive a multitude of opportunities. Still, as the firm is characterized by scarce resources in terms of knowledge, skills, time and money, it cannot and do not act upon all of these. The ‘amount’ of opportunities that the firm acts upon should hence be lower than the amount it perceives (Moran and Ghoshal 1999). In a similar vein, the amount of opportunities that result in successful business models tends to be smaller than the amount of opportunities it acts upon.

In this manner we can conceptualize changes in a business model is to focus on the role of innovative opportunities that a firm identifies and acts upon over time as these are linked to the perception of how a firm can create and appropriate value (Holmén et al 2007). A new and tentative opportunity that a firm perceives acts upon may not yet be described in terms of a fully developed business model, but it may have many of

the core ideas from which a business model may form in place. This stresses the difference over time in terms of the nature of the opportunities that the firm acts upon. Importantly, a change of a business model can be caused by great differences from one opportunity to another as well as adaptations toward an increasing 'fit' towards the perceived opportunities. An essential issue regarding the development of the business model is thus the amount of change within the degree and simultaneity of parameter manipulation (Murray and Tripsas 2004). The greater the degree and the larger amount of simultaneous changes of the parameters of the business model, the more radical the change there is in the perceived opportunities. In a similar manner we characterize incremental business model changes as consisting of relatively small changes in one or a few parameters and often over larger periods of time. A radically changed business model has hence been changed in several parameters simultaneously or over a reasonably short time span.

Our second aspect in order to explain changes of the firm is by looking at the firm as an historical accumulated bundle of activities (Penrose 1959). This Penrosian framework of the firm as bundles of resources has been further developed within the resources and capability based views of the firm. Treating the firm as composed of a bundle of capabilities has a long tradition within management and heterodox economic research. A similar definition of the firm was made by Richardson (1972), who defined the firm as based upon the organizational and internal co-ordination of similar activities, which he entitled capabilities. These capabilities of the firm are accordingly defined as the appropriate knowledge, experience and skills accumulated within the specific firm (Richardson 1972).[3] Within the capability view of the firm, the firm is thus not seen as a portfolio or nexus contacts between individuals and assets, but instead as the organizational structure and the managerial processes which support productive activity. The capabilities of the firm are hence referring to the social aspect of organization itself; facilitating the development, integration and sharing of knowledge for the different activities. Capabilities are hence rooted in the evolved social relationships resulting in an organizational advantage to undertake,

[3] Richardson (1972) says that when activities are complementary but dissimilar they generally are the responsibility of different firms and is accesses externally, and suggests that similar and complementary activities should be maintained within the firm to exploit its capabilities fully. These activities have to be undertaken by firms that have appropriate capabilities to do so under appropriate division of labour.

coordinate and cooperate between different activities (Nahapiet and Ghoshal 1998, Kogut and Zander 1992, Grant 1996). Richardson's original definition of capabilities points to the ability of the organization to perform similar activities. The leverage of capabilities thus mainly occurs across time, by repetition, but also within related and coherent diversification within the firm by replication[4]. Besides the intra-temporal advantages of capabilities there thus also exist inter-temporal advantages in which capabilities can be redeployed within similar activities over time (Helfat and Raubitschek 2000, Helfat and Eisenhardt 2004). This social aspect implies that the capabilities of the firm are not only determined by the contributions of individual constituents but from their systemic relationships (Black and Boal 1994, Spender 1996). The capabilities or organizational knowledge thus represent an integrative or architectural aspect of component knowledge (Henderson and Cockburn 1990, Kogut and Zander 1992). These relationships involves among other individual skills, technological equipment as well as external relations (Dosi, et al 2000). According to Siggelkow (2002) the capabilities of the firm can be seen as the specific configuration of the complex interdependencies of activities, policies, structural elements and resources. This definition of capabilities, as the systemic interaction of different entities also requires a definition of the individual entities within the firm. Leonard Barton (1995) and Drejer (2001) both defines these into four levels of human, technological, formal organizational such as management systems and finally informal organizational such as values and norms. The capabilities of the firm evolves over time, the knowledge of the firm thus gradually accumulates (Dierickx and Cool 1989). As the capabilities of a firm are organizationally embedded, they are also locally dependent and cannot rapidly be imitated or diffuse outside the special context in which they have evolved. These incremental developments thus result in a co-evolution of technologies, knowledge and organizations.

Besides treating capabilities as composed of complex interdependencies of individual entities, the firm as such can in turn be represented by a bundle of capabilities

[4] The application of capabilities to understand organizations within research-based activities might hence be of limited value (Nelson and Winter 1982). In a similar argumentation elaborated managerial strategy practices are of limited value for the firm active within very rapidly changing environments (Brown and Eisenhardt 1998). As a result, science-based firms are thus frequently depicted as rather temporarily *ad hoc* structures (Mintzberg xxx). Yet, it has been shown empirically that even research intensive firms do indeed to have long term, sustainable differences largely ascribed to the accumulation of firm specific capabilities (Henderson and Cockburn xxx).

(Siggelkow 2002). Accordingly such a bundle of capabilities evolve over time (Dosi et al 2000). As a result the firm is a historically and path-dependent entity of evolved capabilities which are distinct and responsible both for competitive development and growth. Within organizational research such interdependencies and relation between performances is a long standing tradition. However, the evolution of the firm as a system of and the resulting capabilities is less well developed. The specific combination of entities and their mutual evolution requires time in order to be associated and adapted towards each other. These historically evolved capabilities simultaneously imply a resistance for the firm to further change (Leonard-Barton 1995). Such disadvantages emerge out of the logic to leverage current complementary assets and capabilities (Christensen 1997). Disadvantages may also arise out of cognitive, with the failure to perceive new and dissimilar opportunities, as well as political reasons (Tripsas and Gavetti 2000). As a result, both out of the required times for the formation of organizational capabilities and of the relative inertia the capabilities of the firm can give rise to rather long lasting competitive differences between firms.

Regardless of the notion of capabilities as giving advantages and disadvantages, the capabilities of the firm gradually evolves over time. Capabilities are hence dynamic in that aspect that they are influenced by past choices, and follow a trajectory or path of competence development[5]. The current activities hence impose a bound on what the firms' internal repertoire is likely to be in the future. The dynamic aspect of capabilities thus involves more fundamental changes such as redeployment, renewal and recombination (Helfat and Peteraf 2003). A similar terminology developed by Siggelkow (2002) describes the development of organizational elements, capabilities, according to four different logics; thickening (increasing), patching (adding), coasting (maintaining) and trimming (deletion). These developments can in turn be managed more or less deliberately and relate to higher order organizational practices in which the capabilities of the firm are developed, a capability for capability development or what has elsewhere been called 'dynamic capabilities' (Teece et al 1997, Eisenhadt and Martin 2000). The dynamics of capabilities can hence be seen both as a deliberate

[5] The concept of 'dynamic capabilities' has been ascribed to capabilities to integrate and build and change otherwise static capabilities (Teece et al 1997). We do not make such distinction between lower or higher ordered capabilities. Any such reasoning would potentially end up in an infinitely regress (Collis 1994).

process in which effort is put toward the change thereof and as a result of an emergent process without attention in which the capabilities evolve. Within a hierarchal view of the dynamics of capabilities, in which higher order 'meta' capabilities operate upon lower level capabilities the ability of firms to change and alter the acquired capabilities could be found within areas such as new product development practices, decision-making and alliances (Eisenhardt and Martin 2000).

Unfortunately, the capability literature does not directly deal with how firms act to create value or how capabilities are formed de novo. Value creation as a phenomenon is almost ignored altogether in the sense that while it is a part of the underlying assumptions of the capability literature, this relation between capabilities and value creation is not explicitly dealt with. This stands in some contrast to early work upon which the capability literature draws, which explicitly stressed that strategic advantages of resources needs to be understood in relation to value creation and external environments (Amit and Shoemaker 1993). Value appropriation is more central to the capability literature as the socially evolved capability of the organization is one obvious isolating mechanism within the antecedent resource based literature (Mahoney and Pandian 1992). While there is little explicit work on the relation of capabilities with value creation and appropriation, it should not be controversial to argue that perhaps it would be a good idea to try to make the connections. To do this we need to combine the capability literature which focuses upon the internal aspects of the firm with the interaction with external opportunities.

Our second way to conceptualize how firm a change is hence to relate the capabilities of the firm with the opportunities the firm perceives and acts upon. According to Shane (2000) the perceived opportunities out of a set of opportunities are dependent upon prior knowledge. The capabilities of the firm, as partially composed of knowledge are hence important in affecting which opportunities the firm actually perceives. Further on, the set of capabilities in themselves may give rise to additional opportunities. For example, technological capabilities of firms can often be leveraged in several different applications (Granstrand et al 1997). The technological firm thus frequently knows more and has a greater extent/number of opportunities than it actually does act upon. According to the capability literature technological capabilities (or resources) are hence fungible and often underused (Danneels 2007). There is thus

a link between opportunities and capabilities as - according to Penrose (1959) - opportunities arise from possibilities to combine the internal resources of a firm in various ways. The resources of a company can accordingly be used and recombined in a multitude of ways, and different ways of deploying the resources render different results. The possible uses of such resources are limited by the ‘‘productive opportunity’’, as perceived by managers in the firm, especially their capacity to envision alternative modes of using the resources at hand (Penrose, 1959: 31–42, 111). Clearly, Penrose’s perspective on opportunities only gives a partial answer to how opportunities evolve over time by emphasizing existing internal resources and different possible reconfigurations of using these specific resources. We hence argue that this internalist view of internal learning and reconfiguration needs to be complemented by external opportunities that a firm perceives and act upon.

Finally we portray the relationship between the co-evolution of the capabilities and the business model of the firm. The capabilities of a firm are accordingly one central aspect that determines what the firm can do profitably (Morris et al 2005). This makes the composition of capabilities within the business model central for the firm in order to capture the forthcoming user value from its capabilities and through complementary capabilities or first mover advantages (Teece 1986, Montgomery 1989)[6]. The accumulated capabilities are thus valuable for the firm only in relation to the fit they have with their current or future business models. Radical changes of business models are hence depend upon the inherited capabilities available allowing it to be perceived and leveraged within the new opportunities On the other hand, radically changed business models are partially determined by the nature of the different opportunities and that the firms may develop suitable business models to appropriate upon on. The business model is hence not entirely determined but merely constrained by the inherited capabilities at hand. The accumulated knowledge and capabilities hence both give the potential to act and appropriate against pursued opportunities as well as the potential to cognitively perceive these opportunities. In the same way the business model adopted around an emerging opportunity does not

[6] Capabilities are hence valuable to the firm only if the firm is able to appropriate some of the value which external consumers ascribe to it. The inward looking nature of much of the RBV literature tends to take the external requirement of value of capabilities for granted, e.g that all capabilities in themselves are valuable.

need to be constrained around the ex-ante accumulated capabilities but may also depend upon the resources which the firm might mobilize.

3. Methodology

In order to study the changes of the firm and the linked build-up of internal capabilities we adopted a multiple case study research design. To obtain access these case studies were performed under the agreement of confidentiality. More precisely, our research process was conducted within four major stages:

First, the selection of case firms' were conducted in a structured process. Initially we identified a majority of all active biotechnology firms, industry associations and research universities and governmental initiatives such as technology parks in Australia and Sweden. This resulted in a significant number of potential case firms which broadly corresponds to the total number of active firms reported elsewhere in the industries (Vinnova 2001, Hopper and Thorburn 2001). To limit the identified population we selected all firms had a size of more than 20 employees and an operating history of more than 5 years. The final selection of the cases were based on theoretical sampling to cover at least one of (a) strategic alliances and collaborations, (b) IPR activities and (c) to include both public and private ownership. These issues were at the outset considered to be highly important to have an affect firm on development within this specific industry (Niosi 2003).

The second stage included archival research in order to reconstruct the historical evolution of each firm. Archival analysis included public information, patent data, trade press, scientific publications, reports and additional internal documents such as corporate presentations. To ensure against the potential problem of historical bias within retrospective interviews (Golden 1992) archival analysis were performed prior to the interviews.

The third stage involved semi structured interviews with each case firm. Two interviews per firm took place dealing with the history of the firms, why the firms were started, how and why the firms acted upon new opportunities and terminated older ones, and their capabilities over time. The interviews were performed in a two stage convergent interview approach in which the respondents initially had a large

degree of freedom while the interviewer increasingly structured the interview (Dick 1990). To ensure and increase validity, the interviews were hence triangulated against the pre-analyzed archival data. The top managers and/or original founders of the firms were interviewed regardless or not whether they were still worked with the company. The semi-structured interviews lasted 1.5– 2 hours, and were recorded and written down. The transcribed interviews resulted in approximately 200 pages.

The fourth stages involve the initial analysis of independent case and eventual revision. These raw data documents were coded into major events and were double checked against other sources and clarified with the firms (Miles and Huberman 1984). In order to reconcile the emergent evidence across the cases and types of data, and between existing literature and theory, the paper proposes a new theoretical contribution. This is achieved by triangulating different data sources (Jick 1979) and undertaking an iterative process between theory and evidence, starting from a loose set of ideas and frameworks from the existing theory. Accordingly we followed an iterative grounded theory approach which combined a theoretical pre-understanding with an exploratory logic (Straus and Corbin 1998, Orton 1997).

To answer the purpose, we need to analyse the co-evolution of the capabilities that the bioscience firms develop, and changes in the firms' business models. Thus, we derive four research questions. The questions are:

(a) What capabilities do companies add to develop and appropriate value based on the initial opportunity?
(b) Why the firms added a distinctly different capability within their business model while pursuing their initial opportunity?
(c) What characterizes the relationship between the different opportunities that bioscience firms act upon over time, the developed set of accumulated capabilities and the radical shifts in business models?
(d) Why are not the initial capabilities further developed within the firm?

The four issues which we focus upon within this paper will thus refer to a distinction of the firm according to a separation between pre- and post- the radically changed business model in order to explain the co-evolution of business models and capability

developments (see Tab 3.1). These four questions are not independent. The first question was formulated prior to the empirical research. The subsequent questions were formulated following the answer to previous questions and are hence empirically grounded. In particular, the second question is phrased in relation - "distinctly different" - to the answer given by the first one. In the same manner, the fourth question - "…further developed" - is phrased in relation to the answer to the third question.

Our first and third question regards the composition, the set, of capabilities which the firm maintains in order to act within the specific chosen business model. These two questions are thus empirical questions. The second and the forth questions are more explanatory in kind. These questions focus upon the motivations and reasons for the resulting composition of capabilities maintained by the firm before and after the radically changed business model. These two questions thus warrants some further theoretical considerations in order to derive theoretical propositions.

Table 3.1 Research focus upon pre- and post- radical change of business models

Focal period	What and how?	Why?
Before the radically changed business model.	1 What capabilities do companies add to develop and appropriate value based on the initial opportunity?	2 Why did these firms add a distinctly different capability within their business model while pursuing their initial opportunity?
After the radically changed business model.	3 What characterizes the relationship between the opportunities that bioscience firms act upon, the developed set of accumulated capabilities and the radical shifts in business models?	4 Why are not the initial capabilities further developed?

We based our analysis on the operationalization of concepts according to a number of constructs (see Tab. 3.2). These were in later stages used in order to map the interactions and sequence the development of the studied bioscience firms.

Table 3.2 Operationalization of concepts

Concept definition	**Concept cluster**	**Key references**	**Construct (empirical proxies)**
Capability	Resources,	Grant (1991), Helfat	Human, physical/

	competencies	and Peteraf (2003)	technological, organizational systems Organizational values.
Set of capabilities	Interaction, reciprocal, combinations	Penrose (1959), Siggelkow (2002)	Organizational systems
Business model	Appropriability	Morris et al (2005), Magretta (2002)	Value offer, costs
Opportunities	-	Shane (2000)	Stated opportunities, initiated projects

The case study based research design has been deemed as a suitable research method to further develop the understanding of resources and capability development within firms (Rouse and Daellenbach 1999,). Our focus upon firm evolution also implies a time dependent research design in order to capture the developments of firm level capabilities and business models. In order to capture such changes we performed a historical and retro perspective study (Pettigrew 1990; Langley 1999). As technology and firm development within the biotechnology industry generally has long cycles (10-15 years) this makes the alternative approach, ethnographical studies, extremely long and costly. Case studies are generally considered to be superior for creating an understanding of empirical phenomena and for generating novel theory (Eisenhardt, 1989). However, single case studies are inherently limited in terms of their generalizability (Yin, 1994). A proper selection of a moderate number of multiple cases will balance the trade-off between detailed single case studies and increase the theoretical gains from inclusion of several additional cases by theoretical sampling. Our multiple case study design hence based the final number of cases upon theoretical saturation rather than statistical (Eisenhardt 1989)[7]. Our final research design hence included the combination of interviews and historical archival studies for a low number of multiple case studies with the aim of being complementary and additive rather than by statistical replication for generating our derived conclusions. Essential for the case study approach is to increase transparency in research methods and possibilities for replicate studies and analysis (Yin 1989). To increase validity and reliability within case study based research we followed the suggestions of Cepeda and Martin (2005), (see Tab.3.3). We obtained increased construct validity by using triangulation of data and independent analysis of multiple researchers. We increased the internal validity through the usage of pattern matching and color coded our

[7] The theoretical sampling to maximize variety within the research design resulted in initial 8 case firms, which where identified based upon pair-wise characteristics representing important events and different development strategies. Of these 8 firms we will here show and analyze 3.

categorization during the analysis across the different cases. To obtain external validity towards the biotechnology industry we used multiple case studies. To ensure high reliability during our research process we used interview protocols and constructed a database out of the full interview transcriptions and archival analysis.

Table 3.3. Research design

Construct validity	**Internal validity**	**External validity**	**Reliability**
Multiple sources: triangulation of archival data, and multiple informants and interviews	Pattern matching & Chain of evidence	Replicate studies, 8 cases	Use of research protocols (semi-structured, open ended questions included 'anything else' questions)
Informant feedback: Review of cases	Categorization, constructs (empirical proxies)*		Use of primary data sources
Multiple researchers: Initial individual analysis	Inclusion of eventual rival explanations		Database construction including, narratives

*Refer to Table 3.2.

The most severe limitation of the study is its internalist perspective. The fact that the initial opportunities terminated for the selected firms cannot just be understood from the firms but needs to be understood from a broader competitive and institutional landscape. Still, we argue that the internalist focus on business models and capabilities do contribute to our understanding of firm dynamics. Any generalization from case studies must be made based upon analogies, similarities and differences rather than from a statistical interference. As an outcome of explorative research design these findings was initially not focused upon changes and developments within business models. The selection of the companies was further on not made to look for radical changes in the nature of opportunities that they pursued nor upon any radical changes in business models. However, because of the limited number of firms analyzed, this paper should be seen only as a start on the under-researched role of radical changes in firms' business models. Another bias is caused by the geographical location of the case firms in geographically remote countries with a relatively small local industrial sector. However this selection bias is not likely to limit the validity of the studies as the companies are all largely internationally active.

4. Case studies

4.1 Alpha

At the time of its foundation, Alpha had a classical pharmaceutical business model. Over time, the venture runs into a financial crisis. This radically changed the business model of Alpha which is transformed into a technology platform and service provider. After this major transformation of the business model Alpha instead serves as a partner in which research products towards a broad area of applications are developed. After a further refinement and adaptation of the business model Alpha finally prosper.

The story of Alpha starts 2000 with a group of senior researchers who are turned down in their application for a joint research proposal with a firm. The group instead turns to a local venture capitalist to finance their planned research activities which is deemed to have some commercial potential. The result is the formation of a research firm, Alpha, which is formed around patent rights which had emerged out of the founders' antecedent academic research. Their vision is to develop biologically based therapeutics, stem cells, and the initial focus is to increase the scale of their production of biological agents for therapeutically applications. To develop the firm, Alpha recruits a CEO with experience from managing a start-up biotechnology company. A small group of scientists are rapidly recruited to the firm and placed under the auspices of the initial academic researchers to learn the practices involved and to further develop the commercial production of the biological therapeutics. The different senior academic scientists and their research groups are active within different biomedical fields, and only united by the potential for further therapeutic applications within the emerging technological area of stem cells. As a consequence Alpha does not target any particular disease and does not have a focus in its operations. After the first year of basic research within the scaling up of biological production, an intermediate goal is set in which Alpha is to focus upon the development of therapeutics towards a particular disease area but still maintain several different research trajectories open for development. Alpha rapidly expands to approximately 20 employees, but remains organizationally distributed and co-located at the different original academic research groups. Yet, after the decision to focus upon a specific therapeutical application the firm increases its independence from the original senior scientists. Alpha has now developed a distinct business model working

towards the major revenues from the therapeutic application within this particular disease area.

Alpha has hence during the first year trained a number of researchers within the techniques originally developed within the public universities. The generated business model, to develop a block buster therapeutics, requires additional financing and new recruitments. First, the CEO intensifies the search for additional funding. Second, Alpha enters a number of joint research collaborations. As a direct result, a diverse set of research relationships together with both public and private actors, towards different disease applications are entered. These research collaborations both provide opportunities to access and develop new technologies but also contributes to small revenues in terms of access to public research grants. As the amount of research work, in terms of research agreements and internal projects increases, a group of project managers with experience from the pharmaceutical industry are recruited. As a consequence, Alpha maintains its focus upon the therapeutic business model but at the same time develops a general capability of working with the commercial production of biological substances. This capability is based upon the accumulated skills, specialized procedures and new technologies for the initial scale up of the biologics. In addition, Alpha gradually has created a very diverse network of different relationships, including the original university based research groups of the initial scientist.

Due to the problems of the need for additional financing the CEO of Alpha gradually realizes the difficulties to raise capital from new investors towards the therapeutic block-buster idea. The investors consider the initial timeframes to be too optimistic, uncertain and costly because of unclear legal aspects of biological therapeutics. Thus, Alpha is forced to cut cost and come up with a more lucrative proposal. In order to save money several tracks of potential further research directions within several different therapeutical applications are discontinued. At this financing crisis, the CEO as well as the owners serious questions Alphas future existence. The financing crisis result in a radical shift in the business model, see Table 4.1. Alpha changes from the therapeutical approach focused upon the development of a proprietary therapeutic product towards a business model built around the development and usage of the biological substance as a research tool. This radically altered business model hence

focuses on the application of the biologics within several research projects and was itself originally a side track that emerged out of one of the early external research collaborations. As an outcome of the changed business model Alpha further reduces the relationship between the more therapeutically oriented university-based research groups, including most of the founding senior scientists. Further on, Alpha relocates the university-based employees to a new site in which all employees are co-located and changes the name of the firm. Finally, reflecting the changed business model a new CEO is hired with extensive experience in marketing and business development, while the previous CEO take over the responsibility of scientific development.

Table 4.1. The business model and capabilities of Alpha

Time	Business model	Essential Capabilities	De emphasized capabilities	Emerging capabilities
T1	Undefined	A wide spectrum of different biological research areas towards broad therapeutic applications		Recruitment of several employees with pharmaceutical research experiences
T2	Block buster within heart diseases	Research capabilities within biological scale-up and production. Research capabilities within heart diseases	Research towards several of the original therapeutic applications are de-emphasized	Developed financial capabilities to finance tong term project.
T3	*Radically changed towards a research platform*	Scale-up and production of biologics	Deemphasizes the original university relationships.	
T4	Services enabling-research approach	Production of biologics. Appropriating form joint research.		Intellectual property and research contract negotiation

Later, a gradual change of the new business model is later forced upon Alpha. The radically new business model consisting of the provision of biologics to use as a simple tools within biologic research does not really work. One particular reason is the legal complications of selling the biological derived substances, this impose restrictions in the ability to actually privatise and appropriate upon the provision of cells for use in further commercial research by external parties. Another is that there is a gradually realized need to further develop specialized procedures around the ability to fully handle and use the rather advance biological technology within the specific research projects. Alpha thus increasingly emphasises a service based business model trying to gain value out of support for the idiosyncratic research activities, by such

offers such as training and education practices, including providing documentation as well as the research products themselves. The final business model of Alpha hence includes the biological artefacts (the cells), services, as well as additional consumables and specialized techniques for research activities (such as a special kits and antibodies). Forced by these changes in the business model, to appropriate from the individual research agreements and collaborations, Alpha expands the competencies within intellectual properties and contract development. Finally Alpha further develops its internal competence within the large scale production of the basic biological substances, the cells.

4.2 Beta

Beta has undergone three radical changes in its business model by first moving from contract research manufacturing to protein and research kit production to become a full fledged pharmaceutical development company.

Beta was founded when a group of private investors bought a bankrupt firm that had produced basic pharmaceutical agents. The idea was to turn the organization and facilities into a contract research manufacturer of biologically produced substances towards the expanding market of university based research. Initially Beta focused on biological production with intent to use the production capabilities to provide services in up-scaling of manufacturing and to shift between the productions of different short term products. An initial development of Beta was thus the hiring of additional scientist and engineers within the field of biotechnical process engineering.

To continue to appropriate return on the up-scaling capabilities, new projects (customers) had to be reached over time rather than just relying on stable customer relations. To fully develop such a business model, additional, complementary capabilities had to be added to the firm to find customers and markets for the internal competencies in up-scaling and manufacturing. The evolved business model hence included the expansion of the internal group within marketing and sales. The second business model that developed gradually was hence to simultaneously leverage the accumulated capabilities for increased sale and distribution of research reagents and

test kits produced externally but also to stress the internal production capabilities, see Table 4.2.

One of the initial major opportunities for Beta involved the standardized and mass-produced biological substances which were developed in collaboration with national university researchers. These products had originally been developed at the different biological research laboratories but could now be produced in larger scale as the aggregate demands from the national universities increased. Beta thus became involved within the scale-up and production of the already existing research products which included the production of a range of different enzymes and research kits. In relation to these existing products an additional proprietary research product was developed. The contract manufacturing services operations were harder to establish, partially due to the focus upon getting the product portfolio of research materials in production. In addition to the initial strategy, to complement the internally produced product range, a distribution agreement was entered with an US base firm. With this agreement Beta intended to expand their available research product range within the local region. Other additional agreements were later entered with both US and European firms that expanded the available product range which were being distributed locally and added an international market to some of the internally produced enzymes. The internal production capacity of Beta was thereby turned towards increased production of more specialized enzymes providing a handful of niche enzymes. As a result out of the increasingly important international distribution of internally produced products, Beta acquires investments in a bankrupt US based firm to develop international market. The development towards large scale production provided spare capacities within the capabilities for up-scaling and small scale production for additional services that led to a number of agreements of protein production for diagnostic applications. During this period, Beta also starts to fund a university based research group active in cancer research in exchange for the product rights of their lead compound, DRUG 1, which seems suitable for the capabilities of Beta within up-scaling.

Table 4.2. Development of the capabilities and business models of Beta

Time	Business model	Essential Capabilities	De emphasized capabilities	Emerging capabilities

T1	Contract manufacturer and for flexible short series of production and services for the local market.	Biological production		Added capabilities in scale-up of biological production processes.
T2	Change into a production, development and distribution of research kits and proteins for the local market.	Scale-up and production capabilities		Added capabilities in marketing and distribution capabilities
T3	*Radical change into a bulk protein production and fewer internally produced products for the international market. Distribution of research kits for the local market.*	Manufacturing capabilities	Scale up	Investments in university based research project.
T4	*Radical change into a clinical drug development of Drug 1 & Drug 2.*	Clinical manufacturing capabilities		Added capabilities in clinical research. Trade sale of marketing and distribution. Discontinued production of standardized proteins.
T5	*Radically changed into a drug development company, to in-license Drug 3 and out-license Drug 1.*	Clinical research capabilities	Scale up and manufacturing capabilities	Added capabilities in drug research

After 5 years of operations Beta faces a strategic choice, to further invest in the upgrade of the production facilities to further increase the scale of operations and/or invest substantially more in the pharmaceutical research performed in collaboration with the external research group at university. This eventually led to a radically changed business model. As the cash reserves of the firm is falling, more effort is put towards developing the existing contract research manufacturing operations and maintain the manufacturing capabilities while new product development for the research material business should be reduced. Nevertheless, a small group of skilled scientist and engineers are focused upon up-scaling of DRUG 1 together with the university collaboration research project. Thus, the manufacturing operations shift towards the more standardized protein manufacturing while the development of products for the research business terminates. All remaining long term investments and up-scaling effort is now devoted towards the drug developed within the university collaboration. During this time sufficient amount of the DRUG 1 is produced by Beta to start basic toxicology testing. A second potential drug, DRUG 2, a derivative of the first is further on also developed. After an additional two year period with low and reduced investments in new product development for the research enzymes and kits results in the complete closure of the internal production of research reagents and the

remaining proprietary products are out-licensed. A secondary reason, behind an empty pipeline of new products is an increased demand on the facilities to increase the production of bulk proteins. A third reason is the reduced demand of research material within local universities due to a reduction in governmental research spending. Altogether this result in a decision to discontinue with investments in further development of internally produced research kits and products. A managerial and marketing effort to expand the contract production manufacturing business is instead emphasised. The business model focuses on the production capabilities as the demands for research grade bulk proteins increased both for diagnostic purposes but also as a result out of the Bovine Spongiform Encephalopathy (BSE, 'mad cow') disease in Europe. Simultaneously the internally produced products had become rather standardized and new products were no longer developed internally. As an outcome of the small investments in new product development, the production and distribution of research products were de-prioritized.

As the scale-up effort of the production of DRUG I increases Beta realizes the growing need to separate the clinical manufacturing and the production of research grade bulk proteins. The solution is to transfer the protein production to a smaller local University which has suitable facilities vacant. After the transfer of equipment work is immediately undertaken to upgrade the internal production facilities to clinical production standards. Simultaneously DRUG I is being tested for toxicology at an independent research organization. The following year Beta is focusing on the development of clinical grade production of DRUG 1, additional research is also devoted to the scale-up of the subsequent compound, DRUG 2 a derivative of the original. In parallel the new bulk protein facilities set up at the local University suffers with extensive problems as most of the available competences are being devoted to the different Drug projects. Simultaneously, the research product business further reduces the product range but increases the distribution of internationally produced products.

The production requirement of DRUG 1 substantially increases as the substance enters the first phase 1 clinical trials. These clinical trials are performed with an international service provider based in UK. As a result out of these initial clinical trials, the time frame of actually developing a novel cancer drug is fully understood by

Beta. Furthermore, as the scale-up capabilities are concentrated upon the transition to clinical production and developing protocols and stable production, the production of bulk protein continues to suffer from extensive problems.

At the collaborating university, the research group succeeds to clone the enzyme involved within the biological processes. This is by Beta seen as a major step and potentially allows for much a more rational drug design research program. A second research collaboration is therefore initiated with another research group at the university, involving in advanced synthesis of the complex drug molecules. For Beta this will potentially open up for the production of additional variants of the underlying drug. After the ongoing reduction in the internal production and the accumulated distribution rights of internationally produced products the business unit which sale and distributes research products is finally made profitable.

As the development of the DRUG 1 project progress Beta needs to add clinical trials and financial competencies. These have initially been performed in collaborations with external partners but as the uncertainty around DRUG 1 is reduces Beta decides to integrate these activities internally. As a result Beta transforms itself to a real drug development company and gains a large capital injection from existing owners as well as international institutions. In a second source for additional capital is a collaboration which is initiated with an international start-up firm. This international firm pays for the rights to pursue additional clinical trials with DRUG 1 and in exchange obtains parts of the future revenues. The sales and distribution business unit is now completely detached from the other activities within Beta. No internally produced products are sold as all the production capabilities have become completely subordinated to the needs of the drug development program.

After the capital injection the business model of Beta is once again radically changed. The research product business, which now consists of only sales and marketing to support the distribution of internationally produced products should be divested. As a result of the transition to become a drug development company, Beta greatly changes internally, forcing a forth business model upon the firm. The capabilities within clinical development focus upon just one product, DRUG 1. Instead of progressing with the development of DRUG 2, better opportunities emerge from the research

carried out at the university to further understand the underlying mechanism of the drug. As the initial production of the compound DRUG I by now is running smoothly there are however opportunities for profiting from additional contract manufacturing as well as scale-up services, as long as they are compatible with the production of clinical productions.

In order to precede with the clinical development into phase 2 of DRUG I additional employees in clinical development and regulatory affairs are employed. To fully exploit the opportunities of the two breakthroughs at the research groups funded at the university, Beta receives a governmental research grant, in exchange for investing a similar amount in the research project. The immediate result is that a drug discovery group of additional scientists are recruited and cooperation with a nearby University is started to complement the ongoing drug discovery research. A key for the established drug discovery strategy is the ability of Beta to scale-up the production of the discovered enzyme for further research purposes. In order to achieve this novel production capabilities of mammalian cells are added. With respect to the development of DRUG I, Beta actively starts to look for a global partner, to out-licence to, as the fully costs and time frames of carrying out Phase 2 clinical trials gradually are realised. To leverage the newly acquired capability of mammalian cell production, Beta there afters enters additional commercial research service contracts. The newly found drug research group (including a group of external scientific advisers) enters an active in-licensing strategy to come up with another compound, as the internal development of a second compound takes to long to develop.

The expansion of clinical requirements for production of DRUG 1 in phase 2 increases, and occupies the manufacturing personal which are forced to requite additional personal competent within pharmaceutical production standards. As the clinical trials increases the demands upon manufacturing resources, opportunities for contract manufacturing are once again reduced. Gradually Beta realises the importance to show their product towards the pharmaceutical industry for an out-licensing of DRUG I. They co-fund a conference on cancer diseases and the application of similar technologies as DRUG 1 which increases the visibility of the company internationally. The out-licence strategy is further intensified together with a US broker firm which is recruited to marketing Betas DRUG 1 towards the global

pharmaceutical industry. As direct result of the rising needs for making a technological licensing deal a new CEO is recruited with a background in licensing and technology venturing. Simultaneously as Beta is focusing upon the DRUG 1 development a trade sale of the research product business unit is finally finalized. This had been the intent of Beta ever since they adopted the business model of further developing Drug 1 three years earlier.

At this point Beta gradually realizes the need to simultaneously out-licence the initial drug product while simultaneously in-licence or internally generate a subsequent pharmaceutical product to leverage the accumulated skills within clinical development and financial connections. The business model thus slightly shifts once again, from being focused on developing the initial drug project, DRUG 1, to actually become a stable drug development firm. This is done in two parts, first to further develops its proprietary technology (which originated from the university research collaboration), but simultaneously also to leverage upon its acquired competencies in early stage drug development such as clinical research, up-scaling and financing/deal-making. A third pharmaceutical product, DRUG 3 is in-licensed from a university after being scrutinized by the internal research group. This product is ready for initial clinical trials, something that Beta now have experience in. The need to find a second pharmaceutical research project is entirely based upon the leverage of the accumulated capabilities within clinical development, financing and the by now established visibility towards the major pharmaceutical firms specialized within cancer drugs.

4.3 Gamma

Gamma has seen one radical shift in its business model. Over time as Gamma dramatically expanded serious growth problems forced this firm to drastically change. The resulting revitalized firm appropriated upon the developed research platform technology but discontinued any further development thereof. Apart form this Gamma also continued to thrive upon one of the earlier opportunistic investments made during the earlier rapid growth phase.

The initial business model of Gamma was to work as contract research organization within protein analysis. The founders had previously been a large research team working at a university and had tried to set up a major research program together with an international company. However, the international company refused to fund such a big research program because of the large overhead expenses at the university. At the same time the research group found a suitable and cheap laboratory space available after a bankrupt local biotech firm. As a result a large fraction, 14 scientists, which had no funding left of the original research group decided to start a new contract research company. This was seen as a natural opportunity to continue their work within protein analysis, and partially necessary for generating revenues as no other financial sources were available. During the first year Gamma rented necessary and very expensive equipment at their former university. In addition, Gamma also bought some old equipment from the university. The initial business model of Gamma was hence based upon taking advantage of the assembled groups of researchers which could provide a rather unique capability in providing contract research services on a fee-for service base. However, the group simultaneously intended to continue to develop the necessary technological solutions required for rapid large scale protein analysis and sell these technological solutions in relations with external collaborating equipment manufactures. Unfortunately at this time the University still had some of the intellectual property rights which the members of the research group previously had generated.

After the initial year Gamma decided to try to change the pure contract service business model which had taken the firm through its first year to develop and use the large scale technology, see table 4.3 below. Thus they began to increasingly focus on the underlying technology and develop this in partnerships, to minimize the capital requirements and still maintain the ownership over the firm. The first collaboration devoted to the development of the new technological research platform was as a result initiated with an established equipment manufacturer. From that moment Gamma had an increasingly clear focus on the development of new research equipment rather than conducting research contracts. The contract research business hence became deemphasised, as this only was seen to provide revenues for keeping the business going but didn’t provide any real future rewards. Some of the founding scientists at Gamma simultaneously got some of the original IP back from the university which

opened up additional possibilities for further technological development within this additional type of research equipment. The business idea was hence to provide a complete integrative technological solution for protein analysis, composed of a range of different interconnected research tools suitable for automated large-scale research. One of the additional outcomes of this first collaboration was the in kind provision of some very expensive research equipment. Apart form being an essential part in the integrated platform tool, access to such equipment internally did also provide the group with opportunities for performing additional contract research without being forced to rent it from the university. Together with the internally developed prototype of the research tool, this opened up for additional opportunities within and expansion of contract research capabilities.

Table 4.3. Development of the capabilities and business models of Gamma

Time	Business model	Essential Capabilities	De emphasized capabilities	Emerging capabilities
T1	Contract research	Research collaboration	Technology development	
T2	Research equipment (Technology Platform) development and manufacturing	Technology platform development. Financial capabilities with the takeover and investments in additional research groups	Research based upon the developed platform technology.	Return of university owned IP. Access to expensive research equipment. Prototype and manufacturing capabilities
T3	*Radically changed into a drug discovery and drug development*	Internal usage of the developed technology for contract research and drug discovery. Clinical development of US based pharmaceutical project.		Abandonment of manufacturing and technology development capabilities

At this time the management team also started to leverage their gained experience in running a start-up a company. One of the major decisions involved starting a small venturing activity. The idea was to sublet some of the office and laboratory space, and to give advices to other university spin-outs in exchange for a small equity stake. Gamma also acquired a development group in the US which had been involved within the technological development of similar large scale protein analysis technology. This US group was taken over from a larger US biotech firm which had to restructure due to financial difficulties. The main motivation was besides the opportunity for strengthening the technological development project to increase the market visibility in the important US market, and to acquire some initial internal manufacturing capabilities. A second major event at this time regarded the contract research deal

which had supported the firm initially. Due to adverse market condition this major research project was cancelled, and the contract research group thus had to look for other commercial research projects as they now had a complete set of a rather unique prototype equipment and experience at their hands.

The expansive growth of Gamma continued within the following year when the group of design engineers which had been involved in the initial development of the prototype was taken over and integrated within Gamma. Further on, a group of researchers within diagnostic applications were taken over from a local biotechnology firm which was going through a reconstruction of their business. Later on this year the contract research group successfully entered a range of another major service contracts. A new business model now was clear within the original contract research unit, to find and analyse proteins based upon the proprietary developed research equipment. The goal was to use the developed prototype technological research platform within the discovery of potential drug targets. This new opportunity within drug discovery was however not pursued with full commitment as both management and financial resources increasingly were focused within the final stage within the development and commercialisation of the research equipment, such as providing quality control and documentation as well as undertaking all the requirements for establishing complete production of the research equipment.

After 3 ½ years of operations Gamma entered its first major sale of its developed research equipment/ technological platform. The development of the complete research platform was thereby completed, including both the internal manufacturing and the supporting IT systems. The final deal became in the form of a Joint Venture with a major international contract research organisation. As a result of the internal growth and takeovers of the different research groups, together with the sale of the first research equipment Gamma received several awards for being a rapid growth company and for pursuing excellent technology development. Yet, during this period of rapid growth real problems started to emerge for Gamma. The amorphous growth in the previous two years started to get out of control. Gamma gradually tried to change all this, efforts were taken to increasing traditional human resource practices, but did not pursue any real change within their business model. Gamma thus adopted

a more conventional business structure, with project mangers and different groups with clear responsibilities.

At this time competing technological solutions also started to appear. Together with the unexpected slow sales of their proprietary technological platform Gamma increasingly became unsure on the market for their developed research equipment. A decision was hence taken to increase the marketing effort. The vision was to further manufacture and install 4-6 additional complete platforms within the upcoming year. In order to do so additional financing was deemed necessary, and the solution was to turn to external investors. Around the time for securing the external financing three major events changed the evolution of Gamma: Firstly the joint venture around the first installed research equipment was cancelled. This was not the direct result of any technological, but rather the outcome of yet another company restructuring within the bioscience industry. Secondly, the US based entity identified and finally took over a US based pharmaceutical research group. This research group had a couple of promising drug development projects which were about to enter clinical trials. Finally, the new owners who had entered the firm in order to finance the increased marketing effort gradually realised the weak opportunities for the technology and forced through a strategically revision of Gammas business. As a result, Gamma once again drastically changed the business model. Everything related to the further commercialization of the technological platform was almost immediately cancelled. Instead Gamma focused upon the discovery business which had evolved out of the original contract research business but which now had access to the internally developed prototype equipments, secondly gamma also focused upon the recently acquired US based drug business which was being based upon the recently acquired US pharmaceutical research group.

5. Analysis

This section presents our analysis of the development and the co-evolution of capabilities and business models of the three bioscience firms. By a closer examination of the three case firms we did find a common pattern of how these firms have developed as well as of the co-evolution of business models and capability development.

Our main finding is that all our studied firms have both gradually and radically changed their business models as well as changed their configuration of capabilities. By 'radical' changes in their business model we mean that the logic of the firms' business models has changed simultaneously within more than one aspect or dimension. This makes a 'radical' change distinct from the slight alteration or adaptation of the initial business model which frequently occur within entrepreneurial ventures in which the business model of the firm gradually evolves. We find that the all studied case firms are forced through at least one radical change of their business model. For Alpha and Gamma we observed one period of radical change of business models during their first 5 years of operation while Beta went through three periods of radical changes in its business models during its 15 years of operations[8]. The radically changed business model thus differed in several dimensions, e.g. in terms of whom the customers were and how the firms would earn money. This means that we also can logically infer that the nature of one opportunity to the next that the firms acted upon had also changed greatly.[9] These radical changes of the business models stand in some relation to the changes in the capabilities of the firms. The radical change in business models from the initial opportunity pursued to the subsequent opportunity was from the perspective of the firms' capabilities partly related and partly non-related.

Based on the case studies in Section 4, we will now analyse the four research questions that were presented in Section 3. The first question is *what capabilities do companies add to develop and appropriate value based on the initial opportunity?*

Our cases show that for Alpha the added capabilities were within biological manufacturing and scale-up of the initial production of biologics. In addition an ability to set up collaborative research contracts were developed to advance the initial opportunities within therapeutics. These added capabilities and the resulting relationships provided Alpha both with additional competencies within drug development, internal production of the biologics for research purposes but also initial

[8] Whether one radical change per five year is high or low we cannot say, although it should be seen in the rather long development times, up to 15 years for pharmaceuticals, and product life cycles within the biotechnology industry.
[9] The case studies in Section 4 indicate that the opportunities were radically different but do not show it conclusively.

access to limited revenues for the long and costly development of therapeutic applications essential for their initial business model.

Beta added and developed a sales and distribution organisation to appropriate upon their initial opportunity within biological manufacturing. This provided Beta with a business model in which the capabilities of scale-up of biological processes could be maintained, but in which the manufacturing capabilities could be leveraged within more stable and distributed customer relations within the local geographical area.

Within Gamma the internal prototype development and manufacturing capabilities together with a capability to enter research contracts and partnership deals became essential for further progressing within the initial business model. These additional capabilities provided the firm with a capability to internally use, manufacture as well as install complete technological systems at potential customer organizations.

As these firms pursued and developed the initial opportunity, they did so initially by drawing on the already established technological capability. None of these three firms could hence be described as started with a single entrepreneur, but instead from a team of actors constituting a technological capability of the emerging firm. However, to continue to advance and create economic value around the initial perceived opportunity, they also needed to 'add' new types of capabilities. As expected from reading the literature regarding development of new ventures and business firms (e.g. Teece 1986), we also find empirically that these additional capabilities are not strictly related to technological activities. In fact, across the different case studies, we found that such developed additional capabilities to a large extent were within the realm of general business practices such as financing, deal making, manufacturing, and distribution and sales/marketing. An important observation here is that these additional capabilities are rather 'generic' and potentially lend itself to a broader range of additional opportunities[10] (Teece 2000). Thus, the answer to the first

[10] Even if these additional capabilities are 'generic' in the sense that they are applicable for the pursuit of a broad range of different opportunities, the independent capability is still defined and limited to a specific kind of activities. Further on, business capabilities are generic only as an outcome of the frequencies of applications for performing the related activities, the broad range of opportunities for employing these. However, such 'generic' capabilities might still be of rather low strategic value as they might be relatively common.

question is that *the bioscience firm adds additional, rather 'generic' capabilities during the development of the initial opportunity*. These can also be characterized as complementary to the original capability which the firm depended upon initially (Teece 1986). Finally, these capabilities were dissimilar to the original capability in the sense that they were not strictly technological and performed by mainly additional employees.

The second issue is *why the firms added a distinctly different capability within their business model while pursuing their initial opportunity?*

Our cases show that Alpha needed to develop three additional competencies within major different areas in order to succeed within their initial business model. Firstly this was in the areas of management of external relations in order to get revenues and to provide the firm with additional competencies within different therapeutic areas. Secondly additional capabilities within the production of biologics were added. Finally Alpha needed to acquire an ability to finance a long term and highly uncertain technological development project. This created a business model in which Alpha could internally produce the necessary biologics for the joint research efforts undertaken while at the same time acquire both additional knowledge and minor revenues through these external research collaborations necessary for the continued development of the therapeutic vision.

For Beta the additional capabilities was initially added within sales and distribution. These were new capabilities which were developed in order to market and distribute the internally as well as externally produced products. These added capabilities thus created a business model in which Beta could provide the emerging local market with a stable supply of research material based upon the initial manufacturing capabilities while simultaneously provide additional services within commercial scale-up and manufacturing.

For Gamma, a rather wide set of capabilities were acquired to compile the initial business model. In order to develop the research equipment technology both collaborative research activities which 'used' the technology as well as development

project aimed at further develop the technological solution was deemed necessary to maintain in-house. Further on, in order to finally commercialize the research equipment capabilities within both manufacturing as well as installation were deemed necessary to be provided by the firm. This provided Gamma with an integrated business model in which Gamma both developed, produced and installed the complete technological system.

We hence observe that for these firms to create value and appropriate returns around the initial opportunity, they added capabilities which are different but rather complementary to their original capabilities (Teece 1986). Hence, to advance and/or support the product development all the case firms acted to develop its business to create economic value further before the firms could capture financial returns. Initially, the firms attempts to create potential economic value around the initial perceived opportunity. As the firms continue with these efforts, the firms also 'added' new capabilities as the combination of these capabilities that moves the firms closer to actual economic value, which can allow for appropriation of returns. The creation and appropriation of value is hence not possible without the addition of complementary but dissimilar capabilities. The observed bioscience firms are thus a collection of rather *dissimilar but complementary capabilities*. This should be contrasted to the original argument put forward by Richardson (1972) who claimed that firms should comprise *similar but not necessary complementary activities*.

Our second question was to elaborate why the firms added a distinctly different capability within their business model while pursuing their initial opportunity. Accordingly the bioscience firm felt that they were 'forced' to add these capabilities in order to both generate and appropriate the value within the initial opportunity. The key aspect here is that neither the initial business model, nor the capabilities is not fully developed for the bioscience firms just because the company is launched[11]. Instead the firms need to continue to work in order to progress with their product or service offerings, creating market channels, dealing with legal issues etc. While the firms did perceive that they could create and launch offerings that should be of value for customers to get there, they needed to improve their business models as a single

[11] In addition these additional capabilities were in some circumstances gradually built, starting from contracting services and consultants gradually more integrated and expanded within the firm.

invention or innovation was not enough. Hence, we propose that *bioscience firms are forced to add these generic capabilities in order to both generate and appropriate the value within the initial opportunity.*

The third issue is: *what characterizes the relationship between the different opportunities that bioscience firms act upon over time, the developed set of accumulated capabilities and the radical shifts in business models*?

For Alpha the radically changed business model emerged from the gradual understanding of the huge financial requirements and long timeframes involved within the traditional drug development model. As the capabilities within internal therapeutic development were deemphasized Alpha instead acted upon the newly acquired capabilities to handle and supply biologics as well as their capabilities within establishing and appropriate from research contracts. The new opportunities were based on providing biologics to externally financed and pursued research projects. This thus implied a business model in which a general research platform rather than a specific drug development project should be pursued. In order to accomplish such a business model the newly acquired capabilities within contract and deal making were essential as well as the internal large scale production of the biologics. These were necessary capabilities as the research applications of the derived technological platform still needed a rather intense support from Alpha to be successfully used within the specific externally performed research projects.

For Beta, a lucky and opportunistic research investment meant that the firm was transformed into a drug research venture. These requirements completely removed the last remains of internally produced products for the sales and distribution organization which became detached from the other main activities within Beta. Gradually understanding the temporary role of the drug development venture the firm tries to fill the product development pipeline. The main driving causes are however not the initial capabilities within manufacturing, scale-up nor the capabilities within sales and distribution but rather the newly assembled and accumulated capabilities of performing clinical development and the managerial task of providing the capability for such clinical development work. That is, the organized ability to raise long term financing and visibility and relation towards potential customers (incumbent

pharmaceutical firms) became the new key capability together with clinical research practices. With respect to the specific research and manufacturing capabilities, the in-licensing of the third drug candidate (DRUG 3) emphasised the importance of these generic capabilities as this product technology does not primarily depend on the original and more specific capabilities within the internally accumulated manufacturing technology neither in pharmaceutical research technology (DRUG 1 and DRUG 2).

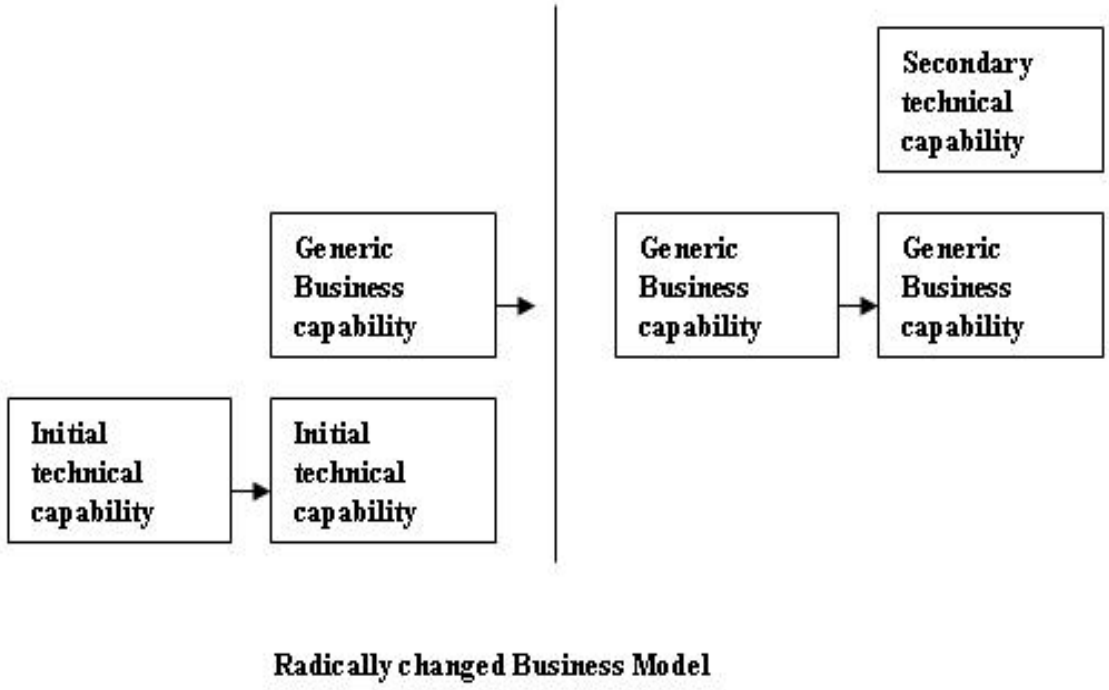
Gamma acted upon the accumulated technological capabilities gained internally from using and developing the research equipment. Together with the acquired capabilities within performing joint research projects and research contracts services this opened up an essential and radically new business model which leveraged upon the internally developed capabilities within protein analysis. Together with the opportunistic outcome of the investment within pharmaceutical development and the acquired financial capabilities derived both from the excessive deal-making this opened up the new opportunities within the acquisition, financing and internal developments of new pharmaceutical projects as well as profiting from research service agreements.

The finding here is that in the subsequent opportunity that the firm acted upon was based on the additional, more ‘generic’ capability that was ‘added’ some time after the firm’s history, rather than the original specialized capability developed in relation to the firms’ initial opportunity. These firms hence drew heavily both on the incumbent capability and – after some time – additional acquired capabilities, but the identification and development of subsequent opportunities are to a large extent based on the later added capability rather than upon further leverage upon the initially developed capability. There is thus only a partial link between the original capabilities and the sequences of opportunities that these firms pursue and act upon.

The resulting changes in the business models are radical in nature. From a capability perspective, the linkage is partially continuous and partially disruptive as new capabilities are added and the old are disbanded or at least not further leveraged upon. The linkage between the initial capabilities that the companies used to pursue an opportunity is hence only an indirect link to subsequent opportunities (Fig 5.1). We can thus infer that the initial opportunity acted upon, with help of the initial capability,

either is emptied or perceived to be inferior by the firm or its investors to the subsequent opportunity which the firm acts upon. In addition this second opportunity and business model requires addition of additional capabilities.

Figure 5.1 Changes in capabilities and business models



The fourth issue is *why are not the initial capability further developed?*
With respect to the continued development of the firm, the terminations of the initially developed capability are frequently observed in relation to the observed radical changes within the business models.

Our cases show that for Alpha which initially had pursued an initial drug development project the capabilities within therapeutic research were not directly supported and continued. These were instead maintained at the university where the original researchers kept working within the different highly uncertain and long term research projects. Alpha increasingly distanced itself from several of these research groups during its radical switch of its business model.

For Beta neither the specific technological capabilities developed within the previous business models would be the foundation upon which the later business model would

be built upon. Within the first business model, in which capabilities within scale-up and contract manufacturing were emphasised, the firm gradually realized the limited demand within the local marked. In the subsequent business model, which emphasised on the capability to produce and distribute the internally produced biologics, a rapidly expanded market led to an increase in the volumes. This rapid expanded, and increasingly global market, led to a decision in which Beta discontinued their investments in increasing the scale of its internal production. Instead beta exited the market and did let the competing incumbent firms take over. Beta instead focused upon the internal drug development projects. Subsequently, the developed capabilities within this area of biologics and kits were sold off.

For Gamma all capabilities related to the development, manufacture and installation of the technology platform was abandoned. This emerging market was instead left open for other firms. Instead the technological platform in itself increasingly was being used for internal research applications, but the further commercial development thereof was deemphasized. This was a direct result out of the potential small market for such research equipments but also on the increased entries of incumbent firms.

Our forth and final question analyze why the initial capability(ies) were not further developed. In several occasions the developed technological capabilities within our case firms were disbanded after given the initial opportunity for the firm. It is thus these capabilities which at the onset of the entrepreneurial development motivated the initial foundation of the firm. The termination of capabilities within these case firms were both found in relation to the abandonment of capabilities such as the divestments of complete business units as in the case of Beta or ‘returned’ to the university as in the case of Alpha. In the case of Gamma, the initial technological capabilities were instead dissolved with the scattering of some of the initial contributing resources and individuals. Another potential which we cannot conclusively dismiss is the possibility that these firms do maintain these originally developed capabilities in a ‘dormant’ stage which our research design fails to capture.

The termination and disbanding of developed capabilities can within our three cases be ascribed to a number of different causes such as both the successes as well as in the complete failure, in technological dead ends, or simply the emergence of other more

lucrative opportunities for the firm. We find that these initially developed technological capabilities can be made redundant regardless of whether they are 'successfully' or not, such as in developing a technology and providing fully functional and successful technical solutions (Tab 5.1). We also find that technological capabilities were changed as a response to market developments such as competitors or increased knowledge about the limited size of the market. In such cases the discontinuity of the internal technological capability can be said to be more exogenously determined. The underlying reasons for capability abandonment were hence both found within endogenous factors caused by such issues as by actually solving a technological problem or developing a (none-) functional solution as well as being exogenously displaced by competing firms.

Table 5.1 Reasons for the capability abandonment

Crisis and abandonment of accumulated capabilities due to:	Endogenous	Exogenous
Technological success	Problem solved but no sequential and related problem (Beta –DRUG 1)	Successful technology but out-competed on the market (Gamma). Successfully technologically by failure due a too small market (Beta-Initial BM)
Technological failure	Technological failure (Alpha, Gamma)	

We hence find that the initial technological capabilities were largely made redundant within the firm due to both exogenous and endogenous factors. This should not be interpreted that these technological capabilities necessarily disappeared. Rather it can be understood as these capabilities did not directly contribute to the new activities of the firms, such as being essential within the radically changed business models adopted. Thus, our fourth finding is thus *as these firms develop and radically change their business models, the initially formed capabilities frequently are made redundant*.

6 Conclusions

This paper set out to show that many bioscience firms change after their formation and explain how and why these firms change and develop. We claimed that changes, including radical changes, are rather common for bioscience firms. Consequently, the purpose of the paper was to demonstrate how new and entrepreneurial bioscience firms do change and explain why this takes place. We suggested that an internalist

perspective, focusing on the co-evolution of capabilities and business models in relation to different opportunities that firms pursue, should be a powerful way to characterize and explain firm changes. Thus, to investigate the development of bioscience firms we hence aim to examine the changes of business models in relation to the development and change of capabilities.

Within the business models literature changes of firms tends to be pictured as the experimentation of a set of given capabilities and resources within the specific context of a firm (Murray and Tripsas 2004) or on the level of learning by individual entrepreneurs (Sanz Velasco 2007). As such the business model literature can be described to a theory of how evolving firms gradually evolves towards a better 'fit' towards the opportunities acted upon. This paper however also attempts to link the changes within business models to the accumulated and developed capabilities. Within the capabilities literature it is usually assumed that capabilities exist ex-ante as a reason for the firm to exist or be achieving superior profits. An alternative interpretation is that firms are dependent upon higher 'meta' level dynamic capabilities for change and prevail in dynamic environments (Teece et al 1997). Literature upon the actual development of capabilities is rather sparse. Consequently, to address the co-evolution of business models and capabilities, we also empirically addressed how capabilities change, see question 1 and 2 in Section 5.

Our empirical findings show that both business models and capabilities do co-evolve. That is, firms do adopt business models in which they lack critical capabilities as well as they adopt business models which leverage their accumulated capabilities. Further on, our empirical findings hence imply that these accumulated capabilities does not entirely define and determine the opportunities these firms acts upon, in terms of the requirements of capabilities needed to succeed with the new and radical changed business models. Instead, these firms do constantly leveraging only parts of their accumulated set of capabilities by gradually adding, developing and scrapping additional capabilities. These firms are thus as much forced to constantly acquire and build up additional capabilities as they seek to leverage already internal accumulated capabilities. Whether this is related to any higher ordered, dynamic, capabilities which constantly can reconfigure the firm we cannot say. However, from our perspective the evolution of the firm is dependent upon the further development and recombination of

its capabilities as well as the opportunities identified. Our findings here on the development of bioscience firms thus bear a resemblance to the patching strategy of firms within dynamic industries such as the ICT industries proposed by Eisenhardt and Brown (1998).

Our empirical study showed that the three bioscience firms under investigation did change their business models several times as well as underwent at least one period of radical change. That is, perhaps the most striking empirical finding is the number of relative frequent and radical changes. Indeed, firm Beta changed its business model three times over a period of approximately 15 years. Within such radical changes the business model is changed within several aspects of the business simultaneously. This hence represents a radical event in terms of multitude of changes rather than magnitude. Having established that this phenomenon does exist, we still do not know how frequent such radical changes of business models are. Our empirical finding thus raises questions regarding the frequency of such observed patterns, and whether this development is limited towards the bioscience industry or exists within other industries as well.

Our second major finding relates to the stability of capabilities upon which these bioscience firms develop. Within our research, technological capabilities are to a less extent stable during these periods of variation and change. Instead a technological capability within these bioscience firms seems not to occupy any different position in relation to other capabilities in order for the firm to develop from. Thus even when leverage of capabilities occurs, changes of technological capabilities are prevalent to the same extent as within any other kind of capabilities.

We also did find that these technological capabilities can be made redundant regardless of whether they are ‘successful’ or not, such as in developing a technology and providing fully functional and successful technical solutions (Tab 5.1). We hence infer that the abandonment of these initial developed technological capabilities is ascribed to their specific nature or lack or future opportunities.

Our finding could be criticized from the aspect that a change of the technological capabilities of the firm requires or cause a radically changed business model. That is,

as a technological capability becomes obsolete the firm is forced to radically change the business model. We would like to emphasise two counter arguments; firstly the technological capability is deemphasized because of *both* the success and the failure of its technology! Technological capabilities or technologies do not guaranty success without a proper business model. Cases where technologies have prospered first after a radically changed business model can be found (Chesbrough and Rosenbloom 2002). Secondly, the leverage of other capabilities besides the technological capability could be interpreted as the relative higher value of such capabilities within other settings and business models rather than due to the failure of the technological capabilities per se.

The implications from our research refer to the accumulation of capabilities which determines the directions for further development of firms. It seems like the technological capabilities per se are not the prevalent determinants for the development of biotechnology firms. The managerial implication is thus to pay attention, not only to development of technological capabilities, but also upon the development of other kinds of capabilities which can generate value and opportunities independently of the strict technologically oriented business model.

On an industrial level, the frequent radical change of business models and the prevalent effort to leverage generic business capabilities rather than continued development of technological capabilities might contribute to the inherent Schumpeterian fragmentation of - and networking within - the bioscience industry. While the paper analyses bioscience firms as such, there are reasons to believe that the findings can be valid in other technological areas as well even if the speed and radical type of experimentation may be less dramatic outside the biosciences. To some extent this limitation is reduced in that the cases are not focused on any specific technology but are linked to the broader issue of the development of firms within science based technologies. Still, certain characteristics of the bioscience industry may impose limitations to the generalization of our findings. This specific industry is characterized by being based on scientific knowledge and an appropriability regime that in many ways depend on rather specific institutional settings, especially intellectual property rights. We believe that much of the observed radical switches in business models and terminations of capability development can be explained by such particularities.

Nonetheless, the internalist perspective of the co-evolution of capabilities and business models developed here cannot be substituted by industry or environmental explanations.

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